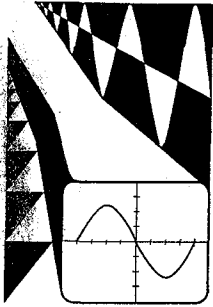


# PHILIPS



15MHz Dual-trace oscilloscope

**PM 3226/..**

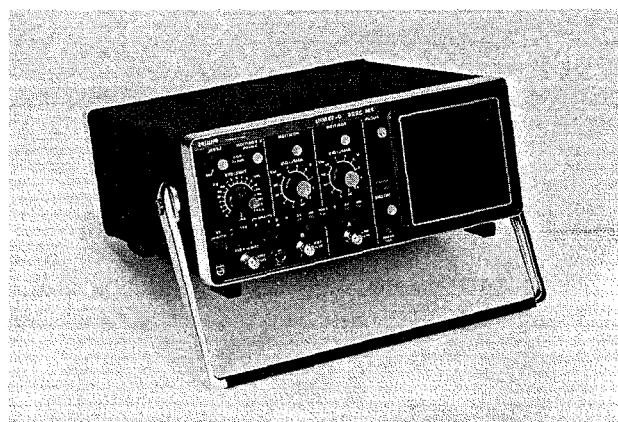
(9432 032 26001)

9499 440 17202

770615



# PHILIPS



**Instruction manual  
Gerätehandbuch  
Notice d'emploi et d'entretien**

**15 MHz Dual-trace Oscilloscope  
15 MHz Zweikanal-Oszilloskop  
Oscilloscope double trace de 15 MHz**

**PM 3226/..**

(9452 032 26001)



**IMPORTANT**

In correspondence concerning this instrument, please quote the type number and serial number as given on the type plate.

**WICHTIG**

Bei Schriftwechsel über dieses Gerät wird gebeten, die genaue Typenbezeichnung und die Gerätenummer anzugeben. Diese befinden sich auf dem Leistungsschild.

**IMPORTANT****RECHANGE DES PIECES DETACHEES (Réparations)**

Dans votre correspondance et dans vos réclamations se rapportant à cet appareil, veuillez TOUJOURS indiquer le numéro de type et le numéro de série qui sont marqués sur la plaquette de caractéristiques.

*Note: The design of this instrument is subject to continuous development and improvement. Consequently, this instrument may incorporate minor changes in detail from the information contained in this manual.*

*Bemerkung: Die Konstruktion und Schaltung dieses Geräts wird ständig weiterentwickelt und verbessert. Deswegen kann dieses Gerät von den in dieser Anleitung stehenden Angaben abweichen.*

*Remarques: Cet appareil est l'objet de développements et améliorations continuels. En conséquence, certains détails mineurs peuvent différer des informations données dans la présente notice d'emploi et d'entretien.*

# Bedienungsanleitung



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<i>Designation</i>	<i>Specification</i>
<b>1.2.5 Triggering</b>	
Sources	: Internal External Line
Trigger sensitivity	: Internal ; Level -0,8 div. at 100 kHz; 0,4 div. typical max. -1,0 div. at 15 MHz; 0,6 div. typical Top -3,0 div. at 15 MHz; 2,0 div. typical TV -2,5 div. for line or frame sync pulses; 1,5 div. typical  External; Level -0,7 V at 100 kHz; 0,4 V typical max. -1,0 V at 15 MHz; 0,5 V typical Top -2,0 V at 15 MHz; 1,2 V typical TV -2,0 V for line or frame sync pulses; 1,0 V typical
Input impedance	: 1 MOhm // 25 pF
Maximum permissible input voltage	: $\pm 400$ V (d.c. + a.c. peak). Resistant against non-repetitive surges of up to 1000 V
Trigger mode	: Timebase generator runs free in absence of trigger signal. a. Trigger-level adjustable over 12 div. or 12 V. Lowest triggerable frequency for sinewaves = 10 Hz. b. Top.
Trigger slope	: + or -
Triggering with TV signals	: Frame (coupled with positions .5 ms/div to 200 ms/div) Line (coupled with positions .2 ms/div to .5 $\mu$ s/div)
Probe adjustment	: Contact point (for conditions see Section 2.2.3)
<b>1.2.6 Environmental characteristics</b>	
The TECHNICAL DATA are valid only if the instrument is checked in accordance with the official checking procedures. Details on these procedures and failure criteria are supplied on request by the PHILIPS Organization in your country, or by N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST & MEASURING DEPARTMENT, EINDHOVEN, THE NETHERLANDS.	
<b>1.2.6.1 Temperature</b>	
Reference value	: 23 deg C
Nominal operating temperature range	: +5 deg C to +40 deg C
Operating temperature range limits	: -10 deg C and +55 deg C
Temperature range for storage and transport	: -40 deg C to +70 deg C
<b>1.2.6.2 Altitude</b>	
Limit range of operation	: 5000 m
Limit range of transport	: 15000 m } in open air
<b>1.2.6.3 Humidity</b>	: Meets IEC 60 Db requirements.
<b>1.2.6.4 Bump</b>	: 1000 bumps of 10 g, 1/2 sine, 6 ms duration, in each of 3 directions.
<b>1.2.6.5 Vibration</b>	: 30 minutes in each of three directions, 10-150 Hz; 0,7 mm p-p and 5 g max. acceleration.

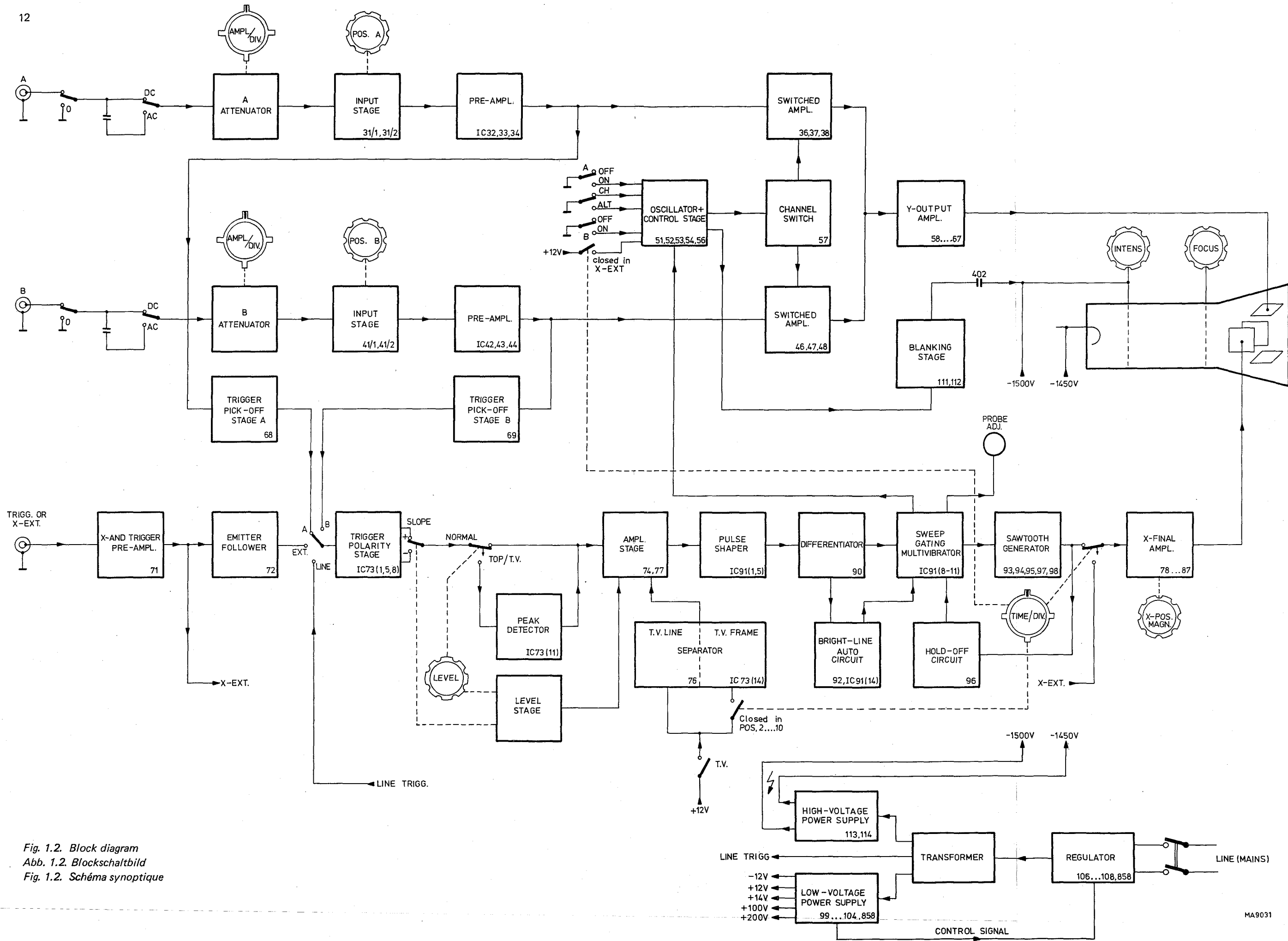
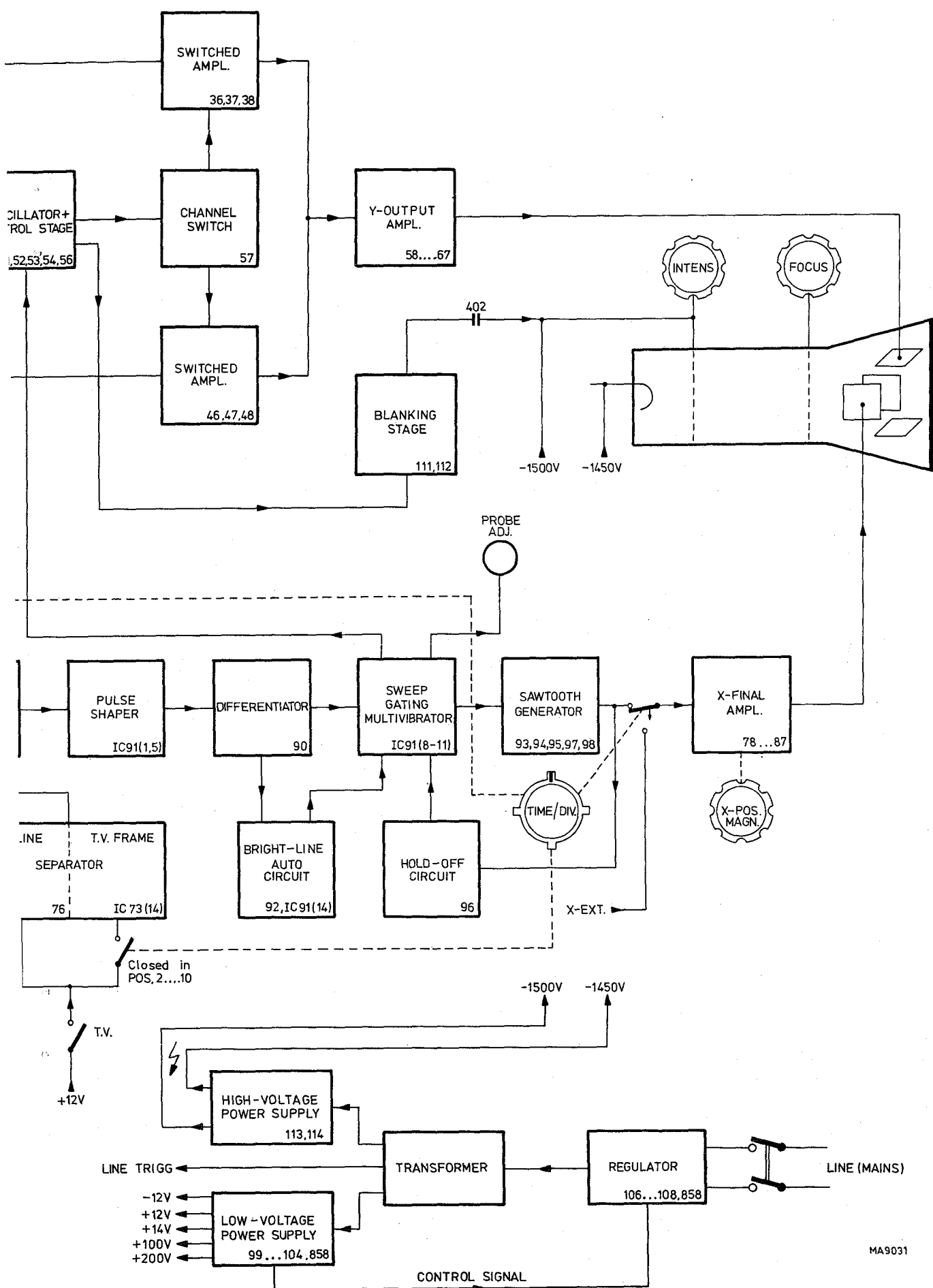


Fig. 1.2. Block diagram  
 Abb. 1.2. Blockschaltbild  
 Fig. 1.2. Schéma synoptique



MA9031

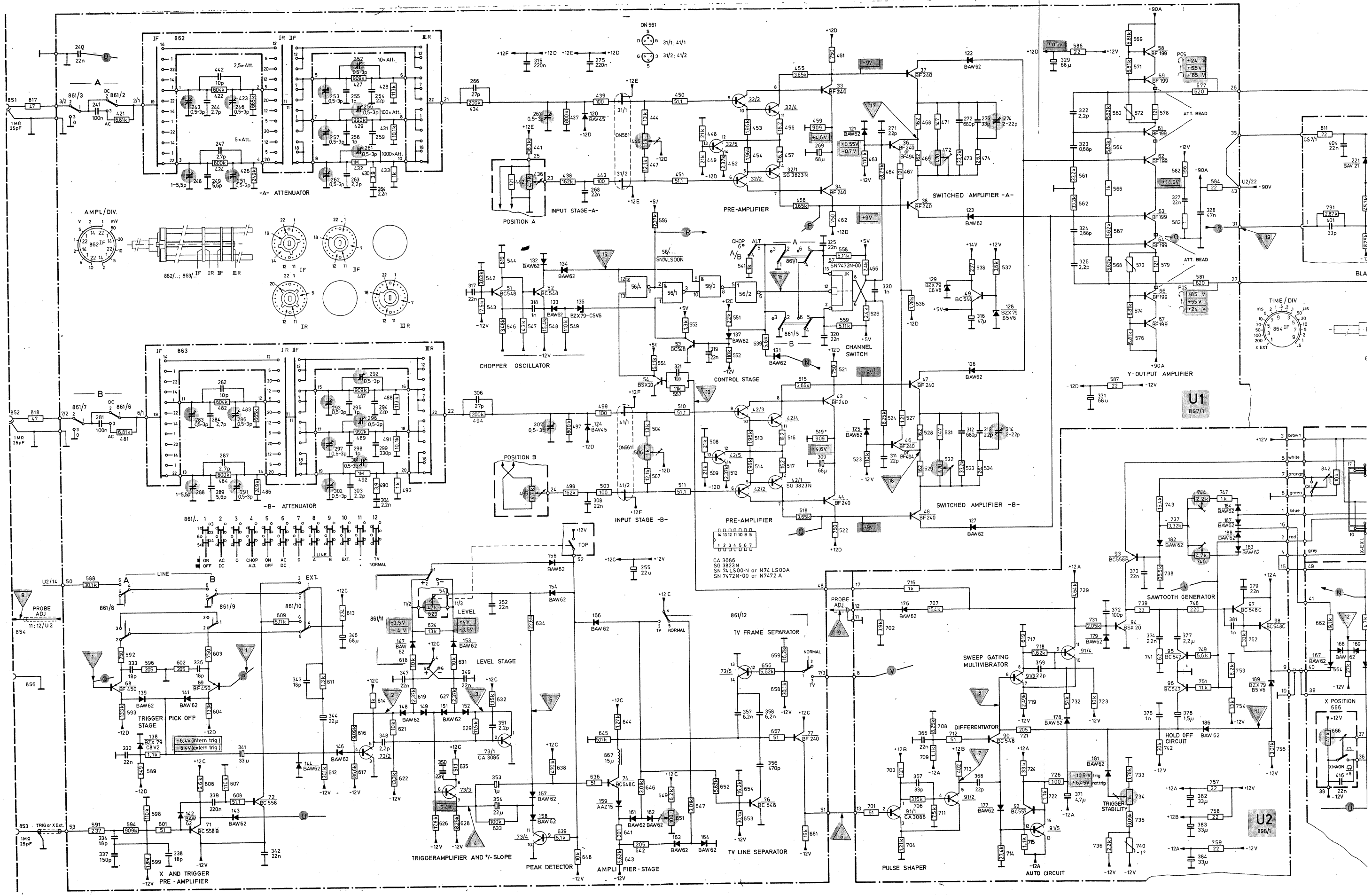
*Designation*

*Specification*

- |         |                              |   |
|---------|------------------------------|---|
| 1.2.6.6 | Electromagnetic interference | : Meets VDE, Stograd K.   |
| 1.2.7.  | Operating position           | : Optional  |
| 1.2.8   | Supply voltages              | : 110 V; 127 V; 220 V and 240 V; a.c. ± 10 %<br>(46 Hz to 400 Hz) |
|         | PM 3226Q (USA-version)       | : For 110 V only  |
|         | Power consumption            | : 18 VA   |
| 1.2.9   | Mechanical data              |   |
|         | Height                       | : 140 mm incl. feet and handle                                    |
|         | Width                        | : 305 mm incl. handle   |
|         | Length                       | : 320 mm incl. front cover  |
|         | Weight                       | : 4,5 kg  |
| 1.2.10  | Cooling                      | : Natural convection  |

1.3 ACCESSORIES

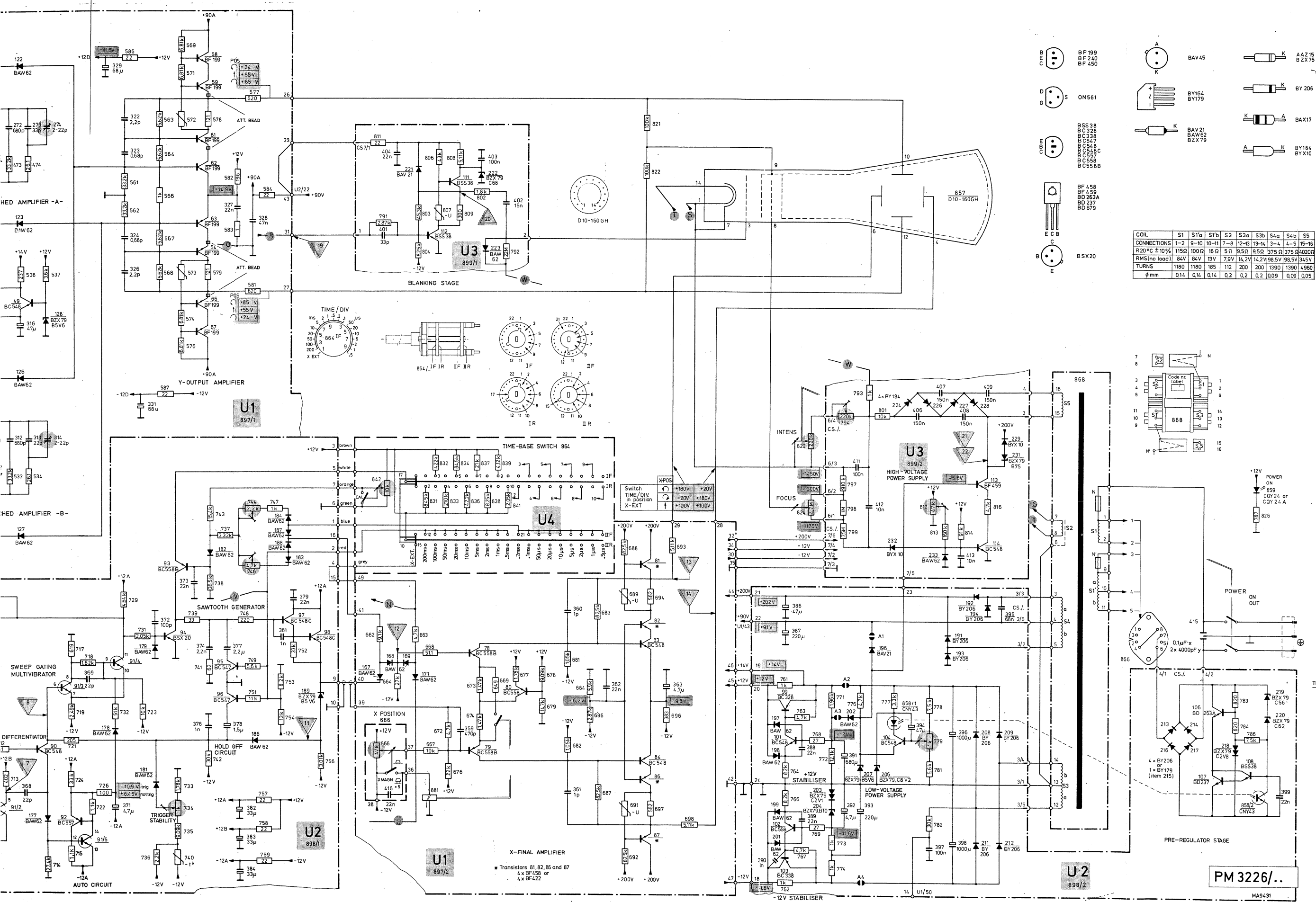
- |  |  |   |
|--|--|---|
| Accessories supplied with the instrument |  | Protective front cover (Chapter 3.6.2, item 1)<br>BNC to banana adaptor (Chapter 3.6.2, item 2)<br>Contrast filter (Chapter 3.6.1, item 5)<br>Operating and service manual  |
| Optional accessories                     | PM 9326<br>PM 9327<br>PM 9335<br>PM 9335L<br>PM 9336<br>PM 9336L<br>PM 9358/01<br>PM 9353<br>PM 9355<br>PM 9346<br>PM 9380<br>PM 8971<br>PM 9051 | Passive probe 1 : 1/10 : 1 (1,1 m)<br>Passive probe 1 : 1/10 : 1 (2,1 m)<br>Passive probe 1 : 1 (1,5 m)<br>Passive probe 1 : 1 (2,5 m)<br>Passive probe 10 : 1 (1,5 m)<br>Passive probe 10 : 1 (2,5 m)<br>Passive probe 100 : 1 (1,5 m)<br>Active FET-probe: 1 : 1; 1 : 10; 1 : 100<br>Current probe; 12 Hz ... 70 MHz<br>Power supply for active probes<br>Multi-purpose oscilloscope camera<br>Adapter (oscilloscope to camera)<br>BNC-4 mm adapter |
|  |  | 19-inch rack-mounting (dimensioned sketch (Fig. 3.27)<br>Antistatic spray<br>Trimming tool kit  |
|  |  | See also chapter 3.5 "Information concerning accessories".  |



U1  
897/1

U2  
898/1

CA 3086  
SG 3823N  
SN 74LS00-N or N74LS00A  
SN 7472N-00 or N7472A



- COMB B F 199
- ON 561
- BSS38
- BC328
- BC538
- BC547
- BC548
- BC558
- BC558C
- BC557
- BC558
- BC558B
- BF 458
- BF 459
- BD 263A
- BD 237
- BD 679
- BSX20

- BAV45
- BY164
- BY179
- BAV21
- BAW62
- BZ X 79
- AAZ15
- BZX75
- BY206
- BAX17
- BY184
- BYX10

COIL	S1	S1a	S1b	S2	S3a	S3b	S4a	S4b	S5
CONNECTIONS	1-2	9-10	10-11	7-8	12-13	13-14	3-4	L-5	15-16
R 20°C ±10%	115Ω	100Ω	15Ω	5Ω	9.5Ω	9.5Ω	375Ω	375Ω	4.02Ω
RMS (no load)	84V	84V	13V	7.9V	14.2V	14.2V	98.5V	98.5V	34.5V
TURNS	1180	1180	185	112	200	200	1390	1390	4960
φ mm	0.14	0.14	0.14	0.2	0.2	0.2	0.09	0.09	0.05

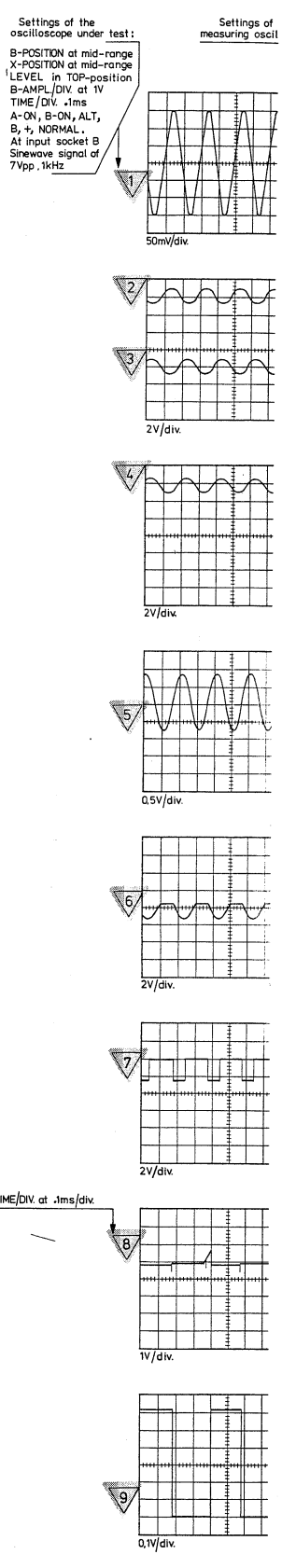
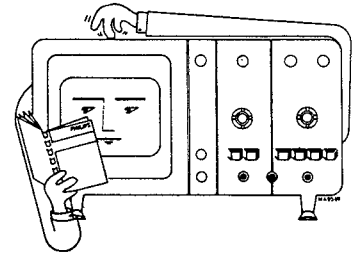


Fig. 3.39. Overall circuit

# 1. Allgemeines



## 1.1. EINLEITUNG

Der tragbare 15-MHz-Zweikanal-Oszilloskop PM 3226 ist ein kompaktes leichtes Gerät. Es lässt sich besonders leicht bedienen und kann durch seine vielseitigen Anwendungsmöglichkeiten für Wartungsarbeiten sowie für Labor- und Unterrichtszwecke verwendet werden.

Das Gerät besitzt die Möglichkeit für gehopped oder alternierende Darstellung des Y-Signals, vollautomatische Triggerung, Netztriggerung und Triggerung mit Zeilen- und Bildsynchronimpulsen eines Fernsehsignals.

Der ausnutzbare Bildschirm der Elektronenstrahlröhre ist mit einem externen Raster in 8 x 10 Div. kalibriert. Das Gerät ist mit Ausnahme der Elektronenstrahlröhre volltransistorisiert, alle Bauelemente befinden sich auf Printplatten, um Wartungsarbeiten und Zugang zu erleichtern.

Der durchdachte Entwurf und die zweckmässige Ausführung gewährleisten mühelose Bedienung und zuverlässigen Betrieb.

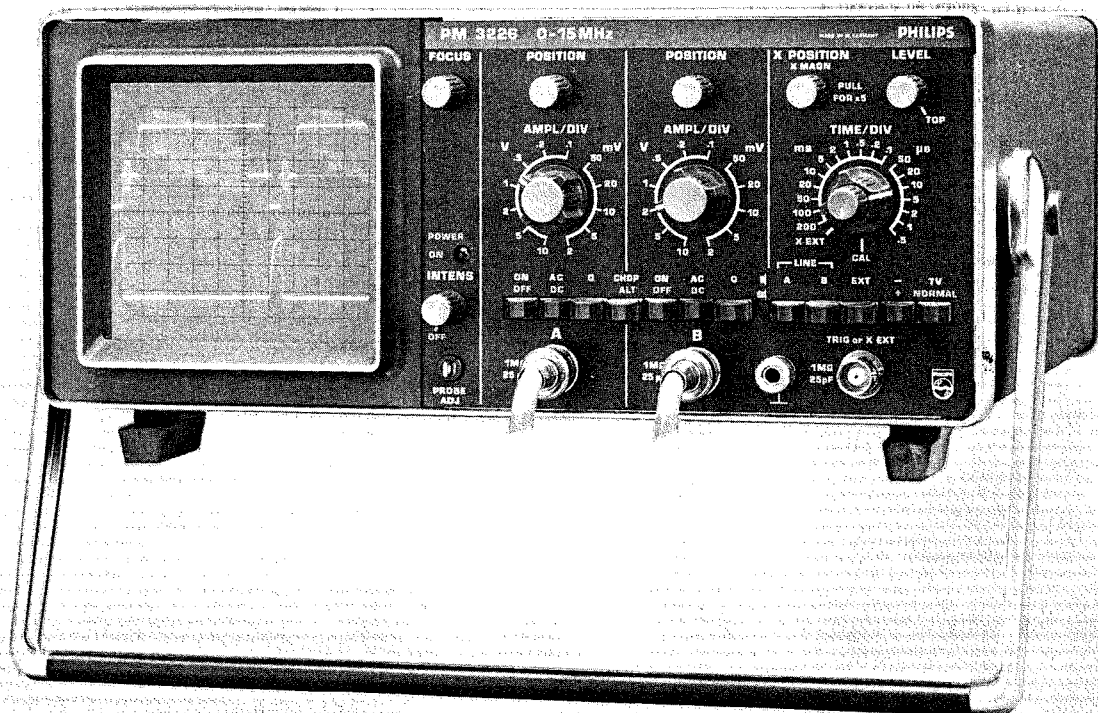


Abb. 1.1. Frontansicht PM 3226



## 1.2. TECHNISCHE DATEN

### Allgemeine Hinweise

Nur Zahlenwerte mit Toleranzangaben werden garantiert.

Zahlenwerte ohne Toleranzangaben sind Durchschnittswerte und dienen zur Information.

<i>Benennung</i>	<i>Beschreibung</i>
<b>1.2.1. Elektronenstrahlröhre</b>	
Type	: D10 – 160 GH
Schirmtypen	: P31 (GH) P7 (GM) wahlweise
Ausnutzbare Schirmfläche	: 8 x 10 Div.; 1 div $\triangleq$ 7,5 mm
Beschleunigungsspannung	: 1,5 kV
Messraster	: Extern, nicht beleuchtet
Einstellungsmöglichkeiten	: Focus, Helligkeit
<b>1.2.2. Y-Verstärker</b>	
Frequenzbereich	: Gleichspannungskopplung 0 Hz ... 15 MHz (–3 dB) Wechselspannungskopplung 2 Hz ... 15 MHz (–3 dB)
Anstiegszeit	: 25 ns
Überschwingen	: $\leq 3\%$ (Testimpuls: 6 div. Amplitude, 3 ns Anstiegszeit)
Ablenkkoeffizient	: 2 mV/div ... 10 V/div., in zwölf kalibrierten Stellungen, Folge 1-2-5; Fehlergrenze $\pm 5\%$
Maximal zulässige Eingangsspannung	: $\pm 400$ V (Gleichspannung + Spitzenwert der Wechselspannung), unempfindlich gegen einzelne kurzzeitige Spannungsimpulse bis 1000 V
Vertikaler Verschiebungsbereich	: $\pm 16$ div.
Dynamischer Bereich	: 24 div. für Sinusspannungen bis 3 MHz $\geq 5$ div. für Sinusspannungen bis 15 MHz
Eingangsimpedanz	: 1 M $\Omega$ // 25 pF
Betriebsarten:	
Kanal A allein	: ON/OFF Drucktaste für Kanal gedrückt
Kanal B allein	: ON/OFF Drucktaste für Kanal B gedrückt
Kanal A und B (elektronisch geschaltet)	: ON/OFF Drucktaste für Kanäle A und B gedrückt (mit Drucktaste CHOP/ALT in Chopper- oder alternierendem Betrieb)
<b>1.2.3. X-Verstärker</b>	
Frequenzbereich	: von Gleichspannung bis 1 MHz (–3 dB)
Ablenkkoeffizient	: 5 V/div., Fehlergrenze $\pm 10\%$ 1 V/div. in Stellung x5 (X-MAGN)
Maximal zulässige Eingangsspannung	: $\pm 400$ V (Gleichspannung + Spitzenwert der Wechselspannung), unempfindlich gegen einzelne kurzzeitige Spannungsimpulse bis 1000 V
Eingangsimpedanz	: 1 M $\Omega$ // 25 pF
Phasenverschiebung	: 5 $^\circ$ bei 50 kHz
<b>1.2.4. Zeitablenkung</b>	
Ablenkkoeffizient	: 0,2 s/div. ... 0,5 $\mu$ s/div. in 18 kalibrierten Stufen, 1-2-5 Folge. Stetige Einstellung zwischen den Stufen 1 : $\leq 2,5$ , nicht kalibriert
Fehlergrenze der Ablenkkoeffizienten	: $\pm 5\%$

<i>Benennung</i>	<i>Beschreibung</i>
Dehnung	: x5, 1 kalibrierte Stufe
Zusätzlicher Fehler	: < 2 %
<b>1.2.5. Triggerung</b>	
Triggerquellen	: Intern Extern Netzfrequenz
Triggerempfindlichkeit	: Intern ; Level –0,8 div. bei 100 kHz; 0,4 div. typisch max. –1,0 div. bei 15 MHz; 0,6 div. typisch Top –3,0 div. bei 15 MHz; 2,0 div. typisch TV –2,5 div. bei Zeilen oder Bildsynchronimpulsen; 1,5 div. typisch Extern; Level –0,7 V bei 100 kHz; 0,4 V typisch max. –1,0 V bei 15 MHz; 0,5 V typisch Top –2,0 V bei 15 MHz; 1,2 V typisch TV –2,0 V bei Zeilen oder Bildsynchronimpulsen; 1,0 V typisch
Eingangsimpedanz	: 1 M $\Omega$ // 25 pF
Maximal zulässige Eingangsspannung	: $\pm$ 400 V (Gleichspannung + Spitzenwert der Wechselspannung), unempfindlich gegen einzelne kurzzeitige Spannungsimpulse bis zu 1000 V
Betriebsarten	: Automatischer Freilauf des Zeitablenkgenerators, wenn kein Triggersignal vorhanden ist. a. Einstellbarer Triggerpegel über 12 div. oder 12 V Kleinste Triggerfrequenz für Sinusspannung ist 10 Hz b. Top (Spitze)
Triggerflanke	: + oder –
Triggerung mit Fernsehsignalen (gekoppelt mit TIME/div.)	: Bildfrequenz in den Stellungen .5 ms/div. ... 200 ms/div. Zeilenfrequenz in den Stellungen .2 ms/div. ... 5 $\mu$ s/div.
Messkopf-Einstellung	: Bedingungen, siehe Abschnitt 2.2.3.
<b>1.2.6. Einflussgrößen</b>	
Die unter 1.2. erwähnten Daten gelten nur dann, wenn das Gerät gemäss den offiziellen Prüfverfahren kontrolliert wurde. Einzelheiten, die diese Verfahren und die Fehlergrenzenkriterien betreffen, können von der PHILIPS Organisation Ihres Landes oder von N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST AND MEASURING DEPT., EINDHOVEN, NIEDERLANDE angefordert werden.	
<b>1.2.6.1. Temperatur</b>	
Bezugswert	: 23 °C
Nennbetriebsbereich	: +5 °C bis +40 °C
Betriebsbereichsgrenzen	: –10 °C und +55 °C
Lagerung und Transport	: –40 °C bis +70 °C
<b>1.2.6.2. Höheneinfluss</b>	
Betriebsgrenzbereich	: 5000 m
Transportgrenzbereich	: 15000 m } in freier Luft
<b>1.2.6.3. Luftfeuchte</b>	
	: Entspricht den Anforderungen gemäss IEC 60 Db
<b>1.2.6.4. Stossfestigkeit</b>	
	: 1000 Stösse von 10 g, ½ Sinus, Dauer 6 ms, in jeder von 3 Richtungen.

<i>Benennung</i>	<i>Beschreibung</i>
1.2.6.5. <i>Vibration</i>	: 30 Minuten in jeder von 3 Richtungen, 10-150 Hz; 0,7 mm (Spitze-Spitze) und 5 g maximale Beschleunigung.
1.2.6.6. <i>Störgrad</i>	: Entspricht den Anforderungen gemäss VDE, Störgrad K.
1.2.7. <b>Betriebslage</b>	: Beliebig
1.2.8. <b>Speisespannungen</b>	: 110 V; 127 V; 220 V und 240 V; Wechselspannung $\pm 10\%$ (46 ... 400 Hz)
PM 3226Q (USA-Ausführung)	: Nur für 110 V
Leistungsaufnahme	: 18 VA
1.2.9. <b>Gehäuse</b>	
Gesamtmessung	
Höhe	: 140 mm
Breite	: 305 mm
Länge	: 320 mm
Gewicht	: 4,5 kg
1.2.10. <b>Kühlung</b>	: Natürliche Luftzirkulation
1.3. <b>ZUBEHÖR</b>	
Standardzubehör	: 1 Frontschutzhaube (Abschnitt 3.6.2., item 1) 2 Adapter BNC-4 mm (Abschnitt 3.6.2., item 2) 1 Kontrastplatte (Abschnitt 3.6.1., item 5) 1 Anleitung
Sonderzubehör:	
PM 9326	Passiver Abschwächer-Messkopfsatz (10:1), Kabellänge 1,1 m
PM 9327	Passiver Abschwächer-Messkopfsatz (10:1), Kabellänge 2,1 m
PM 9335	Passiver Messkopfsatz (1:1), Kabellänge 1,5 m
PM 9335L	Passiver Messkopfsatz (1:1), Kabellänge 2,5 m
PM 9336	Passiver Abschwächer-Messkopfsatz (10:1), Kabellänge 1,5 m
PM 9336L	Passiver Abschwächer-Messkopfsatz (10:1), Kabellänge 2,5 m
PM 9358/01	Passiver Abschwächer-Messkopfsatz (100:1), Kabellänge 1,5 m
PM 9353	Aktiver Abschwächer-Messkopfsatz (100:1, 10:1; 1:1)
PM 9355	Strommesskopf; 12 Hz ... 70 MHz
PM 9346	Speisegerät für aktive Messkopfsätze
PM 9380	Mehrzweck-Registrierkamera
PM 8971	Adapter (oszilloskop/Kamera)
PM 9051	Adapter BNC-4 mm
	19" Gestell (Masszeichnung Abb. 3.27)
	Antistatik Flüssigkeit (Sprühdose)
	Abgleichbesteck
	Siehe auch Abschnitt 3.5. "Information concerning accessories.

## 1.4. BESCHREIBUNG DES BLOCKSCHALTBILDS (siehe Abb. 1.2., Seite 12).

### 1.4.1. Y-Kanäle

Die vertikalen Kanäle für den Zweistrahlbetrieb sind identisch. Jeder Kanal besitzt einen Eingangskopplungsschalter, einen Abschwächer, einen Impedanzwandler mit Schutzschaltung, einen Vorverstärker, dem ein Triggersignal entnommen wird und einen gemeinsamen Endverstärker.

Die Schutzschaltung besteht aus einer vorgespannten Diode, die eine Beschädigung des Feldeffekttransistors durch zu grosse negative Eingangsspannungen, verhindert; ein Widerstandsnetzwerk schützt gegen zu hohe positive Eingangsspannungen.

Die Transistoren der Differenz-Vorverstärkerstufe sind jeweils in einem Gehäuse integriert. Dadurch ist der Arbeitspunkt der hochempfindlichen Verstärker-Stufen weitgehend temperaturkompensiert.

Das Triggersignal wird von einer Seite des Vorverstärkers abgenommen, und gelangt an den Triggerbetriebsart-Schalter, mit dem entweder Kanal A oder Kanal B gewählt werden kann. Die Speisung für den Ausgang der Vorverstärkerstufe wird einer, von der Kanalschaltlogik gesteuerten Konstantstromquelle entnommen. Die von der Kanalummschaltung gesteuerten Signale aus A und B werden an den Endverstärker geschaltet. Der gemeinsame abgeglichenen Endverstärker ist direkt an die Y-Platten der Elektronenstrahlröhre gekoppelt.

### 1.4.2. Kanalummschaltung

Die frontseitigen A und B Kanalwahl-Drucktasten schalten in Betriebsart CHOP einen Oszillator, die elektronische Schaltlogik und ein Flip-Flop für die Kanalummschaltung. Wenn entweder der A- oder B-Kanal gewählt wird, öffnet das Flip-Flop den entsprechenden Kanal. In Betriebsart ALT schaltet ein Impuls vom Sägezahn-Tor-multivibrator über die elektronische Schaltlogik das Flip-Flop und ermöglicht so alternierende Ablenkung. In Betriebsart CHOP wird der Oszillator über die Logikstufe geschaltet, um rasches Umschalten der Kanäle über das Flip-Flop zu bewirken.

### 1.4.3. Triggerung

Ein Triggersignal kann den Kanälen A und B, einer externen Quelle oder intern dem Netzteil entnommen werden. Das gewählte Triggersignal gelangt über eine Verstärkerstufe an den Impulsformer. Der Impulsformer liefert über den Differentiator und den Sweep-gating-Multivibrator eindeutige Triggerimpulse zum Starten des Sägezahn-Generators.

Der Synchronseparator und der Spitzendetektor ermöglichen Triggerung mit Zeilen- und Bildimpulsen. Der Spitzendetektor ist auch in Stellung TOP in Betrieb.

### 1.4.4. Zeitbasiseinheit

Der Zeitbasisgenerator arbeitet nach dem Prinzip des Konstantstrom-Integrators. Der Sweep-gating-Multivibrator, – getriggert von Impulsen des Differenzglied und der Triggerautomatik – startet den Sägezahn-Generator. Es entstehen Sägezähne, deren Dauer kalibriert mit dem Schalter TIME/DIV einstellbar ist. Der X-Endverstärker wird mit diesen Sägezähnen angesteuert.

Der Sweep-gating-Multivibrator liefert einen Torimpuls für die Helltastung der Elektronenstrahlröhre während des Hinlaufs. Zusätzlich wird dieser Impuls über ein Dioden-Netzwerk dem Anschluss PROBE-ADJ für den Messkopfabgleich zugeleitet.

### 1.4.5. X-Kanal

Über einen Diodenschalter erhält der X-Endverstärker sein Eingangssignal je nach Stellung des Schalters TIME/DIV entweder vom Zeitbasisgenerator oder aus einer externen Spannungsquelle (Eingangsbuchse X EXT über den X- und Triggervorverstärker).

Die X-MAGN-Schaltung ist im X-Endverstärker enthalten. Der Ausgang dieses Verstärkers ist direkt mit den horizontalen Ablenkplatten der Elektronenstrahlröhre verbunden.

### 1.4.6. Elektronenstrahlröhre und Netzteil

Die Spannungen für die Elektronenstrahlröhre und die 1,5 kV-Beschleunigungsspannung werden von einem stabilisierten Netzteil erzeugt. Der Elektronenstrahl der Röhre wird beim Hinlauf von einem mit dem Potentiometer INTENS eingestellten Potential hellgesteuert und beim Rücklauf von Impulsen des Sägezahn-Generators über die Strahlaustaststufe ausgetastet.

Das Netzteil wird eingangsseitig mit einem gesteuerten Strombegrenzer geregelt. Der Strombegrenzer wird von einem Signal eines (Strom/Licht – Licht/Strom) Umsetzers gesteuert. Dieses Steuersignal wird vom gleichgerichteten +14 V Speiseteil nach der Netzteil-Eingangsseite rückgekoppelt.

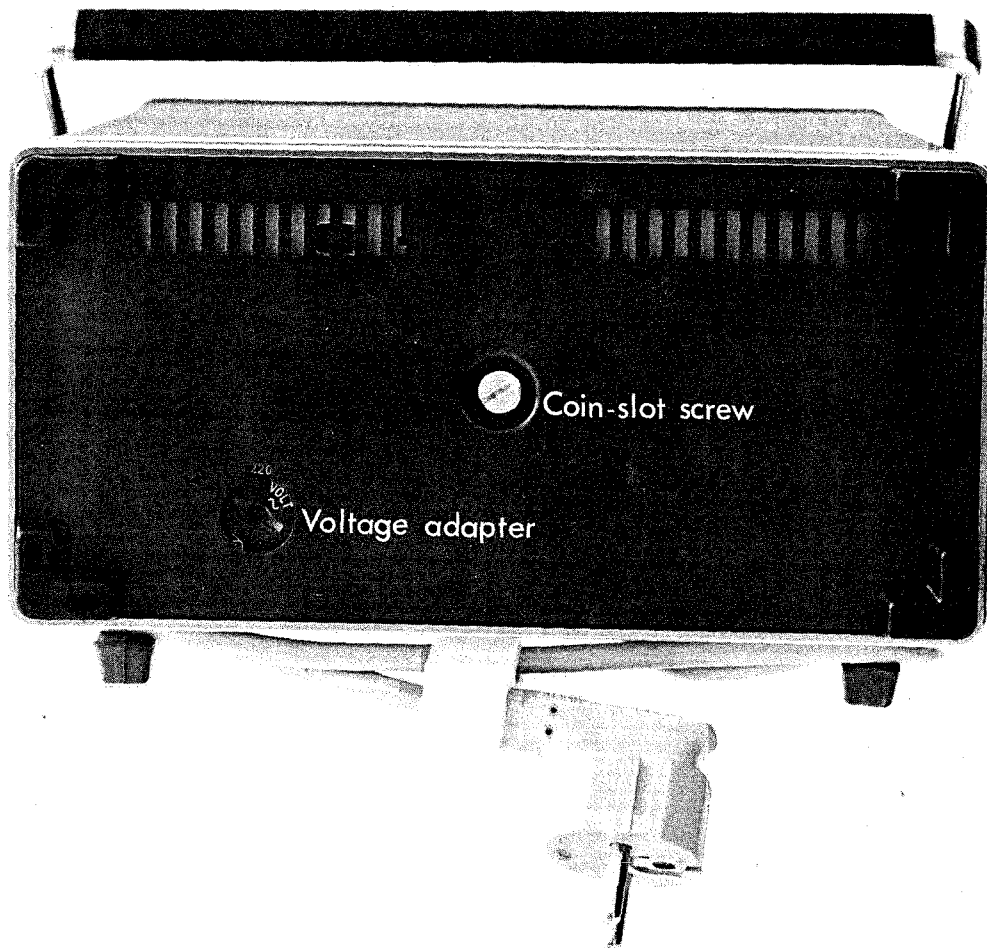
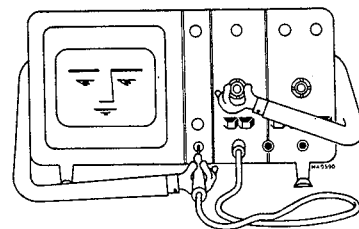


Abb. 2.1. Rückansicht

## 2. Gebrauchsanleitung



### 2.1 WICHTIGE SICHERHEITSTECHNISCHE HINWEISE

Dieses Gerät hat das Werk in sicherheitstechnisch einwandfreiem Zustand verlassen. Zur Erhaltung dieses Zustands und seines gefahrlosen Betriebs empfohlen wird, die nachfolgenden Hinweise sorgfältig zu beachten.

#### 2.1.1 Netzspannung

Das Gerät darf nur an Wechselspannung betrieben werden. Bei Auslieferung ist das Gerät auf eine Netzspannung von 220 V eingestellt. Soll das Gerät an 110 V, 127 V oder 240 V Netzspannungen betrieben werden, lässt sich die erforderliche Spannung durch Drehen des Spannungsumschalters an der Rückwand einstellen (siehe Abb. 2.1).

##### *Vor dem Anschliessen*

- Vor Anschluss des Geräts an das Netz, ist eine Sichtkontrolle des Gehäuses, der Bedienungsorgane, der Anschlüsse u.s.w. vorzunehmen, um sich zu überzeugen, dass das Gerät während Transport oder Lagerung nicht beschädigt wurde.
- Es ist sicherzustellen, dass die eingestellte Betriebsspannung des Geräts und die Nenn-Netzspannung übereinstimmen.

##### *Schutzklasse*

Dieses Gerät ist ein Gerät der Schutzklasse I (Schutzleiteranschluss) gemäss IEC348 oder VDE0411. Die mitgelieferte Netzzuleitung enthält einen Schutzleiter. Ausser in besonders zugelassenen Räumen darf der Netzstecker nur in Schutzkontaktsteckdosen eingeführt werden.

Jede Unterbrechung des Schutzleiters, innerhalb oder ausserhalb des Geräts, ist unzulässig.

#### 2.1.2 Reparatur und Wartung

##### *Fehler und aussergewöhnliche Beanspruchungen*

Wenn anzunehmen ist, dass ein gefahrloser Betrieb nicht (mehr) möglich ist, so ist das Gerät ausser Betrieb zu nehmen und gegen unabsichtlichen Betrieb zu sichern.

Dieser Fall tritt ein,

- wenn das Gerät sichtbare Beschädigungen aufweist,
- wenn das Gerät nicht mehr arbeitet,
- nach Überbeanspruchungen jeglicher Art (z.B. Lagerung, Transport), die die zulässigen Grenzen überschreiten.

##### *Öffnen des Geräts*

Beim Abnehmen von Abdeckungen oder Öffnen von Teilen mit Werkzeug können spannungsführende Teile freigelegt werden. Auch können Anschlussstellen spannungsführend sein.

Vor dem Öffnen des Geräts muss das Gerät von allen Spannungsquellen getrennt sein.

Wenn danach eine Kalibrierung, Wartung oder Reparatur am geöffneten Gerät unter Spannung unvermeidlich ist, so darf das nur durch eine Fachkraft geschehen, welche die damit verbundenen Gefahren kennt.

Kondensatoren im Gerät können noch geladen sein, selbst wenn das Gerät von allen Spannungsquellen getrennt wurde, die Schaltbilder sind zu beachten.

##### *Reparatur, Ersatz von Teilen*

Reparaturen sind fachgerecht durchzuführen. Dabei ist besonders darauf zu achten, dass die konstruktiven Merkmale des Geräts nicht sicherheitsmindernd verändert werden. Insbesondere dürfen die Kriech- und Luftstrecken und die Abstände durch die Isolierung hindurch nicht verkleinert werden.

Zum Ersatz nur Original-Teile verwenden. Andere Ersatzteile sind nur zulässig wenn dadurch die sicherheitstechnischen Eigenschaften des Geräts nicht verschlechtert werden.

#### 2.1.3 Sicherungen

Das Gerät ist gegen Überlastung durch zwei Thermosicherungen geschützt, die sich in den Wicklungen des Netztransformators befinden. Die Sicherungen lassen sich nach Abnahme des Gerätedeckels ersetzen (siehe Abschnitt 2.3.10.).

Es dürfen nur die vorgeschriebenen Sicherungen verwendet werden.

### 2.1.4 Betriebslage

Das Gerät kann in horizontaler Lage, in vertikaler Lage, oder mit Hilfe des heruntergeklappten Tragbügels in verschiedenen gekippten Lagen aufgestellt und betrieben werden. Um den Tragbügel frei zu setzen, beide Schwenknöpfe A (siehe Abb. 2.2) drücken.

Die Belüftungsöffnungen in Bodenplatte und Deckel dürfen nicht verdeckt werden.

Es ist darauf zu achten, dass das Gerät nicht auf andere Wärmequellen gestellt oder übermässiger Wärmeeinstrahlung ausgesetzt wird.

### 2.1.5 Inbetriebnahme (Netzanspannung und -anschluss, Erdung)

#### *Anpassung und anschluss*

Dieses Gerät darf nur an Wechselspannung betrieben werden.

Es ist bei Auslieferung auf einen Netzspannungsbereich von 220 V eingestellt.

Vor dem Anschliessen an das Netz ist zu prüfen, ob der Netzspannungstransformator auf die örtliche Netzspannung eingestellt ist. Die eingestellte Spannung ist durch eine Öffnung an der Rückseite des Geräts sichtbar.

Soll das Gerät auf einen anderen Netzspannungsbereich umgestellt werden, ist wie folgt zu verfahren:

- Netzstecker herausziehen.
- Die erforderliche Spannung durch Drehen des Spannungsumschalters an der Rückwand einstellen (siehe Abb. 2.1).

#### *Erden*

Das Gerät muss den örtlichen Vorschriften entsprechend geerdet werden. Die mitgelieferte Netzzuleitung enthält einen Schutzleiter und ist mit Schutzkontaktsteckern versehen. Hierdurch wird beim Anschluss an eine Schutzkontaktsteckdose das Gehäuse des Geräts zwangsläufig mit Schutzterde verbunden.

**ACHTUNG:** Der Netzanschlussstecker darf nur in eine Schutzkontaktsteckdose eingeführt werden. Diese Schutzmassnahme darf nicht unwirksam gemacht werden, z.B. durch eine unvollkommene Verlängerungsleitung!

Die Aussenkontakte der BNC-Eingangsbuchsen führen das Schaltungsnulldpunkt-Potential und sind mit dem Gehäuse verbunden. Eine Schutzterdung über die Aussenkontakte der BNC-Eingangsbuchsen ist unzulässig!

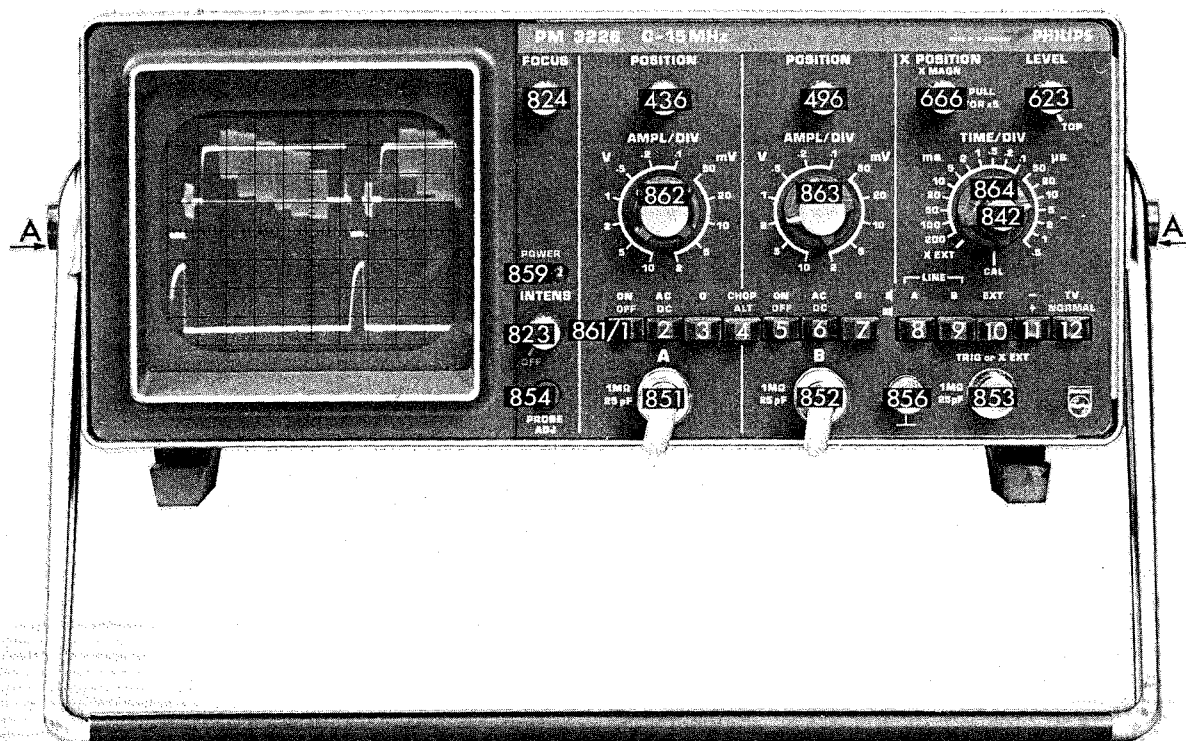


Abb. 2.2. Frontansicht mit Angabe der Bedienungsorgane

## 2.1.6. Bedienungorgane und Buchsen (Abb. 2.2.)

FOCUS	824	Steller für Stufenlose Fokussierung
Y POSITION	Kanal A: 436 Kanal B: 496	} Stufenlose Bildverschiebung in vertikaler Richtung
X POSITION/X-MAGN	666	
LEVEL/TOP	623	Stufenlose Einstellung des Pegels, bei dem der Zeitablenkgenerator startet. Der Schalter ermöglicht eine TOP Stellung für Signale mit grossen Amplituden.
AMPL/DIV	Kanal A: 862 Kanal B: 863	} Einstellung der vertikalen Ablenkoeffizienten in 12 kalibrierten Stufen.
TIME/DIV	864	
TIME/DIV - CAL	842	Stufenlose Einstellung der Zeitmassstäbe. In Stellung CAL ist der Zeitmassstab kalibriert.
POWER ON	859	Leuchtet auf (rot), wenn das Gerät eingeschaltet ist.
INTENS mit Schalter OFF	823	Stufenlose Helligkeitseinstellung des Elektronenstrahls mit ON/OFF Schalter für die Speisung des Oszilloskops.
ON/OFF Drucktasten	Kanal A: 861/1 Kanal B: 861/5	} Schaltet entsprechenden Kanal an Endverstärker
AC/DC Drucktasten	Kanal A: 861/2 Kanal B: 861/6	
O Drucktasten	Kanal A: 861/3 Kanal B: 861/7	} Unterbricht den Y-Eingang und erdet die Eingangsschaltung
CHOP/ALT Drucktaste	861/4	
Triggering Drucktasten	861/8 ... 861/12	Einstellung von Triggerquelle, Flanke und Triggerart
A	861/8	Internes Triggersignal von Kanal A abgenommen.
B	861/9	Internes Triggersignal von Kanal B abgenommen.
LINE (A+B gleichzeitig betätigt)		Triggersignal von einer internen Spannung mit Netzfrequenz abgenommen.
EXT	861/10	Triggersignal abgenommen von einer an Buchse TRIG oder X-EXT (853) gelegten Spannung.
±	861/11	Triggerung auf positiv gerichteten Flanke, wenn Taste ausgelöst, auf die negativ gerichtete Flanke, wenn Taste gedrückt.
TV/NORMAL	861/12	Wenn gedrückt, Triggerung auf Zeilen oder Bildimpulsen eines Fernsehsignals, je nach Stellung des Schalters TIME/DIV (864). Triggerung auf Bildimpulse in Stellung .5 ms/div ... 200 ms/div. Triggerung auf Zeilenimpulse in Stellungen .2 ms/div. ... .5 µs/div.
PROBE ADJ	854	Ausgang für Messkopf-Abgleich.
1 MΩ // 25 pF	851	BNC-Eingangsbuchse für Vertikalablenksignal von Kanal A.
1 MΩ // 25 pF	852	BNC-Eingangsbuchse für Vertikalablenksignal von Kanal B
<u>⊥</u>	856	Erdungsbuchse (keine Schutzterde).
TRIG or X-EXT	853	BNC-Eingangsbuchse für externe Triggersignale oder externe Zeitablenkung.



## 2.2. BEDIENUNG

### 2.2.1. Einschalten

Das Netzkabel ist um die vier Füsse des Geräts gewickelt. Nachdem der Oszilloskop gemäss den Abschnitten 2.1.1. bis 2.1.5. an das Netz angeschlossen wurde, kann er mit dem an Bedienungsknopf INTENS gekoppelten Netzschalter eingeschaltet werden; die rote Lampe POWER ON leuchtet auf. Der Oszilloskop wird die Spezifikationen (siehe Abschnitt 1.2) nach einer Anwärmzeit von etwa 30 Minuten erfüllen. Wenn das Gerät jedoch grosser Kälte ausgesetzt war (z.B. bei Temperaturen unter dem Gefrierpunkt), beträgt die Anwärmzeit mindestens 2 Stunden.

### 2.2.2. Grundeinstellungen der Bedienungsorgane

- Prüfen, ob die richtige Netzspannung eingestellt ist (wie in Abschnitt 2.1.5. angegeben).
- Das Gerät einschalten.
- Bedienungsknopf INTENS (823) in Mittelstellung.
- Triggerquelle, Triggerflanke und Triggerart wählen. Wenn keine dieser Tasten betätigt wurden, triggert der Oszilloskop automatisch und intern (Kanal B).
- Mit Hilfe von Knopf Y POSITION (A, B) den Elektronenstrahl auf den Schirm schieben. Das Gerät ist nun betriebsbereit.

### 2.2.3. Abgleich der Spannungsteiler-Messköpfe

Messkopfsätze PM 9326 und PM 9327

- Betriebsart LINE (Netz-Triggerung) (Drucktasten A+B gleichzeitig drücken) einstellen und eine Zeitablenklinie darstellen.
- Einsteller LEVEL ganz nach rechts drehen (Stellung TOP).
- Taste AC/DC (861/2) in Stellung DC.
- Schalter AMPL/DIV (862) auf 5 mV/div stellen.
- Messkabel an Buchse A (851) anschliessen und die Messkopfspitze an den Anschluss PROBE ADJ (854) legen.
- Entweder .5 ms/div. oder .2 ms/div. wählen.
- Die Verriegelungsschraube lösen und den "Messkopfkörper" (siehe Abb. 2.3.) gegenüber dem Kabel so lange drehen, bis die richtige Einstellung erreicht ist.
- Die Verriegelungsschraube anziehen und sich überzeugen, dass die Einstellung unverändert ist.

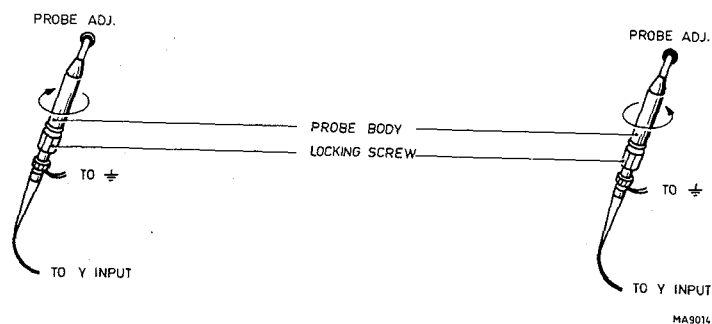
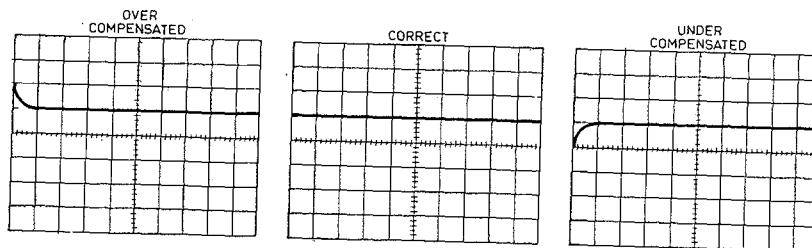


Abb. 2.3. Abgleich der Messköpfe PM 9326 und PM 9327

### Messkopfsätze PM 9336, PM 9336L und PM 9358

- Betriebsart LINE (Drucktasten A+B gleichzeitig drücken) einstellen und eine Zeitablenklinie darstellen.
- Einsteller LEVEL ganz nach rechts drehen (Stellung TOP).
- Taste AC/DC (861/2) in Stellung DC.
- Schalter AMPL/DIV (862) auf 5 mV/div stellen.
- Die Kompensationsdose mit Buchse A (851) verbinden und die Messkopfspitze an den Anschluss PROBE ADJ (854) legen.
- Entweder .5 ms/div. oder .2 ms/div. wählen.
- Mit einem kleinen Schraubenzieher durch die Öffnung der Kompensationsdose den Trimmer so einstellen, dass eine richtige Darstellung erhalten wird (siehe Abb. 2.4.).

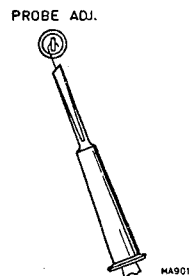
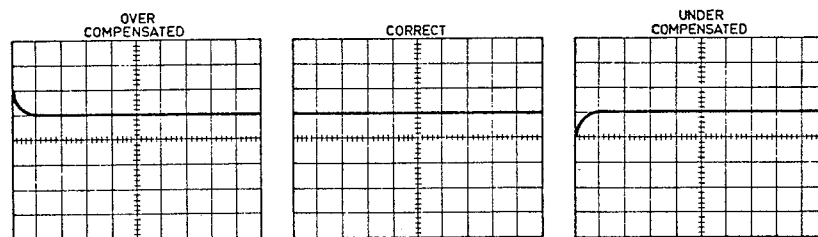


Abb. 2.4. Abgleich der Messköpfe PM 9336, PM 9336L und PM 9358

### 2.2.4. Eingangsfunktionen

Der PM 3226 besitzt zwei Vertikalkanäle die entweder zusammen mit einem Zeitablenkgenerator für Y-T-Messungen bis 15 MHz, oder für X-Y-Messungen bis 1 MHz verwendet werden können.

#### Y-T-Messungen

Eingangssignale an Buchse A und B werden gegen den internen Zeitablenkgenerator über den Bereich des Schalters TIME/DIV (864) für Normalbetrieb (dass heisst nicht in X-EXT Stellung von Schalter TIME/DIV) dargestellt.

#### X-Y-Messungen

Wenn der Schalter TIME/DIV (864) in Stellung X EXT steht, ist der Zeitablenkgenerator ausgeschaltet. Der externe Eingang an der Frontplatte TRIG or X EXT (853) ist nun mit dem Y-Verstärkerkanal verbunden. Ist der Schalter X MAGN PULL FOR x5 (666) gezogen, sind in dieser Betriebsart X-Y-Messungen bis zu 1 MHz möglich.

#### Einfluss der 0 und AC-DC Schalter

Die zu beobachtenden Signale sind an Eingangsbuchsen A oder B zu legen. Je nach Zusammensetzung des Signals ist Schalter AC-DC entweder einzudrücken oder auszulösen. In Stellung DC ist der Eingang direkt an den Y-Verstärker gekoppelt. Da der Y-Verstärker gleichspannungsgekoppelt ist, ist die ganze Bandbreite des Gerätes verfügbar. Daher gelangt das vollständige Eingangssignal an die Ablenkplatten, das bedeutet, dass die Gleichspannungskomponenten als Strahlverschiebungen auf dem Schirm sichtbar werden.

Wenn kleine Wechsellspannungssignale hohen Gleichspannungen überlagert sind, kann dies zu Schwierigkeiten führen. Um in solchen Fällen das Wechsellspannungssignal sichtbar zu machen, ist stärkere Abschwächung nötig, wodurch auch das Wechsellspannungssignal stark abgeschwächt wird. Wird jedoch der Schalter AC/DC in Stellung AC gebracht, dann wird ein Trennkondensator zwischen Eingangsbuchse und Y-Verstärker gelegt, wodurch die Gleichspannungen gesperrt aber auch die niedrigsten Frequenzen unterdrückt oder abgeschwächt werden.

Bei Darstellung von Rechtecksignalen niedriger Frequenz, hat dies Dachschräge zur Folge.

Mit betätigter Drucktaste 0 ist es sofort möglich den Gleichspannungsnullpegel zu bestimmen. Die Verbindung zwischen Verstärkereingang und Eingangsbuchse ist unterbrochen und der Verstärkereingang ist geerdet.

### 2.2.5. Triggerung

#### *Allgemeines*

Um ein stillstehendes Bild zu erhalten muss, die Horizontalablenkung immer an einem festen Punkt des Signals gestartet werden. Deshalb wird der Sweep-gating-Multivibrator von einem kurzen Triggerimpuls gestartet, der in der Triggereinheit erzeugt und durch ein Signal gesteuert wird, das einem vertikalen Eingangssignal, einer externen Quelle oder eine interne Netzspannung (Betriebsart LINE) entstammt.

#### *Triggerpegel*

Bei einem komplizierten Signal mit mehreren periodisch auftretenden, nicht identischen Spannungsformen, muss, um ein stillstehendes Oszillogramm zu erhalten, die Zeitachse immer bei derselben Spannungsform gestartet werden. Dies ist möglich, wenn irgendein Teil des Kurvenzuges eine abweichende Amplitude hat. Mit dem Einsteller LEVEL lässt sich der Triggerpegel so einstellen, dass nur diese grössere Spannungsabweichung diesen Pegel überschreitet.

In Betriebsart TOP ist es möglich, eine Vielfalt von Signalen verschiedener Amplitude und Form abzubilden.

#### *Automatische Schaltung*

Der Oszilloskop arbeitet mit freilaufender Zeitbasis, wenn kein Signal vorhanden ist. Es bleibt daher am Schirm eine Zeitablenklinie sichtbar, die zum Nullpunktvergleich sehr nützlich ist.

#### *Externe Triggerung*

Bei Signalen mit stark schwankender Amplitude kann extern eine Triggerung von einem Signal mit konstanter Amplitude und gleicher Frequenz angewandt werden. Noch wichtiger ist externe Triggerung bei komplexen Signalen und Impulsmustern die zu Doppelbildern führen könnten. Dies erübrigt eine Neueinstellung des Triggerpegels bei jeder Änderung des Eingangssignals. Das Externe Eingangssignal wird an Buchse TRIG oder X EXT (853) gelegt.

#### *Triggerung mit Netzfrequenz (Betriebsart LINE)*

In diesem Falle ist das Triggersignal eine Sinusspannung mit Netzfrequenz. Diese Triggerquelle ist zu verwenden wenn die Frequenz des zu beobachtenden Signals der Netzspannung entstammt.

So lässt sich z.B. die Brummkomponente eines Signals ermitteln, indem auf diese Komponente getriggert wird. Die Netztriggerung (LINE) wird durch gleichzeitiges Drücken der Drucktasten A+B (861/8 + 861/9) gewählt.

#### *Triggerung mit Fernsehsignalen*

Es ist möglich, mit Zeilen- oder Bildsynchronimpulsen von Fernsehsignalen zu triggern. In den Stellungen .5 ms/div bis 200 ms/div des Schalters TIME/DIV (864) wird auf die Bildsynchronimpulse und in den Stellungen .2 ms/div bis .5  $\mu$ s/div dieses Schalters auf die Zeilensynchronimpulse getriggert. Die Stellung des +/- Schalters (861/11) für die Triggerflanke muss der inversen Polarität des Videosignals entsprechen; das heisst, Minusstellung von 861/11 für ein positives Signal und die Plusstellung von 861/11 für ein negatives Videosignal.

### 2.2.6. Dehnung der Zeitablenkung

Die Dehnung der Zeitablenkung wird durch Ziehen des Schalters, der mit dem Bedienungsknopf X POSITION gekoppelt ist, eingestellt. Mit diesem Schalter in Stellung x5, ist ein 5x schnellerer Zeitmassstab eingestellt. Der Zeitmassstab wird durch Teilen des eingestellten Wertes TIME/DIV durch 5 ermittelt.

## 2.3. AUSBAU DES GERÄTS

### 2.3.1. Allgemeines

Dieser Abschnitt behandelt das Ausbaurverfahren zum Entfernen von Bauteilen im Zuge von Reparatur- und Wartungsarbeiten. Alle aus dem Oszilloskop entfernten Leiterplatten sind vor Beschädigung entsprechend zu schützen, und alle normalen Vorsichtmassnahmen beim Gebrauch von Werkzeugen sind zu beachten (siehe auch Abschnitt 2).

Beim Ausbau sind alle gelösten Drahtverbindungen mit Sorgfalt zu markieren, um sie beim Einbau wieder anschliessen zu können.

Es ist immer darauf zu achten, dass vor Abnahme irgendwelcher Deckel oder Platten das Gerät vom Netz getrennt ist.

Einschalten des Geräts, wenn eine Leiterplatte entfernt wurde, oder wenn eine Leiterplatte innerhalb einer Minute nach dem Ausschalten herausgenommen wird, kann Beschädigung des Geräts verursachen.

### 2.3.2. Abnehmen der Abdeckhauben

Das Gerät ist durch drei Abdeckhauben geschützt; eine Frontschutzhaube, einen Mantel mit Handgriff und eine Abdeckplatte für die Rückwand.

Die Frontschutzhaube ist anzubringen, bevor der Mantel entfernt werden soll.

Das Abnehmen geschieht wie folgt:

- den Handgriff von der Frontplatte wegschwenken, dazu sind die beiden Verriegelungsknöpfe A (siehe Abb. 2.2.) zu drücken.
- das Gerät auf seiner Frontschutzhaube auf eine ebene Fläche stellen.
- die Schlitzschraube in der Mitte der rückwärtigen Abdeckplatte lösen (siehe Abb. 2.1.).
- rückwärtige Abdeckplatte abnehmen.
- die Nylon-Durchführung aus dem Mantel herauschieben, um die Netzschnur freizulegen.
- den Mantel abziehen.
- um die Frontplatte zugänglich zu machen, das Gerät horizontal aufstellen und die Frontschutzhaube abziehen.
- das Hochspannungsteil wird zugänglich, wenn die Plastikschutzhaube aus den Löchern der Rückwand gelöst und nach vorne geschoben wird.

### 2.3.3. Abnahme des Bildröhrenrahmens und des Messrasters

- durch leichtes Drücken der linken Seite lässt sich der Rahmen ausschwenken (siehe Abb. 2.5.).
- durch leichten Druck von vorne lassen sich Maske und Raster aus dem Rahmen nehmen.

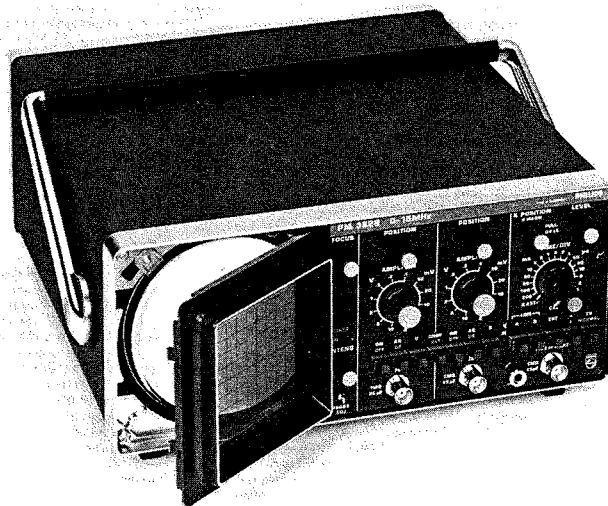


Abb. 2.5. Abnahme des Bildröhrenrahmens und des Messrasters

#### 2.3.4. Abnehmen der Textplatte

- Knopfdeckel der Einstellorgane AMPL/DIV und X POSITION abnehmen, und Knopf TIME/DIV - CAL abziehen.
- Sechskantmuttern und Schlitzmutter lösen und Knöpfe entfernen.
- alle übrigen Knöpfe abziehen.
- die übrigen Sechskantmuttern, mit denen die Textplatte befestigt ist, lösen.
- vorsichtig die Textplatte abnehmen.

#### 2.3.5. Ausbau der Potentiometer FOCUS und INTENS/OFF

- Geräteabdeckhauben wie beschrieben abnehmen (siehe Abschnitt 2.3.2.).
- den entsprechenden Einstellknopf auf der Frontplatte abziehen.
- Plastikklemme B (Abb. 2.6.) durch die Öffnungen an der Rückwand herauschieben.
- gleichzeitig Achse C (Abb. 2.6.) drehen und ziehen bis das viereckige Achsenende genau in die Öffnung passt und sich herausnehmen lässt.
- Plastikklemme und Achse entfernen.
- Sechskantmutter D (Abb. 2.6.) lösen, um Potentiometer zu entfernen.

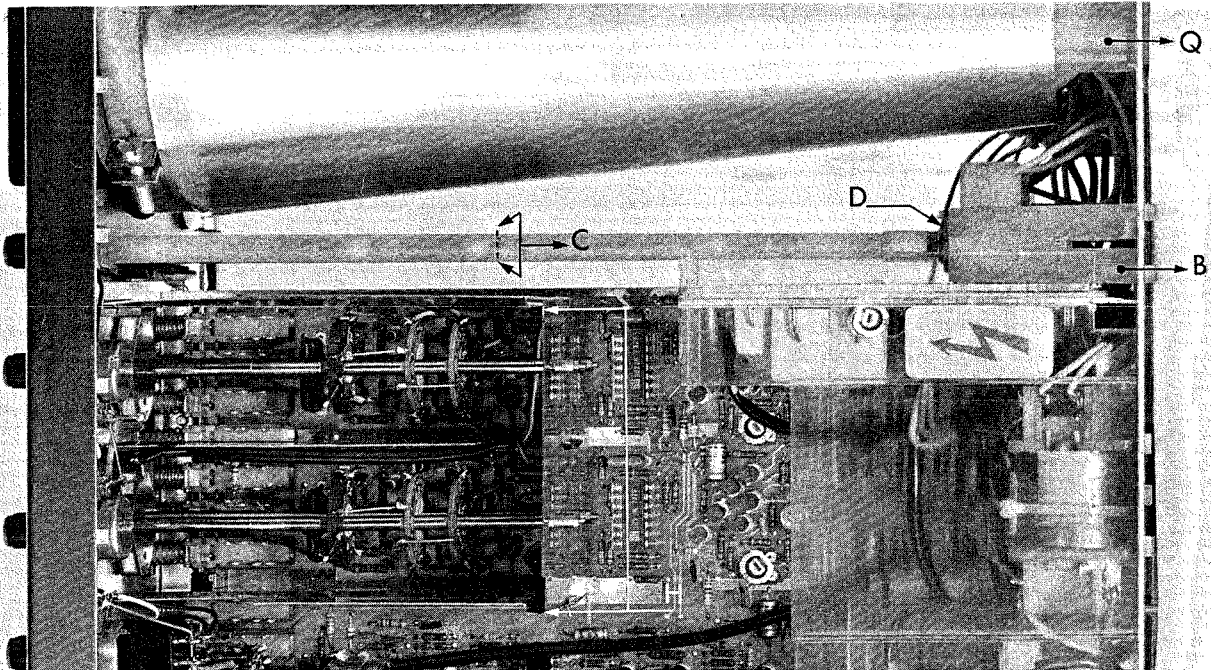


Abb. 2.6. Ausbau

#### 2.3.6. Ausbau des Einschubs (einschliesslich der E.H.T. Leiterplatte)

- Abdeckhauben, wie angegeben abnehmen (siehe Abschnitt 2.3.2.).
- Knöpfe FOCUS und INTENS/OFF abziehen.
- Plastik-Schutzhaube aus den Rückwandlöchern lösen und nach vorne schieben.
- die drei Stocko-Stecker und die freien Zuleitungsstecker entfernen.
- die übrigen Verbindungsdrähte an der Rückseite der liegenden Leiterplatte ablöten.  
Beachten, dass auch die Verbindung der Messkopfeinstellung zur Frontplatte gelöst werden muss.
- sechs Schrauben und eine Mutter von folgenden Stellen entfernen:
  - 5 Schrauben E (Abb. 2.7.) mit denen die Leiterplatten an der Rückwand befestigt sind.
  - 1 Schraube F (Abb. 2.7.) hinter der Frontplatte (oben).
  - 1 Mutter G (Abb. 2.7.) Frontplatte (unten).
- Einschub zusammen mit Textplatte und Knöpfen durch die Frontplatte herausnehmen.

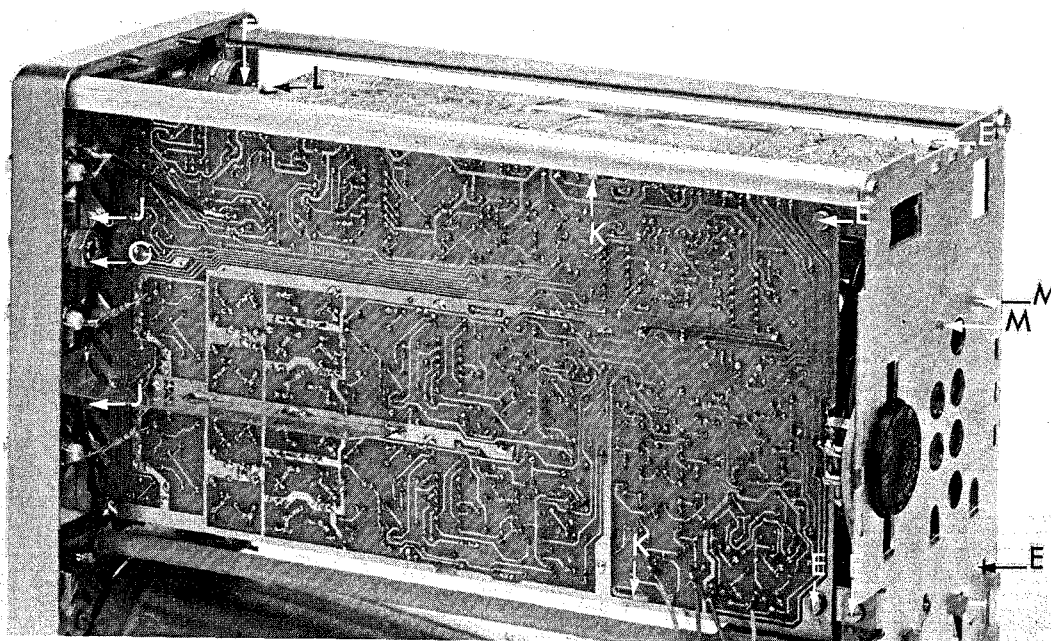


Abb. 2.7. Ausbau

### 2.3.7. Austausch des Abschwächerschalters

- elektronische Baugruppe gemäss 2.3.6. entfernen.
- die seitlichen Abschirmplatten des Abschwächers aushaken dazu die rückwärtige Abschirmplatte (H) am oberen Rand nach vorn drücken (siehe Abb. 2.6.).
- mit einem Vakuum-Lötkolben die Drähte vom Abschwächer zur Printplatte von der Spurensseite ablöten.
- die beiden Schrauben J (Abb. 2.7.) und die beiden Muttern der Eingangsbuchsen für Kanäle A und B lösen.
- Textplatte und Sechskantmutter zur Befestigung des Abschwächerschalters entfernen (siehe Abschnitt 2.3.4.).

Den vorhandenen Schalter entfernen und durch einen neuen Schalter ersetzen.

### 2.3.8. Ausbau einer Printplatte

- Abdeckhauben des Geräts wie angegeben entfernen (siehe Abschnitt 2.3.2.).
- Einschub, gemäss Abschnitt 2.3.6. entfernen.
- die entsprechenden Verbindungen ablöten.
- Scharnier K in der Mitte der Leiterplatte aushaken (Abb. 2.7.).
- um die vertikale Platte auszubauen: Befestigungsschraube L an der Frontplatte lösen (Abb. 2.7.).
- um die horizontale Platte auszubauen: die Abschirmplatten des Abschwächers entfernen (siehe 2.3.7.) und die Abschwächer-Verbindungen ablöten.
- beide Muttern der Eingangsbuchsen für Kanäle A und B lösen, ebenso die beiden Schrauben J, womit die Platte befestigt ist (Abb. 2.7.).

### 2.3.9. Ausbau des Netztransformators

- Abdeckhauben des Geräts, wie angegeben entfernen (siehe Abschnitt 2.3.2.).
- Verbindungsdrähte ablöten, ihre Zuordnung merken.
- Die beiden Stocko-Stecker und die freien Zuleitungsstecker entfernen.
- zwei Befestigungsschrauben M lösen (Abb. 2.7.).
- Transformator seitwärts herausheben.

### 2.3.10. Ersatz der Thermosicherungen (siehe auch Abschnitt 2.1.3.)

- Abdeckhauben wie angegeben abnehmen (siehe Abschnitt 2.3.2.).
- Sicherung I (Abb. 2.8.): Sicherungsdrähte 1 und 2 ablöten.
- Sicherung II (Abb. 2.8.): Netztransformator (siehe Abschnitt 2.3.9.) ausbauen und die Sicherungsdrähte 1' und 2' ablöten.
- defekte Sicherung entfernen; dazu ist der Sperrnocken freizulegen, indem man das in Trafowickel enthaltene Gehäuse der Thermosicherung an der Stirnseite etwas auswärts biegt (Abb. 2.9.).
- auf die gleiche Weise wird eine neue Sicherung aus ihrem Gehäuse herausgenommen. Sie wird dann in das Gehäuse der alten Sicherung geschoben bis der Sperrnocken in der Öffnung einrastet, die Schleife ist Anschluss '1' zugewandt.
- nach Anlöten der Anschlussdrähte und Beseitigung der Überlastungsursachen ist das Gerät betriebsbereit.

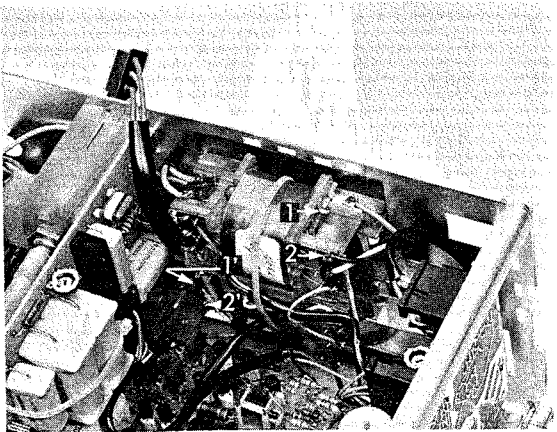


Abb. 2.8. Anordnung der Thermosicherungen

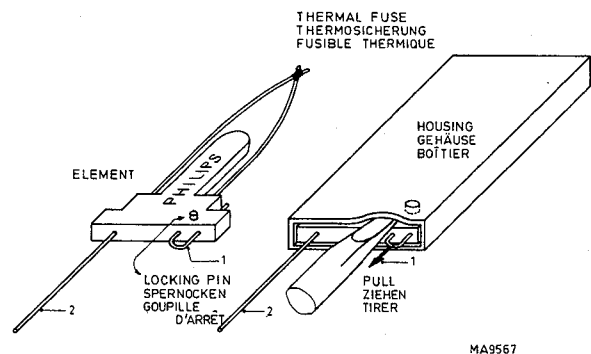


Abb. 2.9. Ersatz der Thermosicherung

### 2.3.11. Ausbau der Elektronenstrahlröhre

- Abdeckhauben des Geräts wie angegebenen entfernen (siehe Abschnitt 2.3.2.).
- Schrauben N und P hinter der Frontplatte lösen (siehe Abb. 2.10.).
- Bildröhrenrahmen entfernen (siehe Abschnitt 2.3.3.).
- Plastik-Verriegelungsstück entfernen.
- die beiden Nylonklemmen Q (siehe Abb. 2.6.) am Ende der Röhre nach innen pressen und unter Rücksichtnahme auf die Mumetallabschirmung die Elektronenstrahlröhre so weit durch die Frontplatte herauschieben, dass die Röhrenfassung gelöst werden kann (Nylonklemme zur Unterstützung zurück-schieben).
- Klemmschraube R des Spannbandes der Röhre lockern (Abb. 2.10.).

*Bemerkung: Bei Montage einer Elektronenstrahlröhre ist darauf zu achten, dass der Röhrenschirm an das Messraster liegt; die Klemmschraube darf nicht zu fest angezogen werden. (Schraubendrehmoment  $\leq 40$  Newton x cm).*

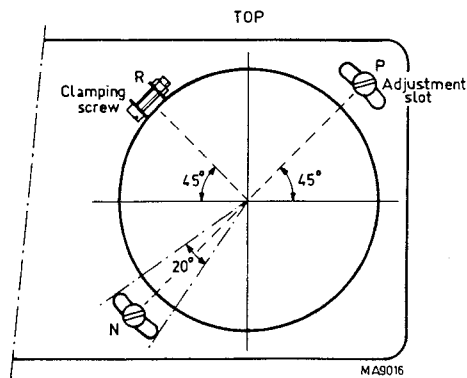


Abb. 2.10. Einstellung der Elektronenstrahlröhre

### 2.3.12. Abnehmen des Traggriffs

- die beiden Kunststoffknöpfe des Traggriffs entfernen (z.B. mit einem Schraubenzieher).
- Schrauben entfernen.

### 2.3.13. Ersatz eines Drucktastenschalters

- die betreffende Leiterplatte wie in Abschnitt 2.3.8. beschrieben ausbauen.
- die 4 Befestigungsfahnen des entsprechenden Schalters wie in Abb. 2.11. gezeigt, geradebiegen.
- das betreffende Schaltergehäuse mit einer Zange zerbrechen und die Stücke herausholen. Die Lötstifte sind dann zugänglich.
- die Lötstifte auslöten und die Löcher in der Leiterplatte reinigen (z.B. mit einem SauglötKolben).
- den neuen Schalter in die Leiterplatte einlöten.
- die 4 Befestigungsfahnen in ihre ursprüngliche Stellung zurückbiegen.

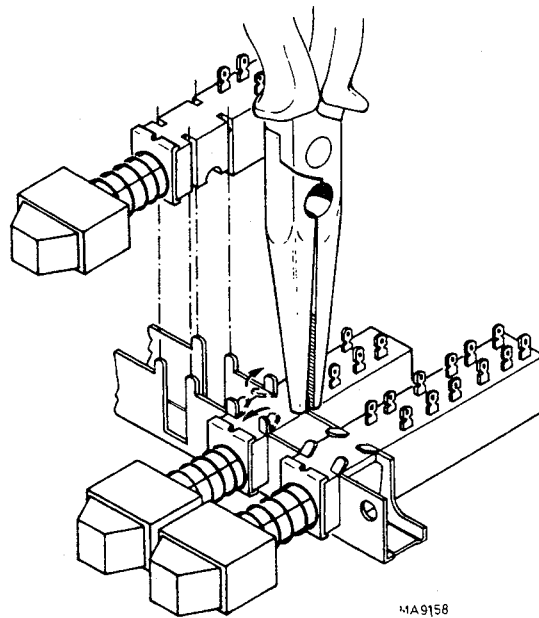


Abb. 2.11. Ersatz eines Drucktastenschalters.



# Operating manual

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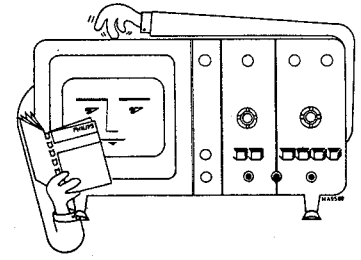
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# 1. General information



## 1.1. INTRODUCTION

The 15 MHz portable dual-trace oscilloscope PM 3226 is a compact, lightweight instrument featuring simplicity of operation, for a wide range of use in servicing, research and educational applications.

Other features include provision for chopped or alternate display of Y signals, automatic triggering, mains triggering and triggering on the line and frame sync pulses of a television signal.

The cathode-ray tube displays a useful screen area calibrated into 8 x 10 divisions by an external graticule.

All circuits are fully transistorized and mounted on printed-circuit boards for ease of maintenance.

The straight-forward design and layout combines simple operation with a high degree of reliability.

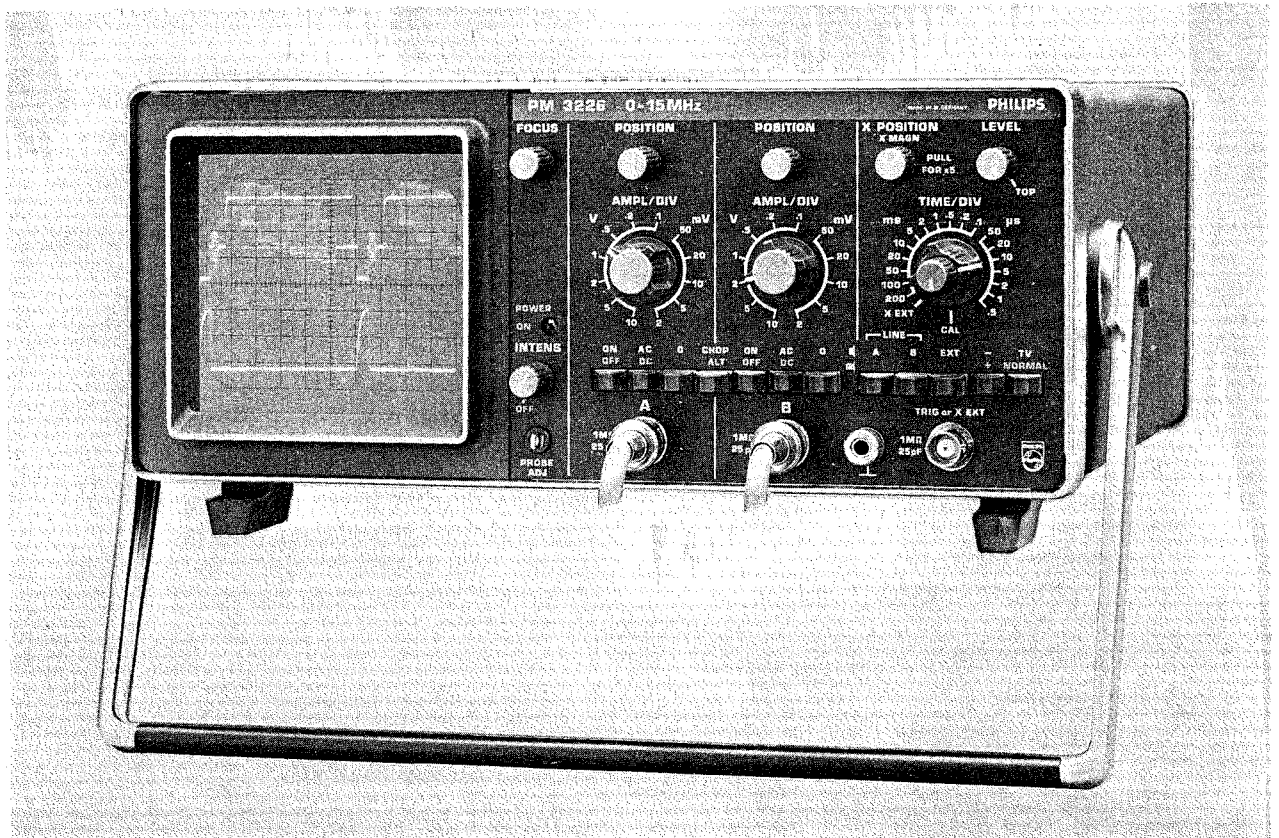


Fig. 1.1. Front view PM 3226

## 1.2 TECHNICAL DATA

### General Instructions

Only properties expressed in numerical values, with tolerances stated, are guaranteed by the factory. Numerical values without tolerances are typical characteristics of an average instrument only.

<i>Designation</i>	<i>Specification</i>
<b>1.2.1 Cathode-ray tube</b>	
Type	: D10 – 160 GH
Measuring area	: 8 x 10 divisions of 7,5 mm
Screen type	: P31 (GH) P7 (GM) optional
Acceleration voltage	: 1,5 kV
Graticule	: External, non-illuminated
Controls	: Focus, intensity
<b>1.2.2 Vertical amplifier</b>	
Frequency range	: d.c. 0 Hz to 15 MHz (–3 dB bandwidth d.c. coupled) a.c. 2 Hz to 15 MHz (–3 dB bandwidth a.c. coupled)
Risetime	: 25 ns
Overshoot	: $\leq 3\%$ (test pulse: 6 div. amplitude, 3 ns risetime)
Deflection coefficients	: 2 mV/div. to 10 V/div. in twelve calibrated steps in 1-2-5 sequence; accuracy $\pm 5\%$
Maximum permissible input voltage	: $\pm 400$ V (d.c. + a.c. peak) Resistant against non-repetitive surges of up to 1000 V
Vertical position range	: $\pm 16$ divisions
Dynamic range	: 24 div. for sinewave signals with frequencies of up to 3 MHz $\geq 5$ div. for sinewave signals of up to 15 MHz
Input impedance	: 1 MOhm // 25 pF
Operating modes:	
Channel A	: channel A, ON/OFF pushbutton depressed
Channel B	: channel B, ON/OFF pushbutton depressed
Channel A and B (electronically switched)	: channel A and B, ON/OFF pushbuttons depressed (chopped or alternate modes, pushbutton selected)
<b>1.2.3 Horizontal amplifier</b>	
Frequency range	: 0 ... 1 MHz (–3 dB bandwidth)
Deflection coefficients	: 5 V/div. at x1 magnifications, accuracy $\pm 10\%$ 1 V/div. at x5 magnification
Maximum permissible input voltage	: $\pm 400$ V (d.c. + a.c. peak). Resistant against non-repetitive surges of up to 1000 V
Input impedance	: 1 MOhm // 25 pF
Phase shift	: $5^\circ$ at 50 kHz
<b>1.2.4 Timebase</b>	
Time coefficients	: 0,2 sec/div to 0,5 $\mu$ sec/div in 18 calibrated steps in 1-2-5 sequence. Uncalibrated continuous control 1 : $\leq 2,5$ .
Coefficient error	: $\pm 5\%$
Expansion	: x5, 1 calibrated step
Additional error	: $< 2\%$

## 1.4. DESCRIPTION OF THE BLOCK DIAGRAM

### 1.4.1. Y channels

The A and B vertical channels for producing the dual-trace facility are identical. Each comprises an input coupling switch, an input step attenuator, a source-follower input stage with protection circuit, a preamplifier from which a trigger signal is derived, and a combined final amplifier.

The input stage protection circuit consists of a diode, which prevents damage to the field-effect transistors that could occur with excessive negative input potentials, and a resistor network protects the input stage against large positive voltage swings.

As the transistors of the balanced preamplifier stage share the same integrated circuit blocks, the resulting stabilisation provides a measure of correction to reduce the drift inherent in high-gain amplifiers.

The trigger pick-off signal is taken from one side of the balanced preamplifier to the trigger mode switch where either channel A or channel B triggering can be selected. The supply for the output of the preamplifier stage is derived from a constant-current source controlled by the channel switching logic. Under the control of the channel switching, signals from A and B channels are switched to the final amplifier. The combined balanced final amplifier is direct-coupled to the Y plates of the C.R.T.

### 1.4.2. Channel switching

The front-panel A and B channel selection pushbuttons, control an oscillator in the CHOP mode, the electronic switching logic and a flip-flop for the channel switching.

When either the A or B channels are selected, the flip-flop is switched to allow the appropriate channel. In the ALT mode, a pulse from the sweep-gating multivibrator via the electronic switching logic switches the flip-flop thus allowing the A and B channels for alternate sweeps. In the CHOP mode, the oscillator is switched via the logic stage to provide rapid switching of the channels via the flip-flop.

### 1.4.3. Triggering

A triggering signal can be obtained from vertical amplifier channels A and B, from an external source, or internally from the mains supply (LINE triggering). The triggering signal is selected and normally fed, via the amplifier stage, to the pulse shaper which supplies well-defined trigger pulses to the sweep-gating multivibrator for starting the sawtooth generator.

Triggering from TV line and frame signals is facilitated by the sync separator and peak detector stages. The latter stage is switched into circuit also in the TOP position.

### 1.4.4. Time-base

The time-base generator circuit operates on the constant-current integrator principle.

The sweep-gating multivibrator, triggered by pulses from the differentiator and auto-circuit, starts the sawtooth generator. As a result, sawtooth waveforms, of duration dependent on the TIME/DIV switch position, are fed to the final X amplifier.

A gate pulse is supplied by the sweep-gating multivibrator for unblanking the c.r.t. during the forward sweep. In addition, this pulse is supplied to an external socket for probe adjustment, via a diode network.

### 1.4.5. X channel

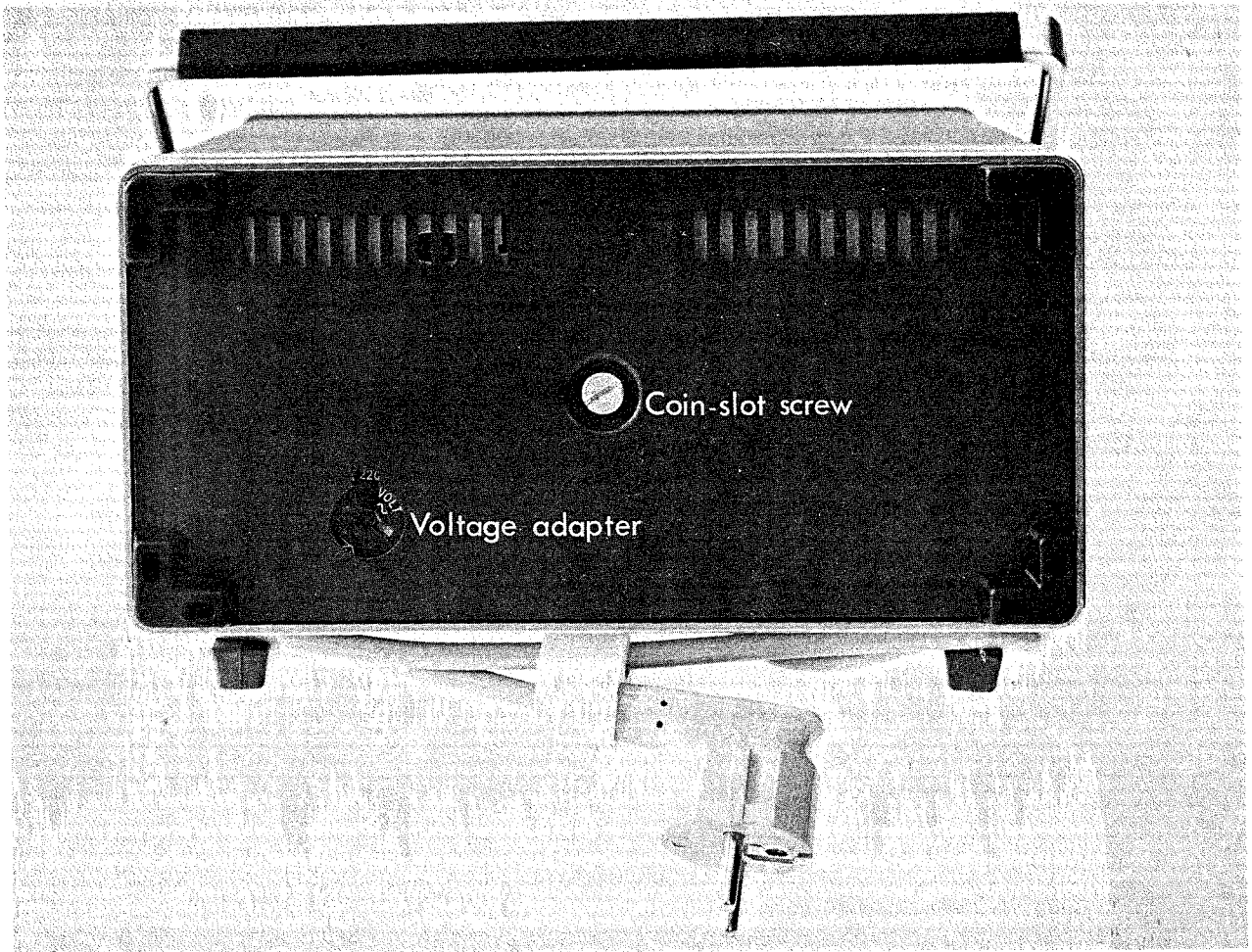
Under the control of diode switching from the TIME/DIV switch, the X final amplifier receives its input signal from either the time-base sawtooth generator or from an external source (X EXT input socket via the X and trigger preamplifier). The X MAGN (x5) circuit is incorporated in the X-final amplifier. The output of this amplifier is direct-coupled to the horizontal deflection plates of the c.r.t.

### 1.4.6. Cathode-ray tube circuit and power supplies

The high voltages for the c.r.t., which has an acceleration potential of 1.5 kV, are generated by a voltage multiplier circuit controlled by the stabilised power supply. The c.r.t. beam current is controlled by the INTENS potentiometer network across the e.h.t. supply and, during flyback, by the blanking pulses from the sawtooth generator via the beam blanking stage.

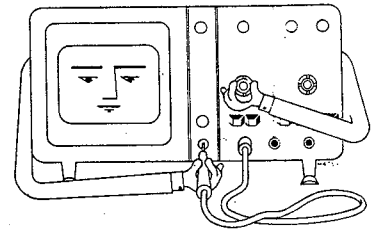
Regulation of the mains input voltage is achieved by a diode clipper network controlled by a signal fed back from a light-emitting diode in the +14 rectified supply.





*Fig. 2.1. Rear view*

## 2. Directions for use



### 2.1 IMPORTANT SAFETY REGULATIONS

This instrument leaves the factory in safe and impeccable condition. In view of this and safe functioning, we recommend to follow carefully the instructions below.

#### 2.1.1 Mains voltage

The instrument should be connected to an a.c. mains supply. On delivery the instrument is set to 220 V. If the instrument is to be used with 110 V, 127 V or 240 V supply, the appropriate voltage should be selected by turning the coin-slot adapter on the rear panel to indicate the voltage required (see Fig. 2.1.).

##### *Before connecting*

- Before connecting the instrument to the mains, visually check the cabinet, controls and connectors etc., to ascertain whether any damage has occurred during transport or storage.
- Check that the voltage adjusted corresponds to the nominal mains voltage.

##### *Protection class*

The present instrument meets the protection class I (protective earth) according to IEC 348 or VDE 0411. The mains cable supplied on delivery contains a protective conductor. Except for use in especially permitted rooms, the mains plug must be inserted into a mains socket with rim earthing only.

#### 2.1.2 Repair and maintenance

##### *Faults and special requirements*

In the case, harmless functioning is no longer guaranteed, the instrument must be put out of operation and protected against unintentional use.

This is the case:

- when the instrument shows visible damages
- when the instrument does no longer work
- when the requirements (e.g. storage, transport) exceed the permissible limits.

##### *Opening the instrument*

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 by a skilled person who is aware of the danger involved.

Bear in mind that capacitors inside the instrument may still be charged, even if the instrument has been separated from all voltage sources.

##### *Repairing and replacing parts*

Repairs must be performed competently. They must not affect the safety of the instrument. Take especially care that creepage and air distances between parts are not decreased.

For replacing, original parts must be used only. Different parts are permitted if they do not affect the safety of the instrument.

#### 2.1.3 Fuses

The instrument is protected from overloads by two thermal fuses fitted between the mains transformer windings. They can be replaced after having removed the instrument covers (see section 2.3.10).

Only the fuses prescribed must be used.

### 2.1.4 Position

The instrument may be used horizontally or in several sloping positions by employing the carrying handle as a tilting bracket. To release the handle, push both pivot centre buttons A (see Fig. 2.2).

Ensure that the ventilation holes in the rear and bottom plates are free from obstructions.

Do not position the instrument on any surface which produces or radiates heat.

### 2.1.5 Installation, Mains adaption and connection, earthing

#### *Mains adaption and connection*

The instrument should be connected to an a.c. mains supply.

On delivery the instrument is set to 220 V. Before connecting to the mains, check that the mains-voltage transformer is set to the local mains voltage.

The voltage set is visible through an opening at the rear of the instrument.

If the instrument must be adjusted to another mains voltage, proceed as follows:

- disconnect the supply cord from the mains
- set the required voltage by rotating the voltage converter at the rear (see Fig. 2.1).

#### *Earthing*

The instrument should be connected to a protective earth in accordance with the local safety regulations.

When the instrument is connected to a mains socket with rim-earth contacts, the cabinet is connected to earth via the three-core mains cable.

---

**WARNING:** Any interruption of the protective conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Intentional interruption is prohibited.

When an instrument is brought from a cold into a warm environment, condensation may cause a hazardous condition. Therefore, make sure that the earthing requirements are strictly adhered to.

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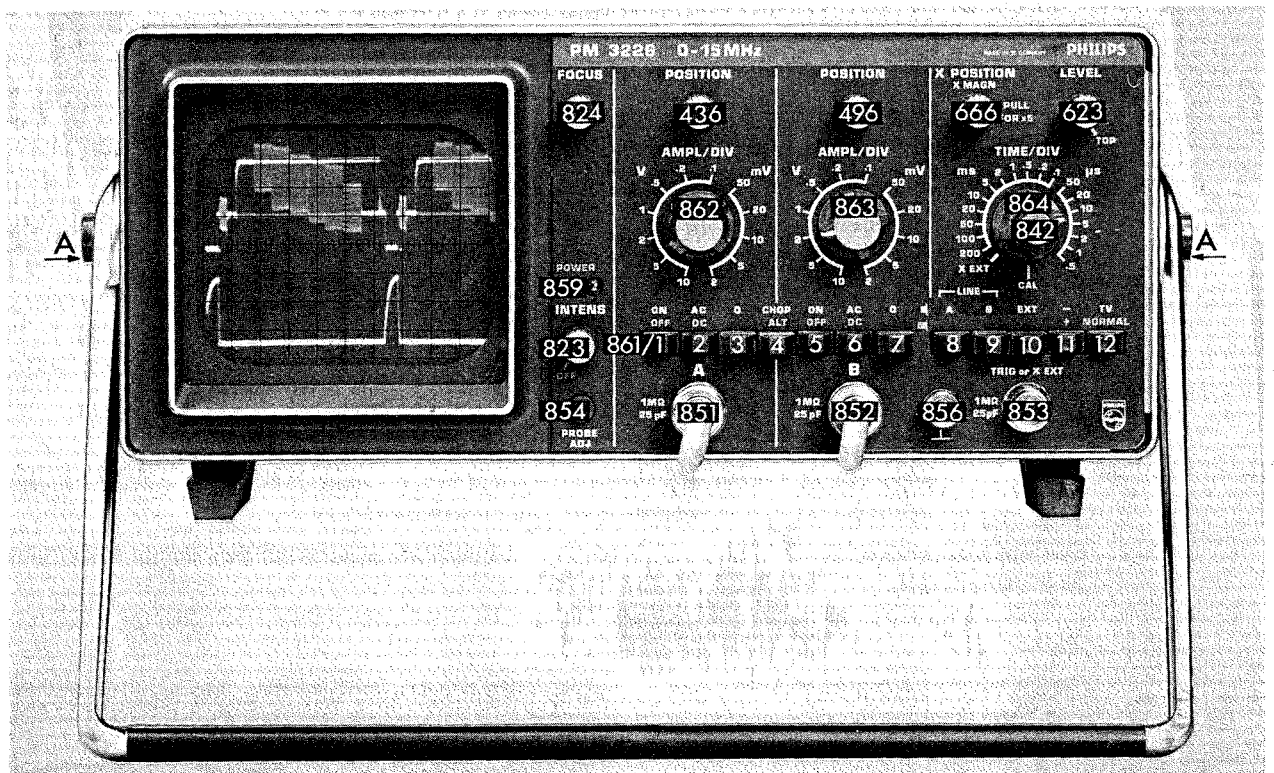



Fig. 2.2. Front view showing controls and sockets

## 2.1.6. Controls and sockets (Fig. 2.2)

FOCUS	824	Continuously variable control of the electron-beam focusing.
Y POSITION	A channel 436 } B channel 496 }	Continuously variable controls giving vertical positioning of the display.
X POSITION/X MAGN	666	Continuously variable control giving horizontal positioning of the display. Incorporates a switch for calibrated x5 magnification of the time-base.
LEVEL/TOP	623	Continuously variable control for selecting the level at which the time-base generator starts. The switch provides a TOP position for large pulse-shaped signals.
AMPL/DIV	A channel 862 } B channel 863 }	Control of the vertical deflection coefficients in 12 calibrated steps.
TIME/DIV	864	Time-coefficient control of the time-base in 18 calibrated steps, plus a position for external X deflection (X EXT).
TIME/DIV - CAL	842	Continuously variable control of the time coefficient of the time-base generator. In the CAL position the time coefficient is calibrated.
POWER ON	859	Illuminates (red) to indicate instrument is switched on.
INTENS with OFF switch	823	Continuously variable control of the trace brilliance, incorporating ON/OFF switch for supply to the oscilloscope.
ON/OFF pushbuttons	A channel: 861/1 } B channel: 861/5 }	Switch appropriate channel to final amplifier.
AC/DC pushbuttons	A channel: 861/2 } B channel: 861/6 }	AC (depressed): Y input via a coupling capacitor. DC (released): Y input direct coupled
O pushbuttons	A channel: 861/3 } B channel: 861/7 }	Interrupts Y input connection and earth input circuit.
CHOP/ALT pushbutton	861/4	Selects chopped mode when depressed, alternate mode when released.
Triggering pushbuttons	861/8 ... 861/12	Controls for trigger source slope and mode.
A	861/8	Internal triggering signal derived from A channel.
B	861/9	Internal triggering signal derived from B channel.
LINE (A + B selected simultaneously)		Triggering signal derived from an internal voltage at mains frequency.
EXT	861/10	Triggering signal derived from a voltage applied to the TRIG or X-EXT socket 853
±	861/11	Provides triggering on the positive slope of the signal when released, and triggering on the negative slope when depressed.
TV/NORMAL	861/12	When depressed enables triggering on line or frame sync pulses of TV signals, according to the position of TIME/DIV switch 864. Triggering on frame pulses in positions .5 ms/div to 200 ms/div. Triggering on line pulses in positions .2 ms/div to .5 $\mu$ s/div.
PROBE ADJ	854	Output terminal for adjusting test probes.

1 M $\Omega$ // 25 pF	851	Input BNC socket for the A vertical deflection signal
1 M $\Omega$ // 25 pF	852	Input BNC socket for the B vertical deflection signal
	856	Earth socket
TRIG or X-EXT	853	Input BNC socket for external triggering signals or external X deflection.

## 2.2. OPERATION

### 2.2.1. Switching on the instrument

The mains cable is wound round the four feet on the base of the instrument.

After the oscilloscope has been connected to the mains in accordance with sections 2.1.1. to 2.1.4., it may be switched on by means of the mains switch incorporated in the INTENS control; the red POWER ON lamp will light.

The oscilloscope will meet specifications (see Section 1.2.) normally after a warming-up period of approximately 30 minutes. However, if the instrument has been subjected to an extremely cold environment (e.g. left in a car overnight in freezing conditions) and is then brought in for use in a warm room, a warming-up period of at least 2 hours should be allowed.

### 2.2.2. Preliminary settings of the controls

- Check that the correct mains voltage has been selected in accordance with section 2.1.3.
  - Switch on the oscilloscope.
  - Set INTENS control (823) to its mid-position.
  - Select trigger source, mode and slope. If no trigger button is selected, the oscilloscope triggers in an automatic and internal mode (channel B).
  - Display the trace(s) by means of the appropriate POSITION controls.
- The instrument is then ready for use.

### 2.2.3. Adjustment of attenuator probes

*Probe sets PM 9326 and PM 9327*

- Display a time-base line by selecting LINE mode (depress pushbuttons A + B simultaneously).
- Turn LEVEL control fully clockwise (position Top).
- Set AC/DC pushbutton switch (861/2) to DC.
- Set AMPL/DIV switch (862) to 5 mV/div.
- Connect the measuring lead to socket A (851) and place the tip of the probe on socket PROBE ADJ (854).
- Select either .5 ms/div or .2 ms/div.
- Loosen the 'locking screw' and turn the 'probe body' (see Fig. 2.3.), in relation to the cable until correct adjustment is obtained.
- Secure the locking screw, ensuring that the adjustment is not altered.

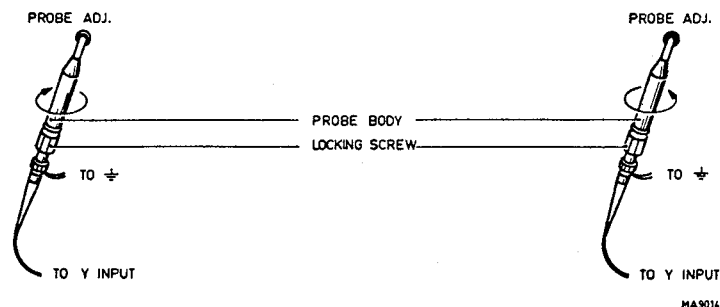
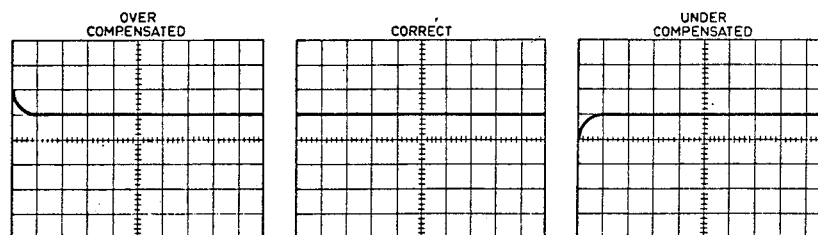
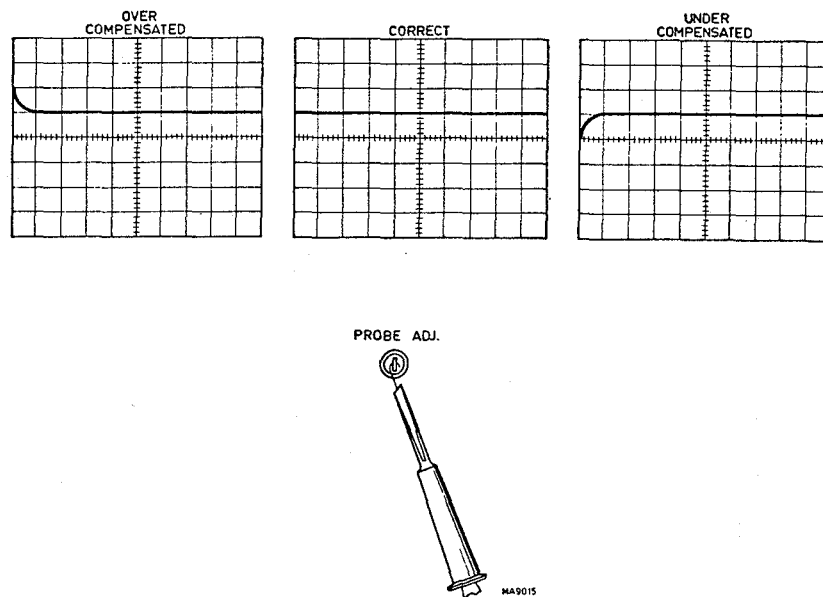


Fig. 2.3. Adjusting an attenuator probe

*Probe sets PM 9336, PM 9336L and PM 9358*

- Display a time-base line by selecting LINE mode (depress pushbuttons A+B simultaneously).
- Turn LEVEL control fully clockwise (position TOP).
- Set AC/DC pushbutton switch (861/2) to DC.
- Set AMPL/DIV switch (862) to 5 mV/div.
- Connect the compensation box to socket A (851) and place the tip of the probe on socket PROBE ADJ (854).
- Select either .5 ms/div or .2 ms/div.
- Insert a small screwdriver through the hole in the compensation box and adjust the trimmer to obtain a correct display as shown in Fig. 2.4.



*Fig. 2.4. Probe compensation*

#### 2.2.4. Input functions

The PM 3226 is provided with two vertical channels, they can be used for either YT measurements in combination with the time-base generator, or XY measurements up to frequencies of 1 MHz.

##### *YT Measurements*

Input signals on channels A and/or B are displayed against the internal time-base generator over the range of the TIME/DIV switch (864) for normal operation (ie. not in the X EXT position of the TIME/DIV switch).

##### *XY Measurements*

If the TIME/DIV switch (864) is switched to the X EXT position the time-base generator is switched off. An external input on the TRIG or X EXT frontpanel socket (853) is now connected to the X amplifier channel. The X MAGN front-panel switch (666) PULL FOR x5 facility is still available. In this mode, XY measurements can be made up to a frequency of 1 MHz.

##### *Influence of the 0 and AC-DC switches*

Signals to be studied can be fed to input sockets A or B (851 or 852). Depending on the composition of the signal, the AC-DC switch should be depressed or released.

In the DC position, the input is coupled direct to the Y amplifier. Because the Y amplifier is d.c. coupled, the entire bandwidth of the instrument is available. Therefore, the complete input voltages are fed to the deflection plates, which means that the d.c. components result in trace shifts on the screen.

This may cause difficulties when a.c. signals superimposed on high direct voltages have to be displayed. In order to make the a.c. signal visible in this case, greater attenuation will be necessary with the result that the a.c. signal will also be strongly attenuated.

However, by selecting the AC position of AC/DC switches (861/2, 861/6), a blocking capacitor is connected between the input socket and the Y amplifier. As a result of this, d.c. voltages are blocked, but the lower frequencies are also suppressed or attenuated. When squarewave signals of low frequency are displayed, this will result in some pulse droop.

With the 0 pushbutton selected, it is immediately possible to determine the zero volt d.c. level. The connection between the amplifier input and the input socket is interrupted, the amplifier input being earthed.

### 2.2.5. Triggering

#### *General*

In order to obtain a stationary trace, the horizontal deflection must always be started at a fixed point of the signal. The sweep-gating multivibrator is, therefore, started by narrow trigger pulses formed in the trigger unit, controlled by a signal originating from the vertical input signal, an external source, or internal mains pulses (LINE mode).

#### *Trigger level*

In the case of a complicated signal in which a number of non-identical voltage shapes occur periodically, the time axis should always be started with the same voltage shape so as to obtain a stationary trace. This is possible when one of the details has a deviating amplitude. By means of the LEVEL control, the trigger level can be set in such a way that only this larger voltage variation passes this level. In the TOP mode it is possible to display a large variety of waveforms of different amplitude and shape.

#### *Auto circuit*

The oscilloscope operates in the free-run triggering mode when no signal is present. A time-base line is therefore visible on the screen if no trigger signal is present; this provides a useful zero reference indication.

#### *External triggering*

Where signals vary widely in amplitude, external triggering can be applied from a signal of constant amplitude and equivalent frequency. External triggering is even more important where complex signals and pulse patterns could give rise to double traces. This obviates the necessity of readjusting the level setting at every variation of the input signal. The external input signal is applied to TRIG or X EXT socket (853).

#### *Triggering with the mains frequency (LINE mode)*

In this instance, the triggering signal is a sinewave of mains frequency. This trigger source is useful if the frequency of the signal under observation is derived from the mains supply. It is, for example, possible to recognize the hum component of a signal by triggering on that component.

The mains triggering facility (LINE) is selected by depressing pushbuttons A + B (861/8 + 861/9) simultaneously.

#### *Triggering with television signals*

It is possible to trigger on the line or frame sync pulses of television signals. In positions .5 ms/div to 200 ms/div of the TIME/DIV switch (864) triggering takes place on the frame sync pulses, and in positions 2 ms/div to .5  $\mu$ s/div of this switch, on the line sync pulses.

The position of the trigger slope switch (861/11) must correspond to the inverse polarity of the video information of the signal; i.e. — position of 861/11 for a positive signal, + position of 861/11 for a negative video signal.

### 2.2.6. Time-base magnifier

The magnifier is operated by pulling the switch incorporated in the X position control.

When this switch is in the x5 position, the time-base sweep speed is increased 5 times. The sweep time is therefore determined by dividing the indicated TIME/DIV value by 5.



## 2.3. DISMANTLING THE INSTRUMENT

### 2.3.1. General information

This section provides the dismantling procedures required for the removal of components during repair and routine maintenance 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 (see also Chapter 2.).

During dismantling procedures, a careful note of all leads disconnected must be made so that they may be reconnected to their correct terminals during assembly.

Always ensure that the mains supply is disconnected before removing any instrument cover plates.

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 of switching off the instrument.

### 2.3.2. Removing the instrument covers

The instrument is protected by three covers: a front-panel protection cover, a wrap-around cover with carrying handle, and a rear cover plate.

To facilitate removal of the wrap-around cover and the rear cover, first ensure that the front cover is in position.

Then proceed as follows:

- hinge the carrying handle clear of the front cover to this end, push both pivot centre buttons A (see Fig. 2.2.).
- stand the instrument on its protective front cover on a flat surface
- slacken the coin-slot screw located in the centre of the rear cover plate (see Fig. 2.1.).
- remove the rear cover plate.
- slide out the nylon grommet from the wrap-around cover to free the mains lead.
- lift off the wrap-around cover.
- for access to the front-panel, stand the instrument horizontally and snap off the front cover.
- for access to the high tension part, slide forward transparent protective cover out of the rear panel holes.

### 2.3.3. Removing the bezel and graticule

- to extract bezel, swivel out by applying slight pressure to the left-hand edge (see Fig. 2.5.).  
The mask and graticule can both be unclipped from the bezel by slight pressure from the front.

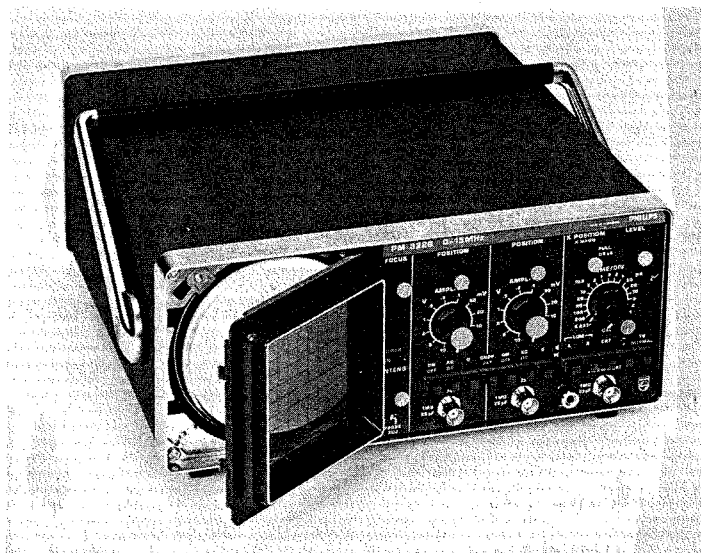


Fig. 2.5. Removing bezel and graticule

### 2.3.4. Removing the text plate

- prise off covers from the AMPL/DIV and X POSITION controls, and pull off the TIME/DIV-CAL knob.
- unscrew hexagon nuts and the slotted nut and remove the knobs.
- pull off all remaining knobs.
- unscrew remaining hexagon nuts securing the textplate.
- carefully remove the text plate.

### 2.3.5. Removing the FOCUS and INTENS/OFF controls

- remove instrument covers as described (see Section 2.3.2.).
- remove appropriate front-panel control knob.
- spring out nylon brackets B (Fig. 2.6.) through the holes of the rear panel.
- simultaneously rotate spindle C (Fig. 2.6.) and pull to withdraw square through alignment hole.
- remove nylon bracket and spindle.
- unscrew hexagonal nut D (Fig. 2.6.) to remove potentiometer.

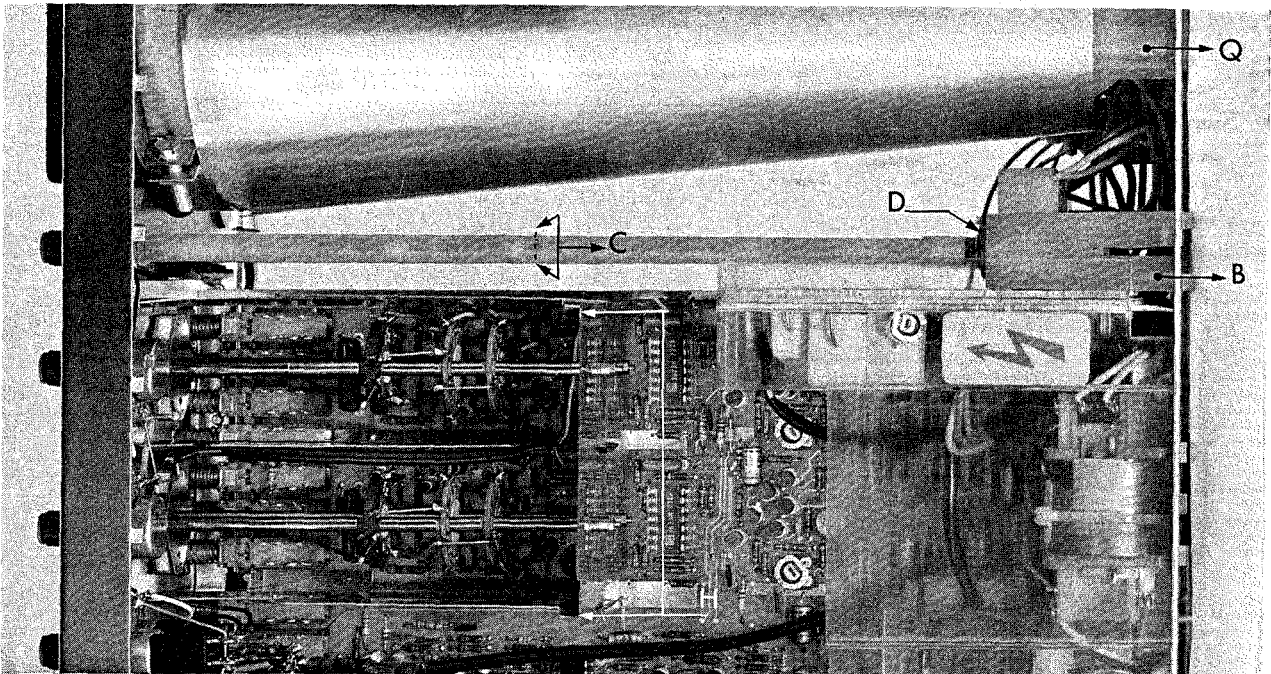
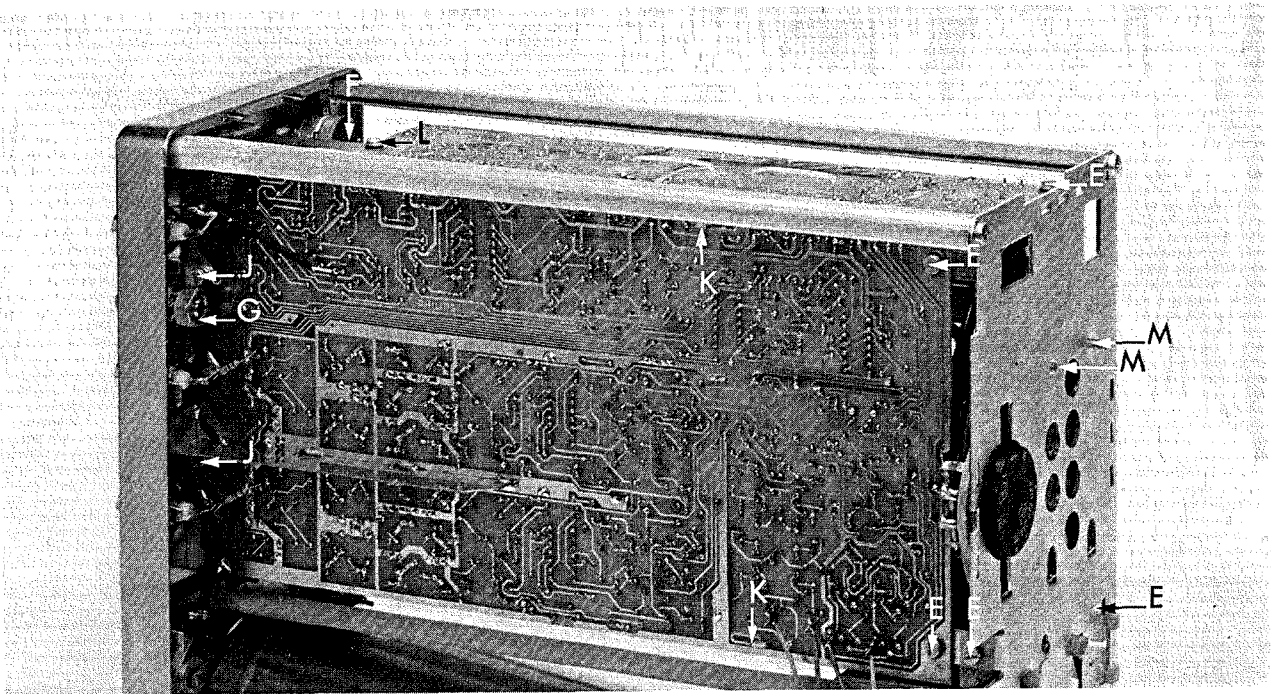


Fig. 2.6. Dismantling

### 2.3.6. Removing the electronic unit assembly complete (including the E.H.T. board)

- remove instrument covers as described (see Section 2.3.2.).
- Remove the FOCUS and INTENS/OFF control knobs.
- slide forward transparent protective cover out of rear panel holes.
- remove three Stocko connectors and the flying lead connectors.
- unsolder the remaining connection leads at the rear side of the bottom board.
- Note that probe adjustment lead to front panel must also be removed.
- remove six screws and one nut located as follows:
  - 5 screws E (Fig. 2.7.) holding p.c. boards to rear plate.
  - 1 screw F (Fig. 2.7.) behind front panel (top).
  - 1 nut G (Fig. 2.7.) behind front panel (bottom).
- withdraw complete electronic unit assembly through front panel together with text plate and knobs.



*Fig. 2.7. Dismantling*

### 2.3.7. Access to attenuator unit for replacement

- remove electronic unit assembly in accordance with 2.3.6.
  - unhook attenuator screening side plate(s) by pressing in the rear screening plate (H) at the top edge (see Fig. 2.6.).
  - unsolder wires to attenuator printed-circuit board from the printed side using a vacuum soldering iron.
  - unscrew two screws J (Fig. 2.7.) and the two nuts of ch. A and B input sockets.
  - remove text plate and hexagonal nuts securing attenuator (see Section 2.3.4.).
- For replacement, remove existing switch and make identical connections on new switch.

### 2.3.8. Removing a printed-circuit board

- remove the instrument covers as described (see Section 2.3.2.).
- remove the electronic unit assembly (see Section 2.3.6.).
- unsolder appropriate connections.
- unhook angle bracket K located halfway along edge of the p.c. board (Fig. 2.7.).
- to remove vertical board: remove one screw L securing it to the front panel (Fig. 2.7.).
- to remove horizontal board: remove the attenuator screening plates (see Section 2.3.7.) and unsolder the attenuator connections.
- unscrew two nuts of ch. A and B input sockets and the two screws J securing the board to the front panel (Fig. 2.7.).

### 2.3.9. Removing the mains transformer

- remove the instrument covers as described (see Section 2.3.2.).
- unsolder connecting wires, noting positions.
- remove two Stocko connectors and the flying lead connectors.
- unscrew two mounting screws M (Fig. 2.7.).
- lift out transformer sideways.

### 2.3.10. Fuse replacement (see also Section 2.1.3.)

- remove the instrument covers as described (see Section 2.3.2.).
- fuse I (Fig. 2.8.): unsolder the fuse terminals 1 and 2.
- fuse II (Fig. 2.8.): remove the mains transformer (see Section 2.3.9.) and unsolder the fuse terminals 1' and 2'.
- remove the fuse; to this end, bend the housing slightly to the outside so that the locking pin can be disengaged (Fig. 2.9.).
- a new fuse is removed from its housing in the same way as described above. It is then pushed in the same housing as the old one until the locking pin snaps into the hole, the loop pointing to the "1" terminal.
- after having terminals "1" and "2" soldered, the instrument can be considered as ready for use.

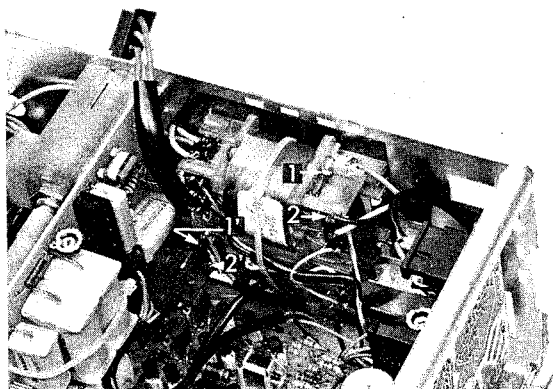


Fig. 2.8. Fuse location

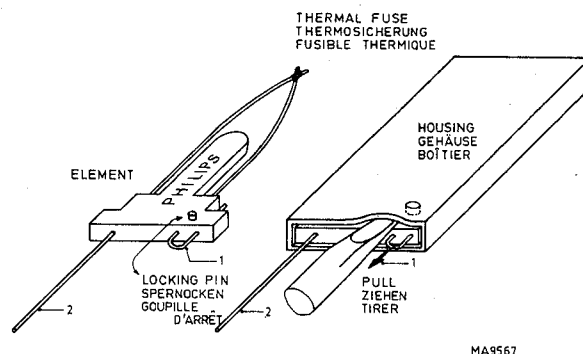


Fig. 2.9. Fuse replacement

### 2.3.11. Removing the cathode-ray tube

- remove instrument covers as described (see Section 2.3.2.).
- remove screws N and P behind front panel (see Fig. 2.10.).
- remove bezel (see Section 2.3.3.).
- remove plastic locking piece.
- spring the two nylon bracket lips Q (see Fig. 2.6.), at rear of tube, inwards and taking care of mumetal screen, withdraw the c.r.t. through front panel sufficiently to allow the c.r.t. base connector to be removed. (Push in nylon bracket to assist.)
- slacken clamping screw R in bracket around tube fuse (Fig. 2.10.).

*Note: When fitting a c.r.t., well-adjust the tube face against graticule. Take care not to overtighten the clamping screw R (screw pressure  $\leq 40$  newton x cm).*

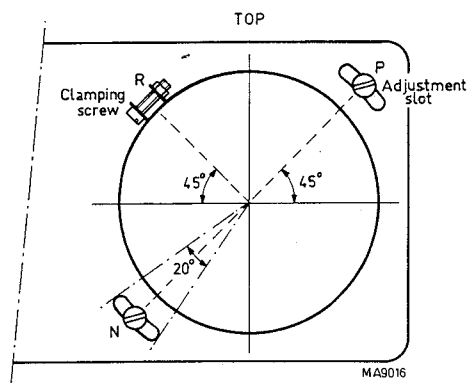


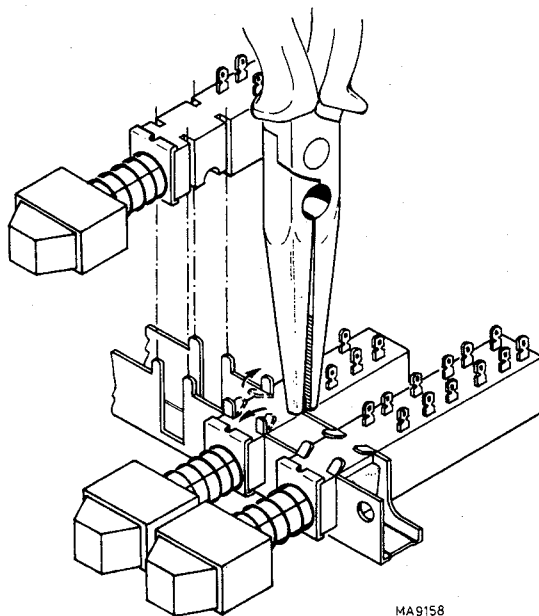
Fig. 2.10. Cathode-ray tube positioning

### 2.3.12. Removing the carrying handle

- prise off the plastic centre buttons from each pivot with a screwdriver.
- remove the posidrive screws.

### 2.3.13. Replacing a push-button switch

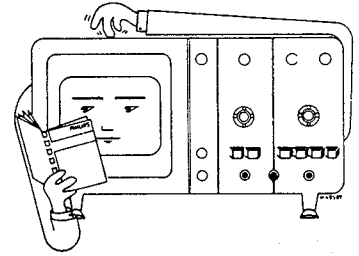
- Remove the printed-circuit board in accordance with section 2.3.8. for replacing a switch in this unit.
- Straighten the 4 retaining lugs of the relevant switch as shown in Fig. 2.11.
- Break the body of the relevant switch by means of a pair of pliers and remove the pieces. The soldering pins are then accessible.
- Remove the soldering pins and clean the holes in the printed-wiring board (e.g. with a suction soldering iron).
- Solder the new switch onto the printed-circuit board.
- Band the 4 retaining lugs back to their original positions.



*Fig. 2.11. Replacing a push-button switch*

## Notice d'emploi

# 1. Généralités



## 1.1. INTRODUCTION

L'oscilloscope portable double trace de 15 MHz PM 3226 est un appareil compact et léger au fonctionnement simple; il a été conçu à des fins de service de recherche et d'enseignement.

L'appareil est pourvu de dispositifs pour affichage découpé ou alterné des signaux Y, pour déclenchement automatique, sur secteur et sur les impulsions de synchronisation (ligne et trame) d'un signal télévision.

Le tube à rayons cathodiques présente une surface utile étalonnée de 8 x 10 divisions par graticule externe.

Tous les circuits sont entièrement transistorisés et montés sur des platines, ce qui facilite la maintenance.

Le dessin et la composition directes offrent, en plus d'un fonctionnement simple, un haut degré de fiabilité.

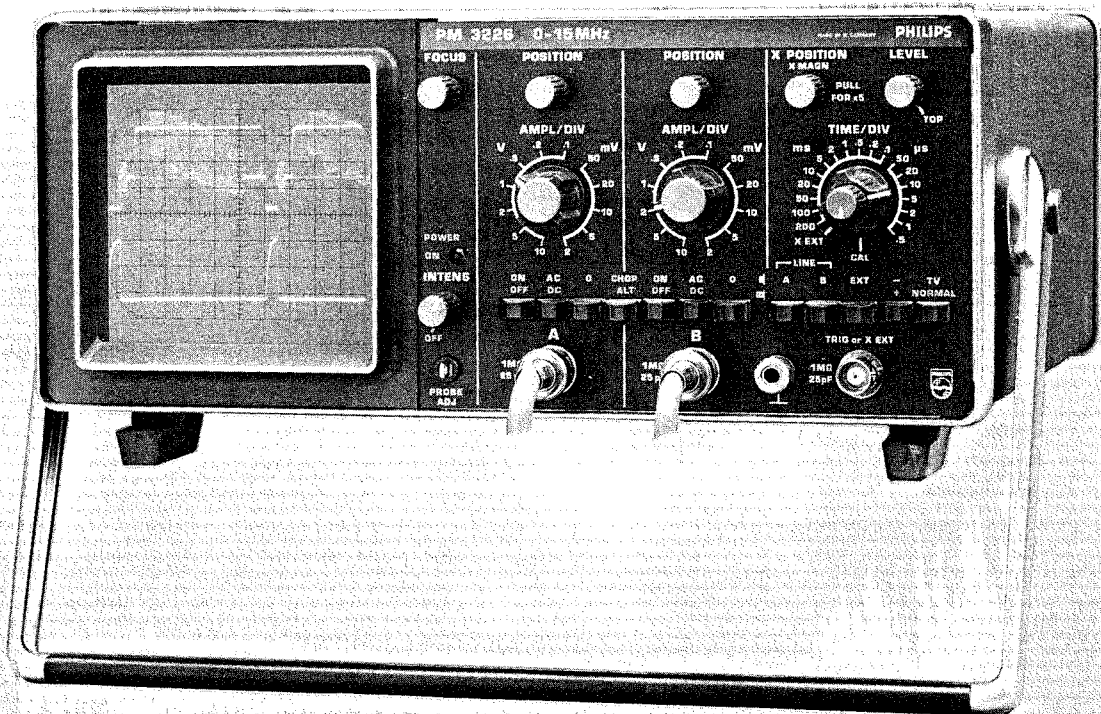


Fig. 1.1. Vue avant PM 3226

## 1.2. CARACTERISTIQUES TECHNIQUES

### Instructions générales

Seules les valeurs indiquées avec tolérance sont garanties par l'usine. Les chiffres sans tolérance ne servent qu'à titre d'information et correspondent aux caractéristiques d'un appareil moyen.

<i>Désignation</i>	<i>Spécification</i>
<b>1.2.1. Tube à rayons cathodiques</b>	
Type	: D10 – 160 GH
Aire de mesure	: 8 x 10 divisions; 1 div. = 7,5 mm
Type d'écran	: P31 (GH) P7 (GM) en option
Tension d'accélération	: 1,5 kV
Graticule	: Externe, pas illuminé
Possibilités de réglage	: Focalisation, luminosité
<b>1.2.2. Amplificateur vertical</b>	
Gamme de fréquence	: Continu 0 Hz à 15 MHz (–3 dB) Alternatif 2 Hz à 15 MHz (–3 dB)
Temps de montée	: 25 ns
Dépassement	: ≤ 3 % (impulsion de test: amplitude 6 div, temps de montée 3 ns)
Coefficients de déviation	: 2 mV/div à 10 V/div en 12 échelons calibrés, en progression 1-2-5, précision ± 5 %
Tension d'entrée maxi admise	: ± 400 V (tension continue + tension alternative crête) Résiste à des crêtes non-répétitives jusqu'à 1000 V.
Gamme de position verticale	: ± 16 divisions
Gamme dynamique	: 24 divisions pour signaux sinusoïdaux à fréquences allant jusqu'à 3 MHz ≥ 5 divisions pour signaux sinusoïdaux jusqu'à 15 MHz
Impédance d'entrée	: 1 MΩ // 25 pF
Modes de fonctionnement:	
Voie A	: Voie A, bouton-poussoir ON/OFF enfoncé
Voie B	: Voie B, bouton-poussoir ON/OFF enfoncé
Voies A et B (electronique)	: Voies A et B, boutons-poussoirs ON/OFF enfoncés (modes découpé on alterné, en fonction du bouton-poussoir)
<b>1.2.3. Amplificateur horizontal</b>	
Réponse	: Continu à 1 MHz (–3 dB)
Coefficients de déviation	: 5 V/div pour agrandissement 1x, précision ± 10 % 1 V/div pour agrandissement 5x (X-MAGN)
Tension d'entrée maxi admise	: ± 400 V (tension continue + tension alternative crête) Résiste à des crêtes non-répétitives jusqu'à 1000 V
Impédance d'entrée	: 1 MΩ // 25 pF
Déphasage	: 5° à 50 kHz
<b>1.2.4. Base de temps</b>	
Coefficients de temps	: 0,2 sec/div à 0,5 μsec/div en 18 échelons étalonnés, en progression 1-2-5. Réglage continu entre les échelons 1:2,5 fois pas étalonnés
Erreur de coefficient	: ± 5 %



<i>Désignation</i>	<i>Specification</i>
Expansion	: x5, 1 échelon étalonné
Erreur supplémentaire	: < 2 %
<b>1.2.5. Déclenchement</b>	
Sourches	: Interne Externe Secteur
Sensibilité de déclenchement	: Interne : déclenchement sur la valeur ajustée (LEVEL): max. 0,8 div. à 100 kHz; 0,4 div. typique 1,0 div. à 15 MHz; 0,6 div. typique déclenchement sur la valeur de crête (TOP): 3,0 div. à 15 MHz; 2,0 div. typique déclenchement sur le signal télévision (TV): 2,5 div. pour impulsions de synchronisation de ligne ou de trame; 1,5 div. typique  Externe : déclenchement sur la valeur ajustée (LEVEL): max. 0,7 V à 100 kHz; 0,4 V typique 1,0 V à 15 MHz; 0,5 V typique déclenchement sur la valeur de crête (TOP): 2,0 V à 15 MHz; 1,2 V typique déclenchement sur le signal télévision (TV): 2,0 V pour impulsions de synchronisation de ligne ou de trame; 1,0 V typique
Impédance d'entrée	: 1 MOhm // 25 pF
Tension d'entrée maxi admise	: ± 400 V (tension continue + tension alternative crête) Résiste aux crêtes non-répétitives jusqu'à 1000 V.
Mode de déclenchement	: Le générateur de base tourne librement en l'absence de signal de déclenchement a. Niveau de déclenchement réglable sur 12 divisions ou 12 V. Fréquence à déclenchement inférieur pour ondes sinusoïdales = 10 Hz b. Crête (TOP)
Pente de déclenchement	: + ou -
Déclenchement par signaux télévision	: Trame (couplé avec positions .5 ms/div à 200 ms/div) Ligne (couplé avec positions .2 ms/div à .5 µs/div)
Réglage de sonde	: Point de contact (pour ajustage de sonde, voir section 2.2.3.)

### 1.2.6. Caractéristiques d'environnement

Les données mentionnées sous CARACTERISTIQUES TECHNIQUES ne sont valables que si l'appareil est contrôlé conformément aux normes officielles. Des détails à ce sujet et sur les critères de défaillance sont disponibles sur demande à l'Organisation PHILIPS de votre pays, ou à N.V. PHILIPS' GLOEILAMPEN-FABRIEKEN, TEST AND MEASURING DEPT., EINDHOVEN, HOLLANDE.

#### 1.2.6.1. Température

Valeur de référence	: 23 °C
Gamme nominale de travail	: +5 °C à +40 °C
Gamme limite de travail	: -10 °C à +55 °C
Gamme de stockage et de transport	: -40 °C à +70 °C

#### 1.2.6.2. Altitude

Limite opérationnelle	: 5000 m	} à l'air libre
Limite de transport	: 15000 m	

<i>Désignation</i>	<i>Spécification</i>
1.2.6.3. <i>Humidité</i>	: Répond aux normes CEI 60 Db.
1.2.6.4. <i>Résistance aux chocs</i>	: 1000 chocs de 10 g, 1/2 sinusoïde, durée 6 ms, dans chacune des trois directions.
1.2.6.5. <i>Résistance aux vibrations</i>	: 30 minutes dans chacune des trois directions, 10-150 Hz; 0,7 mm crête-à-crête et 5 g accélération maximale
1.2.6.6. <i>Interférence électromagnétique</i>	: Répond aux normes VDE, Störgrad K
1.2.7. <b>Position de fonctionnement</b>	: selon le choix
1.2.8. <b>Tensions d'alimentation</b>	: 110 V, 127 V, 220 V et 240 V; en alternatif $\pm 10\%$ (46 Hz à 400 Hz)
PM 3226Q (Version E-U)	: Seulement pour 110 V
Consommation	: 18 VA
1.2.9. <b>Caractéristiques mécaniques</b>	
Hauteur	: 140 mm
Largeur	: 305 mm
Longueur	: 320 mm
Poids	: 4,5 kg
1.2.10. <b>Refroidissement</b>	: Par convection naturelle

### 1.3. ACCESSOIRES

Accessoires livrés avec l'appareil:

1 couvercle frontal (Chapitre 3.6.2., item 1)  
 2 adaptateurs BNC-4 mm (Chapitre 3.6.2., item 2)  
 1 plaque de contraste (Chapitre 3.6.1., item 5)  
 1 notice d'emploi

Accessoires en option:

PM 9326	Sonde passive 10 : 1 (1,1 m câble)
PM 9327	Sonde passive 10 : 1 (2,1 m câble)
PM 9335	Sonde passive 1 : 1 (1,5 m câble)
PM 9335L	Sonde passive 1 : 1 (2,5 m câble)
PM 9336	Sonde passive 10 : 1 (1,5 m câble)
PM 9336L	Sonde passive 10 : 1 (2,5 m câble)
PM 9358/01	Sonde passive 100 : 1 (1,5 m câble)
PM 9353	Sonde FET active 1 : 1, 1 : 10, 1 : 100
PM 9355	Sonde de mesure des courants
PM 9346	Bloc d'alimentation pour des sondes actives
PM 9380	Appareil de photographie d'oscillogrammes
PM 8971	Adaptateur (oscilloscope — PM 9380)
PM 9051	Adaptateur BNC-4 mm

Croquis côté pour montage en rack 19" (Fig. 3.27.)  
 Aérosol anti-statique  
 Jeu d'outils d'ajustage

Voir également Chapitre 3.5. "Information concerning accessories".

## 1.4. DESCRIPTION DU SCHEMA SYNOPTIQUE (voir Fig. 1.2., page 12)

### 1.4.1. Voie Y

Les voies verticales A et B pour double trace sont identiques. Chacune d'elles comprend un commutateur de couplage d'entrée, un atténuateur d'entrée, un étage d'entrée source-follower avec circuit de protection, un pré-amplificateur, d'où est dérivé un signal de déclenchement, et un amplificateur de sortie combiné. Le circuit de protection de l'étage d'entrée est une diode évitant l'endommagement des transistors à effet de champ en cas de potentiels d'entrée négatifs excessifs, et un circuit à résistance protège l'étage d'entrée contre forts potentiels positifs.

Etant donné que les transistors de l'étage pré-amplificateur équilibré occupent les mêmes circuits intégrés, la stabilisation obtenue constitue une mesure de correction pour réduire la dérive dans les amplificateurs à forte amplification.

Le signal sélectif de déclenchement est pris d'un côté du pré-amplificateur équilibré au sélecteur mode de déclenchement pour sélection de voie A ou B. La sortie du pré-amplificateur est alimentée à partir d'une source de courant constant commandée par la logique de commutation de voies. De la sorte les signaux de A et B sont conduits à l'amplificateur de sortie. L'amplificateur de sortie équilibré est couplé directement aux plaques Y du t.r.c.

### 1.4.2. Commutation de voie

Les boutons-poussoirs pour sélection des voies A et B (panneau avant) commandent un oscillateur en mode CHOP, la logique de commutation électronique et un flip-flop en vue de la commutation de voie.

Lorsque soit A soit B est sélectionnée, le flip-flop est basculé pour permettre le fonctionnement sur la voie appropriée. En mode ALT une impulsion produite par le multivibrateur de déverrouillage par l'intermédiaire de la logique de commutation électronique fait basculer le flip-flop, permettant ainsi le balayage alterné par voies A et B. En mode CHOP, l'oscillateur est commandé par l'étage logique en vue d'une commutation rapide des voies par l'intermédiaire du flip-flop.

### 1.4.3. Déclenchement

Le signal de déclenchement peut être obtenu à partir des voies A et B d'amplificateur vertical (par l'intermédiaire de l'étage sélectif de déclenchement), d'une source externe ou internement par l'alimentation secteur (déclenchement LINE). Le signal de déclenchement est sélectionné et normalement appliqué, par l'intermédiaire de l'amplificateur, au conformateur d'impulsions, lequel alimente des impulsions bien définies au générateur de déverrouillage, en vue du démarrage du générateur de dents de scie.

Le déclenchement par signaux télévision (ligne et trame) est facilité par le séparateur de synchronisation et le détecteur de crêtes. Ce dernier étage est également mis en circuit en position TOP.

### 1.4.4. Base de temps

Le générateur de base de temps fonctionne selon le principe de l'intégrateur de courant constant.

Le générateur de déverrouillage, déclenché par des impulsions du différenciateur et du circuit automatique, démarre le générateur de dents de scie. De ce fait, des impulsions en dents de scie, dont la durée dépend de la position du commutateur TIME/DIV, sont appliquées à l'amplificateur de sortie X.

Une impulsion de porte est appliquée au générateur de déverrouillage en vue de la commande du t.r.c. pendant le balayage avant. De plus, cette impulsion est appliquée à une douille externe pour réglage de sonde, par l'intermédiaire d'un circuit à diode.

### 1.4.5. Voie X

Par l'action du commutateur TIME/DIV (diode pilotée) l'amplificateur de sortie X reçoit son signal d'entrée du générateur de dents de scie ou d'une source externe (douille d'entrée X EXT par X et pré-amplificateur de déclenchement).

Le circuit X MAGN (x5) est incorporé à l'amplificateur de sortie X. La sortie de cet amplificateur est couplé directement aux plaques de déviation horizontale du t.r.c.

### 1.4.6. Circuit de t.r.c. et alimentations

Les hautes tensions pour t.r.c., lequel a un potentiel d'accélération de 1,5 kV sont engendrées par un circuit multiplicateur de tension commandé par l'alimentation de puissance stabilisée. Le courant de faisceau t.r.c. est commandé par le réseau de potentiomètre INTENS par l'alimentation EHT et pendant le retour, par les impulsions de suppression provenant du générateur de dents de scie par l'intermédiaire de l'étage de suppression de faisceau.

La tension secteur d'entrée est réglée par un signal retourné d'une diode LED dans l'alimentation redressée +14 V.

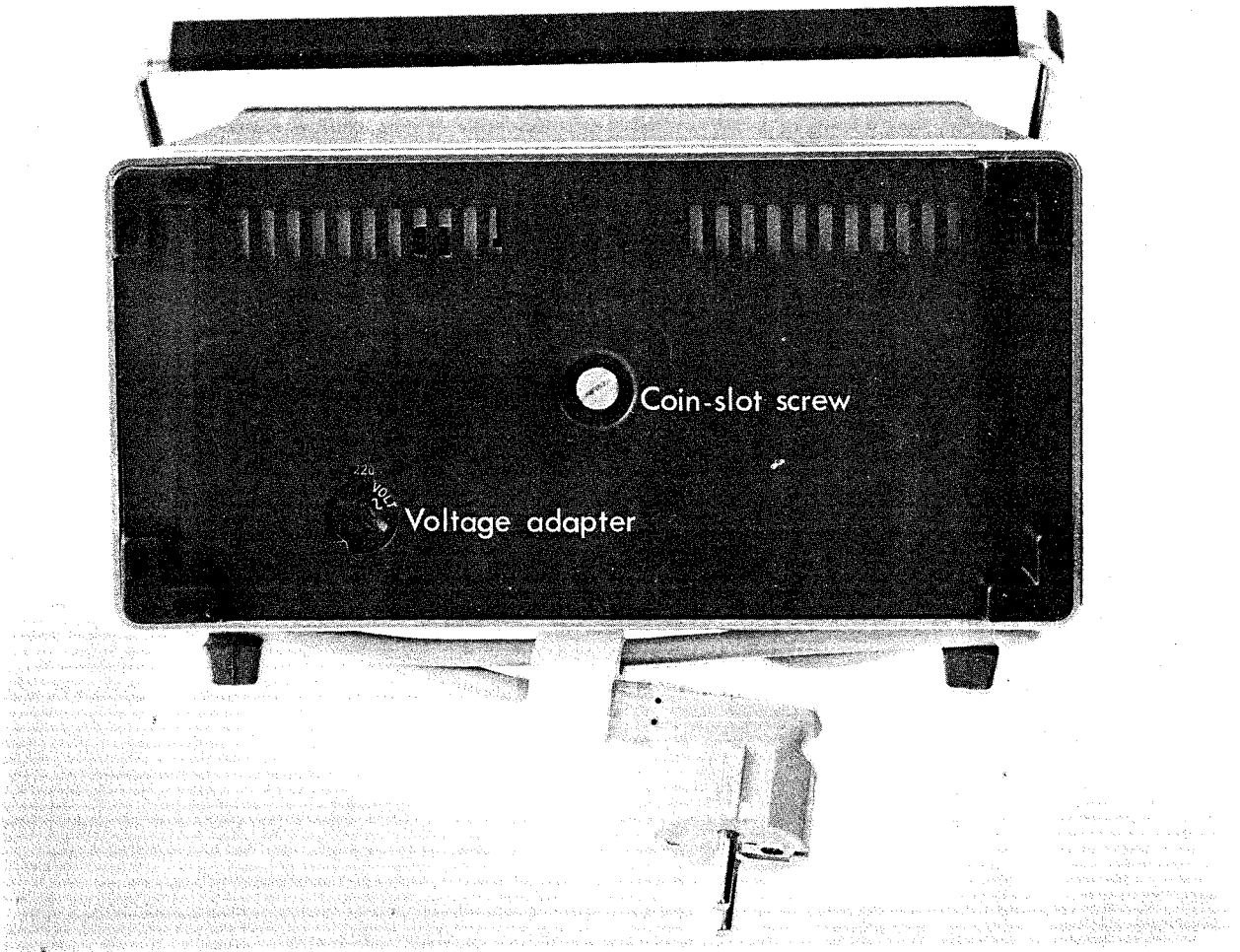
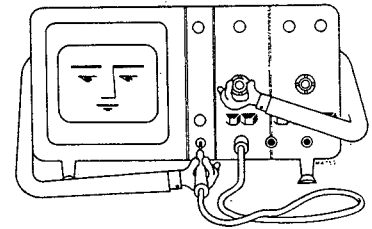


Fig. 2.1. Vue arrière

## 2. Mode d'emploi



### 2.1 IMPORTANTES REGLES DE SECURITE

Le présente appareil quitte l'usine dans un état impeccable et répondant aux règles de sécurité. Dans cette optique et en vue d'un fonctionnement sans risque, nous vous recommandons de suivre à la lettre les instructions ci-après.

#### 2.1.1 Tension secteur

L'appareil doit être branché à un secteur alternatif. A la livraison, l'appareil est réglé sur 220 V. En cas d'utilisation sur 110 V, 127 V ou 240 V, la tension appropriée doit être en mettant l'adaptateur à l'arrière sur la tension requise (voir Fig. 2.1.).

##### *Avant usage*

- Avant d'utiliser l'appareil après stockage et transport, vérifier s'il présente des dommages matériels (coffret, commandes, connecteurs, etc.).
- Vérifier si la tension réglée correspond à la tension secteur nominale.

##### *Classe de protection*

Le présent appareil répond à la classe de protection I (conducteur de terre) conforme à CEI 348 ou VDE 0411. Le cordon secteur compris à la livraison comporte un conducteur de terre. A moins qu'utilisé dans des endroits spécialement préparés (permis), la fiche secteur ne doit être introduite que dans une prise possédant un contact de terre.

#### 2.1.2 Réparation et entretien

##### *Erreurs et conditions spéciales*

Au cas où le fonctionnement sans risque n'est plus garanti, l'appareil doit être mis hors service et protégé contre l'usage involontaire.

##### *C'est le cas:*

- lorsque l'appareil présente des dommages visibles
- lorsque l'appareil ne fonctionne plus
- lorsque les conditions (par ex. stockage, transport) dépasse les limites admises.

##### *Ouverture de l'appareil*

L'ouverture des capots ou la dépose d'organes, à l'exception de ceux directement accessibles à la main sont susceptibles de mettre à jour des composants et des connecteurs sous tension.

L'appareil doit être débranché de toute source de tension avant de procéder à un réglage, un remplacement, une opération d'entretien ou une réparation demandant l'ouverture de l'appareil.

Au cas où le réglage, l'entretien ou la réparation de l'appareil ouvert sous tension sont inévitables, seule une personne qualifiée peut se charger de cette tâche.

Ne pas oublier que les condensateurs à l'intérieur de l'appareil peuvent être chargés, même si l'appareil est déconnecté de toute source de tension.

##### *Réparation et remplacement de pièces*

Les réparations doivent se faire en compétence. Elles ne peuvent affecter la sécurité de l'appareil. Veiller surtout à ce que les distances d'air et de grimpement entre les pièces ne soient pas diminuées.

Seules les pièces originales peuvent être utilisées. Des pièces différentes ne sont permises que si elles n'affectent pas la sécurité de l'appareil.

#### 2.1.3 Fusibles

L'appareil est protégé contre les surcharges par deux fusibles thermiques montés entre les enroulements du transformateur. Ils peuvent être remplacés après dépose des couvercles de l'appareil (voir section 2.3.10.).

Les fusibles spécifiés doivent être utilisés.

### 2.1.4 Position

L'appareil doit être placé horizontalement ou incliné après avoir pivoté l'étrier-support. Pour déposer le poignée, enfoncer les deux boutons centraux de pivotement A (voir Fig. 2.2.).

Les ouvertures de ventilation dans les plaques arrière et inférieure ne peuvent pas être recouvertes. Veiller à ne pas mettre l'appareil sur des objets produisant de la chaleur.

### 2.1.5 Installation (adaptation et connexion au secteur, mise à la terre)

#### *Adaptation et connexion*

L'appareil doit être branché au secteur alternatif. A la livraison, l'appareil est réglé sur 220 V. Avant de brancher l'appareil au secteur, vérifier si le transformateur de tension secteur est bien réglé sur la tension secteur locale. La tension réglée est visible par une ouverture à l'arrière de l'appareil.

Pour régler l'appareil sur une autre tension secteur, procéder comme suit:

- déconnecter la fiche secteur
- régler la tension secteur par rotation du convertisseur de tension à l'arrière (voir Fig. 2.1.)

#### *Mise à la terre*

L'appareil doit être mis à la terre conformément aux règles de sécurité locales.

En cas de branchement à une prise murale à ergot de terre, le châssis est automatiquement relié à la terre par le câble secteur à trois conducteurs.

**ATTENTION:** Toute interruption de la ligne de terre, à l'intérieur ou à l'extérieur de l'appareil ou le débranchement de la borne de terre peuvent rendre l'appareil dangereux. L'interruption intentionnelle est formellement interdite.

Lorsqu'un appareil passe d'un endroit froid à un endroit chaud, la condensation peut provoquer un certain risque. En conséquence, il faut appliquer strictement les prescriptions de mise à la terre.

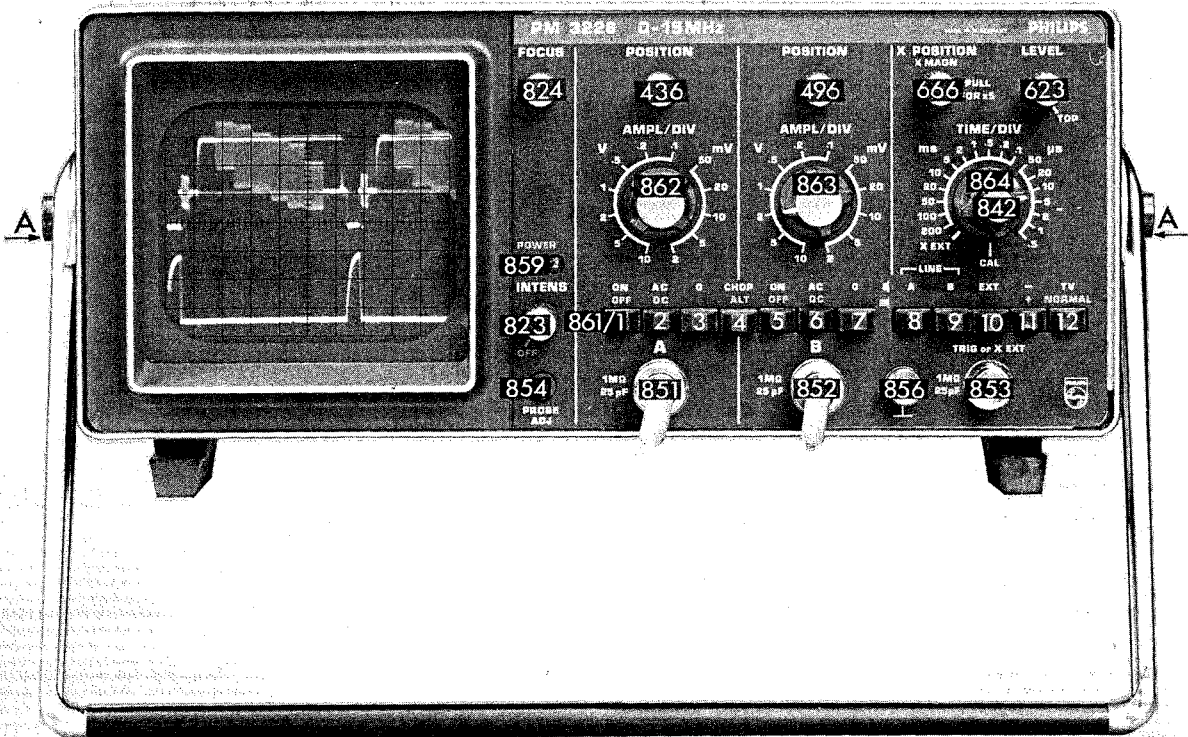



Fig. 2.2. Vue avant illustrant commandes et douilles

## 2.1.6. Commandes et douilles (Fig. 2.2.)

FOCUS	824	Commande continuellement variable de focalisation du faisceau électronique
Y POSITION	Voie A: 436 Voie B: 496	Commande continuellement variable indiquant la position verticale de l'affichage
X POSITION/X MAGN	666	Commande continuellement variable indiquant la position horizontale de l'affichage. Elle comprend un commutateur pour agrandissement x5 étalonné de la base de temps.
LEVEL/TOP	623	Commande continuellement variable pour sélection du niveau où le générateur de base de temps démarre. Le commutateur a une position TOP pour grands signaux.
AMPL/DIV	Voie A: 862 Voie B: 863	Commande pour coefficients de déviation verticale et 12 échelons étalonnés.
TIME/DIV	864	Commande de coefficient de temps de la base de temps en 18 échelons étalonnés, plus une position pour déviation externe X (X EXT).
TIME/DIV - CAL	842	Commande continuellement variable des coefficients de temps. En position CAL les coefficients de temps sont étalonnés.
POWER ON	859	S'allume (rouge) pour indiquer que l'appareil est enclenché.
INTENS avec commutateur OFF	823	Commande continuellement variable de la luminosité de trace; comporte le commutateur ON/OFF pour alimentation de l'oscilloscope.
Boutons-poussoirs ON/OFF	Voie A: 861/1 Voie B: 861/5	Commutent la voie appropriée à l'amplificateur de sortie.
Boutons-poussoirs AC/DC	Voie A: 861/2 Voie B: 861/6	AC (enfoncé): entrée Y par condensateur de couplage DC (relâché): entrée Y directement couplée
Boutons-poussoirs O	Voie A: 861/3 Voie B: 861/7	Interrompt la connexion d'entrée Y et met le circuit d'entrée à la terre.
Bouton-poussoir CHOP/ALT	861/4	En mode découplé (CHOP) lorsqu'enfoncé, en mode alterné (ALT) lorsque relâché.
Boutons-poussoirs de déclenchement	861/8 à 861/12	Commandes pour source, pente et mode de déclenchement
A	861/8	Signal de déclenchement interne dérivé de la voie A.
B	861/9	Signal de déclenchement interne dérivé de la voie B.
LINE (A+B sélectionnés simultanément)		Signal de déclenchement dérivé d'une tension interne à fréquence secteur.
EXT	861/10	Signal de déclenchement dérivé d'une tension appliquée à la douille TRIG ou X-EXT (853).
±	861/11	Produit le déclenchement sur la pente positive du signal (position relâchée) et sur la pente négative (position enfoncée).
TV/NORMAL	861/12	Enfoncé, il permet le déclenchement sur impulsions (ligne ou trame), de signaux télévision conformément à la position du commutateur TIME/DIV (864). Déclenchement sur impulsions de trame en positions .5 ms/div à 200 ms/div. Déclenchement sur impulsions de ligne en positions .2 ms/div à .5 μs/div.

PROBE ADJ	854	Borne de sortie pour sondes et test d'étalonnage.
1 M $\Omega$ // 25 pF	851	Douille BNC d'entrée pour signal A de déviation verticale.
1 M $\Omega$ // 25 pF	852	Douille BNC d'entrée pour signal B de déviation verticale.
	856	Douille de terre
TRIG or X-EXT	853	Douille BNC d'entrée pour signaux de déclenchement externe ou déviation X externe.



## 2.2. MANIPULATION

### 2.2.1. Enclenchement de l'appareil

Le cordon secteur est enroulé autour des quatre pieds d'appareil. Après son branchement au secteur conformément aux sections 2.1.1. à 2.1.5., l'oscilloscope peut être enclenché à l'aide de l'interrupteur secteur incorporé dans la commande INTENS; la lampe rouge POWER ON s'allume.

L'appareil répond aux spécifications (voir section 1.2.) après une période de chauffage d'environ 30 minutes. Cependant, si l'appareil est laissé dans un endroit extrêmement froid (par exemple une nuit dans une voiture alors qu'il gèle) et qu'ensuite on le place dans une pièce chauffée, une période de chauffage d'environ 2 heures doit être observée.

### 2.2.2. Réglages préliminaires des commandes

- Vérifier si la tension secteur correcte est choisie conformément à la section 2.1.5.  
Enclencher l'appareil.
- Mettre la commande INTENS (823) en position médiane.
- Choisir source, mode et pente de déclenchement. Si aucun bouton de déclenchement n'est choisi, l'oscilloscope déclenche en mode automatique et interne (voie B).
- Représenter la trace appropriée à l'aide de la commande Y POSITION.  
L'appareil est alors prêt à l'usage.

### 2.2.3. Réglage des sondes atténuatrices

*Sondes PM 9326 et PM 9327*

- Représenter une ligne de base de temps en choisissant le mode LINE (enfoncer simultanément les boutons-poussoirs A et B).
- Tourner le potentiomètre LEVEL complètement vers la droite (position TOP).
- Relâcher le bouton-poussoir 861/2; choisir DC par exemple.
- Mettre le commutateur AMPL/DIV (862) sur 5 mV/div.
- Connecter le fil de mesure à la douille A (851) et placer l'extrémité de sonde sur la borne PROBE-ADJ (854).
- Choisir .5 ms/div ou .2 ms/div.
- Desserrer la vis de serrage et tourner le corps de sonde (voir Fig. 2.3.) par rapport au câble jusqu'à ce que le réglage correct soit obtenu.
- Fixer la vis de serrage tout en s'assurant que le réglage n'est pas modifié.

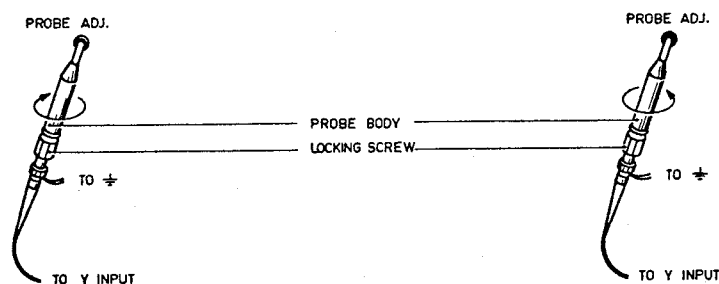
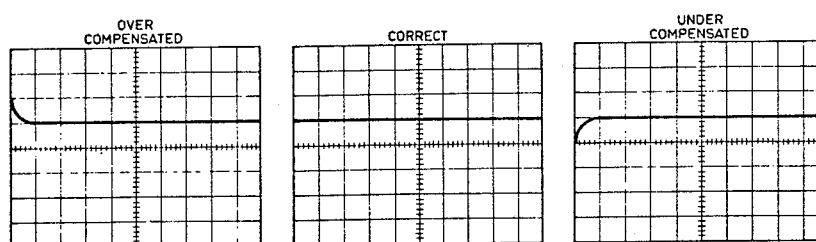


Fig. 2.3. Réglage des sondes PM 9326 et PM 9327

### Sondes PM 9336, PM 9336L et PM 9358

- Représenter une ligne de base de temps en sélectionnant le mode LINE (enfoncer les boutons-poussoirs A et B simultanément).
- Tourner le potentiomètre LEVEL complètement vers la droite (position TOP).
- Relâcher le bouton-poussoir 861/2; choisir DC par exemple.
- Mettre le commutateur AMPL/DIV (862) sur 5 mV/div.
- Connecter la boîte de compensation à la douille A (851) et placer l'extrémité de sonde sur la borne PROBE-ADJ (854).
- Choisir .5 ms/div ou .2 ms/div.
- Introduire un petit tournevis dans l'ouverture de la boîte de compensation; régler ainsi le trimmer afin d'obtenir une représentation correcte comme illustré à la figure 2.4.

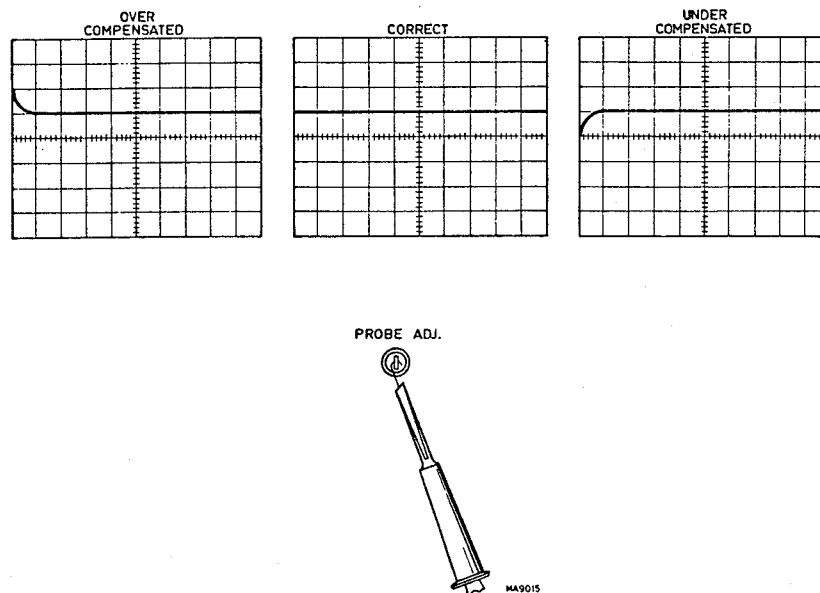


Fig. 2.4. Réglage des sondes PM 9336, PM 9336L et PM 9358

#### 2.2.4. Fonctions d'entrée

Le PM 3226 a deux voies verticales, lesquelles peuvent être utilisées soit pour des mesures YT combiné avec le générateur de base de temps, soit pour des mesures XY jusqu'à des fréquences de 1 MHz.

##### Mesures YT

Les signaux d'entrées verticaux sont représentés par rapport au signal produit par le générateur de base de temps interne, sur la gamme du commutateur TIME/DIV (864) en fonctionnement normal (pas en position X EXT du commutateur TIME/DIV).

##### Mesures XY

Lorsque le commutateur TIME/DIV (864) est mis sur X EXT, la base de temps est mise hors circuit. Une entrée externe sur la douille TRIG ou X EXT (853) (panneau avant) est alors connectée à la voie amplificateur X. Le commutateur X MAGN (666), PULL FOR x5 (panneau avant) est disponible. Dans ce mode, les mesures XY peuvent être effectuées jusqu'à 1 MHz.

##### Influence des commutateurs 0 et AC-DC

Les signaux à étudier peuvent être appliqués aux douilles d'entrées A et/ou B (851 et/ou 852). En fonction du signal, le commutateur AC-DC doit être enfoncé ou relâché. En position DC, l'entrée est couplée directement à l'amplificateur Y. Etant donné que l'amplificateur Y est couplé directement, la largeur de bande totale de l'appareil est disponible. A cet effet, les tensions d'entrée complètes sont appliquées aux plaques de déviation ce qui signifie que les composants continus donnent des décalages de trace sur l'écran.

Ceci cause des problèmes lorsque des signaux alternatifs superposés à de hautes tensions continues doivent être représentés.

Pour visualiser le signal alternatif dans ce cas, il faudra une forte atténuation de sorte que le signal alternatif sera fortement atténué.

Cependant, en position AC du commutateur AC/DC, un condensateur de blocage est connecté entre la douille d'entrée et l'amplificateur Y. De ce fait, les tensions continues sont bloquées, mais les fréquences inférieures sont également supprimées ou atténuées. Lorsque des signaux sinusoïdaux à basse fréquence sont représentés, ce qui donne une certaine pente de toit.

En choisissant le bouton-poussoir 0, il est possible de déterminer le niveau continu zéro volt. La connexion entre l'entrée amplificateur et la douille d'entrée est interrompue, l'entrée amplificateur étant mise à la terre.

## 2.2.5. Déclenchement

### *Généralités*

Pour obtenir une trace stationnaire, la déviation horizontale doit toujours être démarrée à point fixe du signal. A cet effet, le générateur de déverrouillage est démarré par d'étroites impulsions formées dans l'unité commandées par un signal; ce dernier peut provenir d'un signal d'entrée vertical, d'une source externe ou d'impulsions secteur internes (en mode LINE).

### *Niveau de déclenchement*

En cas de signal compliqué présentant périodiquement des formes de tension différentes, l'axe de temps doit toujours être démarré par la même forme de tension afin d'obtenir une trace stationnaire. Ceci est possible lorsqu'un des détails présente une amplitude différente. La commande LEVEL permet de régler le niveau de déclenchement de telle sorte que seule cette forte variation de tension dépasse ce niveau. En mode TOP il est possible de représenter une grande variété d'ondes d'amplitude et de forme différentes.

### *Circuit automatique*

Lorsqu'il n'y a pas de signal, l'oscilloscope fonctionne en mode de déclenchement libre. A cet effet, une ligne de base de temps est visible sur l'écran lorsqu'il n'y a pas de signal de déclenchement. On obtient ainsi une indication de référence du zéro utile.

### *Déclenchement externe*

Au cas où des signaux varient fortement en amplitude, le déclenchement externe peut être appliqué à partir d'un signal d'amplitude constante et de fréquence équivalente. Le déclenchement externe est encore plus important là où des signaux et des impulsions complexes peuvent constituer des doubles traces. Dans ce cas, il n'est pas nécessaire de rajuster le niveau à chaque variation du signal d'entrée. Le signal d'entrée externe est appliquée à la douille TRIG ou X EXT (853).

### *Déclenchement avec fréquence secteur (mode LINE)*

Le signal de déclenchement est une sinusoïde de fréquence secteur. Cette source de déclenchement est utile lorsque la fréquence du signal observé est dérivée de l'alimentation secteur. Par exemple, il est possible de déterminer le composant de bruit d'un signal en déclenchant sur ce composant.

La possibilité de déclenchement secteur (LINE) est obtenue en enfonçant les boutons-poussoirs A + B (861/8 + 861/9) simultanément.

### *Déclenchement avec signaux télévision*

Il est possible de déclencher sur les impulsions de synchronisation (ligne ou trame) de signaux télévision. En position .5 ms/div à 200 ms/div du commutateur TIME/DIV (864), le déclenchement se fait sur les impulsions de trame, tandis qu'en positions .2 ms/div à .5  $\mu$ s/div de ce commutateur il se fait sur les impulsions de ligne. La position du commutateur de pente de déclenchement (861/11) doit correspondre à la polarité inverse de l'information vidéo du signal; par ex. position - pour signal positif, position + pour signal vidéo négatif.

## 2.2.6. Agrandisseur de base de temps

L'agrandisseur est actionné en tirant le commutateur incorporé dans la commande de position X.

En position x5 de ce commutateur, la vitesse de balayage de la base de temps est agrandie 5 fois. Le temps de balayage peut alors être déterminé en divisant la valeur TIME/DIV indiquée par 5.

## 2.3. DEMONTAGE DE L'APPAREIL

### 2.3.1. Généralités

La présente section décrit les procédés de démontage requis à la dépose des composants en cours de réparation et de maintenance de routine. Toutes les platines extraites de l'oscilloscope doivent être protégées contre tout dommage. De plus les précautions d'usage doivent être observées quant à l'utilisation des outils. (Voir également chapitre 2.).

Pendant le démontage il faut prendre consciencieusement note des fils déconnectés afin d'éviter toute erreur lors du montage.

Toujours s'assurer que l'appareil est débranché avant de déposer les couvercles et plaques de l'appareil.

L'enclenchement de l'appareil peut causer son endommagement si une platine a été déposée ou encore si une platine a été déposée dans la minute suivant la mise hors service de l'appareil.

### 2.3.2. Dépose des couvercles

L'appareil est protégé par trois couvercles: un couvercle de protection à l'avant, une enveloppe avec poignée et une plaque arrière.

Pour faciliter la dépose de l'enveloppe et la plaque arrière, s'assurer d'abord que le couvercle avant est bien en position.

Procéder comme suit:

- pivoter la poignée du couvercle avant. Pour ce faire, enfoncer les deux boutons A (voir Fig. 2.2.).
- Placer l'appareil avec couvercle frontal sur une surface plane.
- Desserrer la vis au centre de la plaque arrière (voir Fig. 2.1.).
- Enlever la plaque arrière.
- Enlever le presse-étoupe de l'enveloppe afin de libérer le cordon secteur.
- Soulever l'enveloppe.
- Pour accéder au panneau avant, mettre l'appareil en position horizontale et déboîter le couvercle frontal.
- Pour accéder à la partie haute tension, coulisser le couvercle protecteur transparent qui est fixé dans le panneau arrière vers l'avant.

### 2.3.3. Dépose de la visière et du graticule

- Pour déposer la visière, tourner en appliquant une légère pression sur le flanc gauche (voir Fig. 2.5.).  
Le masque et le graticule peuvent tous deux être déboîtés de la visière en exerçant une légère pression de l'avant.

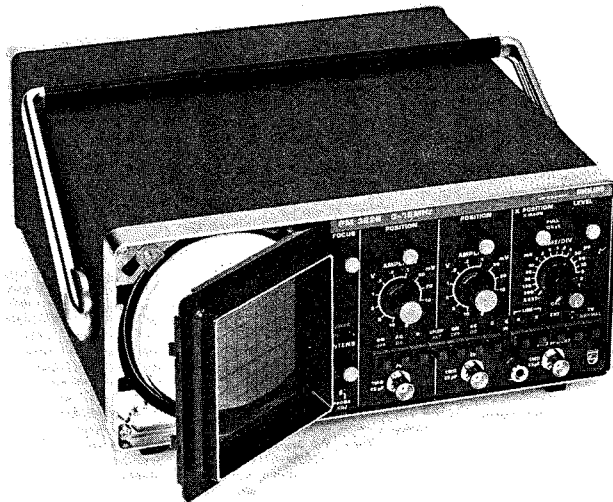


Fig. 2.5. Dépose de la visière et du graticule

### 2.3.4. Dépose de la plaque de texte

- Déposer les capots des commandes AMPL/DIV et X POSITION et enlever le bouton TIME/DIV-CALL de l'axe.
- Dévisser les écrous hexagonaux et l'écrou à encoche; déposer les boutons.
- Déposer les autres boutons par traction.
- Dévisser les autres écrous hexagonaux fixant la plaque de texte.
- Déposer avec soin la plaque de texte.

### 2.3.5. Dépose des commandes FOCUS et INTENS/OFF

- Enlever les couvercles d'appareil comme décrit à la section 2.3.2.
- Déposer le bouton de commande (panneau avant) approprié.
- Fier sauter les étriers plastique B (Fig. 2.6.) par les trous du panneau arrière.
- Tourner et tirer simultanément l'axe C (Fig. 2.6.) jusqu'à ce son extrémité soit aligné avec le trou (comme une clé).
- Déposer l'étrier plastique et l'axe.
- Dévisser l'écrou hexagonal D (Fig. 2.6.) afin de déposer le potentiomètre.

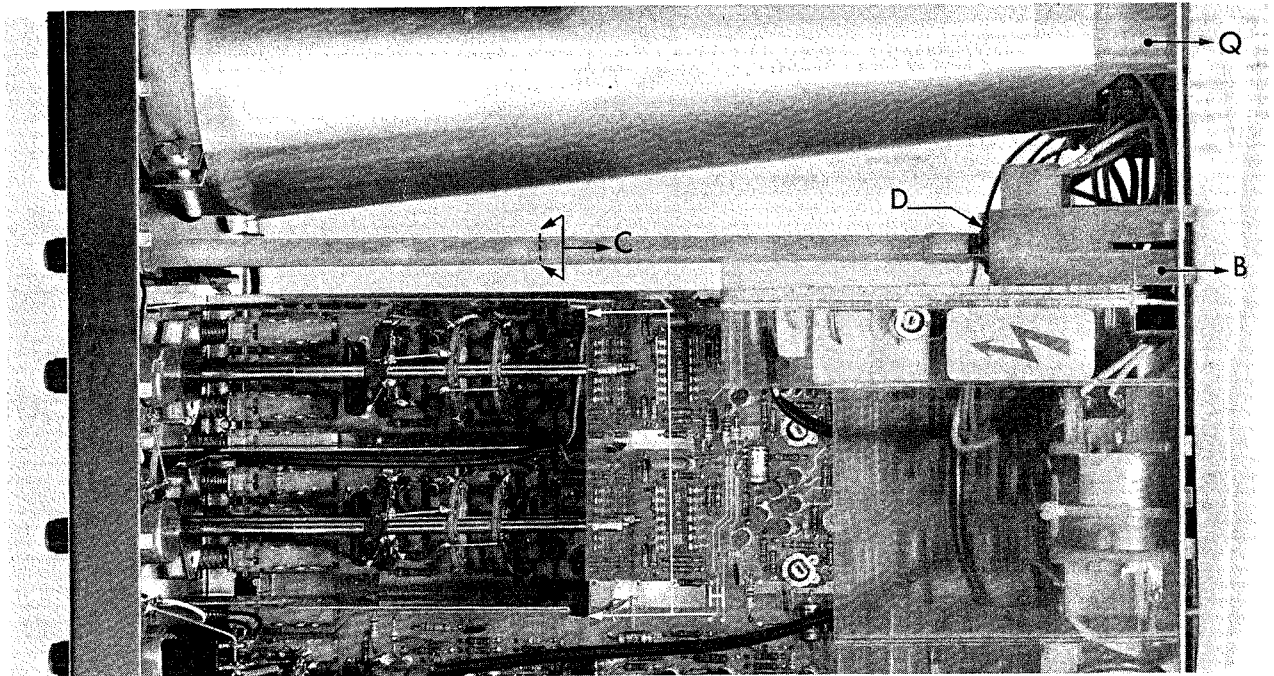


Fig. 2.6. Démontage

### 2.3.6. Dépose de l'ensemble électronique (y compris la platine E.H.T.)

- Déposer les couvercles d'appareil comme décrit à la section 2.3.2.
- Enlever les boutons FOCUS et INTENS/OFF.
- Coulisser le couvercle protecteur transparent qui est fixé dans le panneau arrière vers l'avant.
- Enlever trois connecteurs Stocko et les connexions volantes.
- Dessouder les autres fils de connexion à l'arrière de la platine de fond.  
A noter que le fil de réglage de sonde au panneau avant doit également être déposé.
- Déposer les six vis et un écrou dans l'ordre suivant:
  - 5 vis E (Fig. 2.7.) maintenant les platines sur le panneau arrière.
  - 1 vis F (Fig. 2.7.) derrière le panneau avant (au-dessus).
  - 1 écrou G (Fig. 2.7.) derrière le panneau avant (au-dessous).
- Extraire l'unité électronique entière par l'avant avec plaque de texte et boutons.

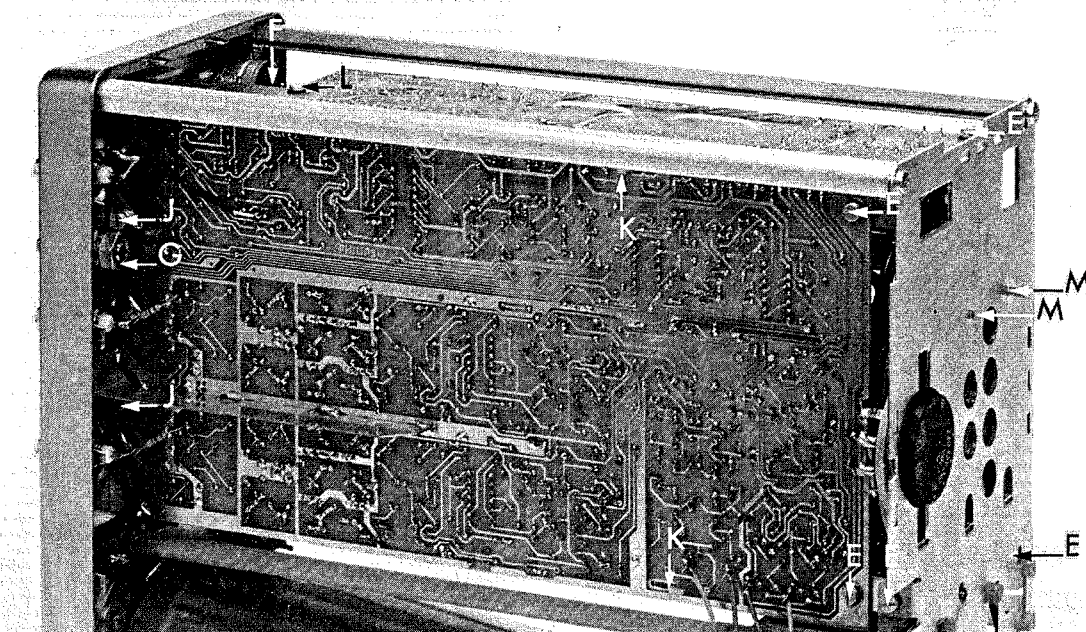


Fig. 2.7. Démontage

### 2.3.7. Accès à l'unité atténuatrice en vue du remplacement

- Déposer l'unité électronique conformément à 2.3.6.
- Déboîter les plaquettes latérales de blindage de l'atténuateur en enfonçant la plaquette arrière (H) sur le flanc supérieur (voir Fig. 2.6.).
- Dessouder les fils vers platine d'atténuateur côté piste à l'aide d'un fer à souder aspirateur.
- Dévisser les deux écrous J (Fig. 2.7.) ainsi que les deux écrous des douilles d'entrée A et B.
- Déposer la plaque de texte et le écrous hexagonaux fixant l'atténuateur (voir Section 2.3.4.).

En cas de remplacement, enlever le commutateur et réaliser des connexions identiques sur le nouveau commutateur.

### 2.3.8. Dépose d'une platine

- Enlever les couvercles d'instrument comme décrit à la section 2.3.2.
- Enlever l'ensemble électronique (voir section 2.3.6.).
- Dessouder les connexions appropriées.
- Déboîtier l'étrier K placé à mi-chemin le long de la platine (Fig. 2.7.).
- Pour déposer une platine verticale enlever une vis L fixant le panneau avant (Fig. 2.7.).
- Pour déposer une platine horizontale enlever les plaquettes de blindage d'atténuateur (section 2.3.7.) et dessouder les connexions d'atténuateur.
- Dévisser les deux écrous des douilles d'entrée A et B et les deux vis J qui fixent la platine au panneau avant (Fig. 2.7.).

### 2.3.9. Dépose du transformateur secteur

- Enlever les couvercles d'appareil comme décrit à la section 2.3.2.
- Dessouder les fils de connexion, noter les positions.
- Enlever deux connecteurs Stocko et les connexions volantes.
- Dévisser les deux écrous de montage M (Fig. 2.7.).
- Soulever le transformateur latéralement.

### 2.3.10. Remplacement des fusibles (voir également Chapitre 2.1.3.)

- Enlever les couvercles d'appareil comme décrit à la section 2.3.2.
- Fusible I (Fig. 2.8.): dessouder les bornes thermiques 1 et 2.
- Fusible II (Fig. 2.8.): enlever le transformateur secteur (voir section 2.3.9.) et dessouder les bornes 1' et 2'.
- Enlever le fusible; à cet effet, recourber légèrement le boîtier vers l'extérieur de sorte que la goupille d'arrêt soit dégagée (Fig. 2.9.).
- Un nouveau fusible est déposé de son boîtier de la même façon que décrit ci-avant. Il est placé dans le même boîtier que l'ancien jusqu'à ce que la goupille d'arrêt s'adapte dans le trou avec un déclic, la cosse pointant vers la borne "1".
- Après soudage des bornes "1" et "2", l'appareil peut être considéré comme prêt à

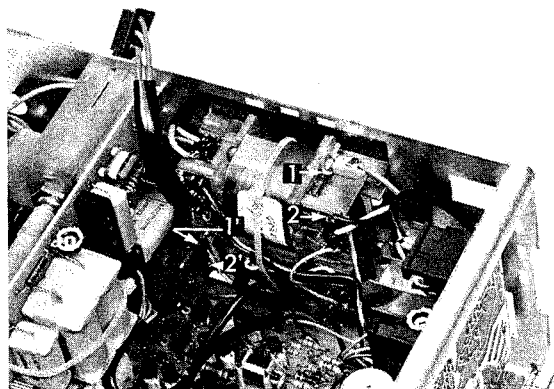


Fig. 2.8. Emplacement des fusibles

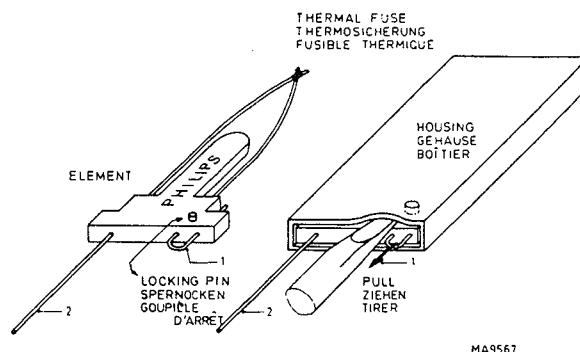


Fig. 2.9. Remplacement du fusible

### 2.3.11. Dépose du t.r.c.

- Enlever les couvercles d'appareil comme décrit à la section 2.3.2.
- Enlever les vis N et P derrière le panneau avant (voir Fig. 2.10).
- Enlever la visière (voir section 2.3.3.).
- Enlever la pièce de blocage plastique.
- Faire sauter les deux cosses nylon Q (voir Fig. 2.6.) arrière du tube, vers l'intérieur et tout en prêtant une attention particulière à l'écran métallique faire passer le t.r.c. par le panneau avant suffisamment que pour permettre la dépose du connecteur de base (pousser sur l'étrier nylon le cas échéant).
- Desserrer la vis de blocage R dans l'étrier autour de la face de tube (Fig. 2.10).

*Remarque: Lors du montage du t.r.c. bien régler la face de tube contre le graticule. De plus, veiller à ne pas serrer trop fort la vis R (pression de vis  $\leq 40$  newton x cm).*

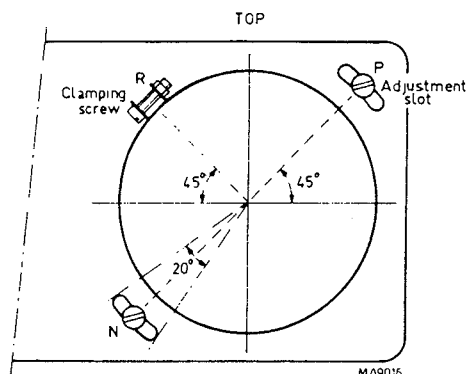


Fig. 2.10. Positionnement du t.r.c.

### 2.3.12. Dépose de la poignée

- Enlever les boutons de plastique de chaque pivot à l'aide d'un tournevis.
- Déposer les vis.

### 2.3.13. Remplacement d'un commutateur bouton-poussoir

- Déposer l'unité en question conformément aux données de la section 2.3.8.
- Redresser les 4 pattes de fixation du commutateur correspondant (voir Fig. 2.11.).
- Casser le corps du commutateur avec une pince et extraire les composants. Les cosses à souder sont alors accessibles.
- Extraire les cosses à souder et nettoyer les trous dans le platine imprimée (par exemple avec un fer à souder à aspiration).
- Souder le nouveau commutateur sur le platine imprimée.
- Courber les quatre boucles de retenue en position originale.

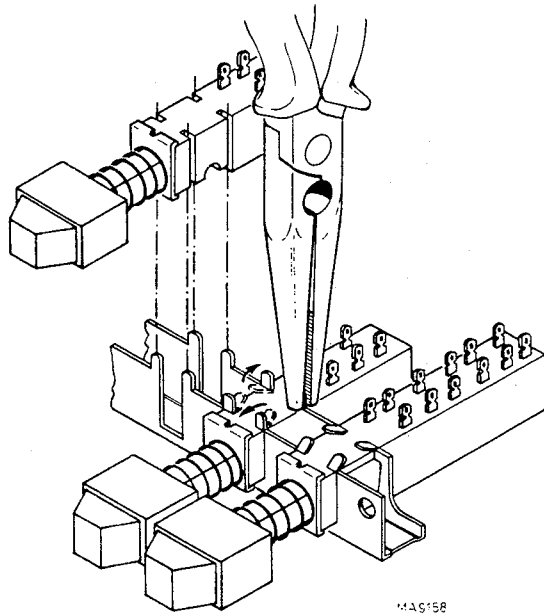


Fig. 2.11. Remplacement d'un commutateur bouton-poussoir.



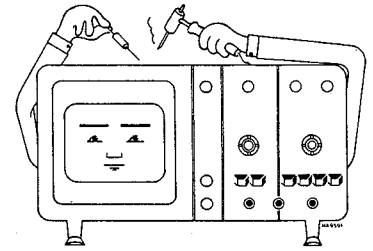
## Service data

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## 3. Service data



### 3.1. CIRCUIT DESCRIPTION

#### 3.1.1. Vertical Deflection System

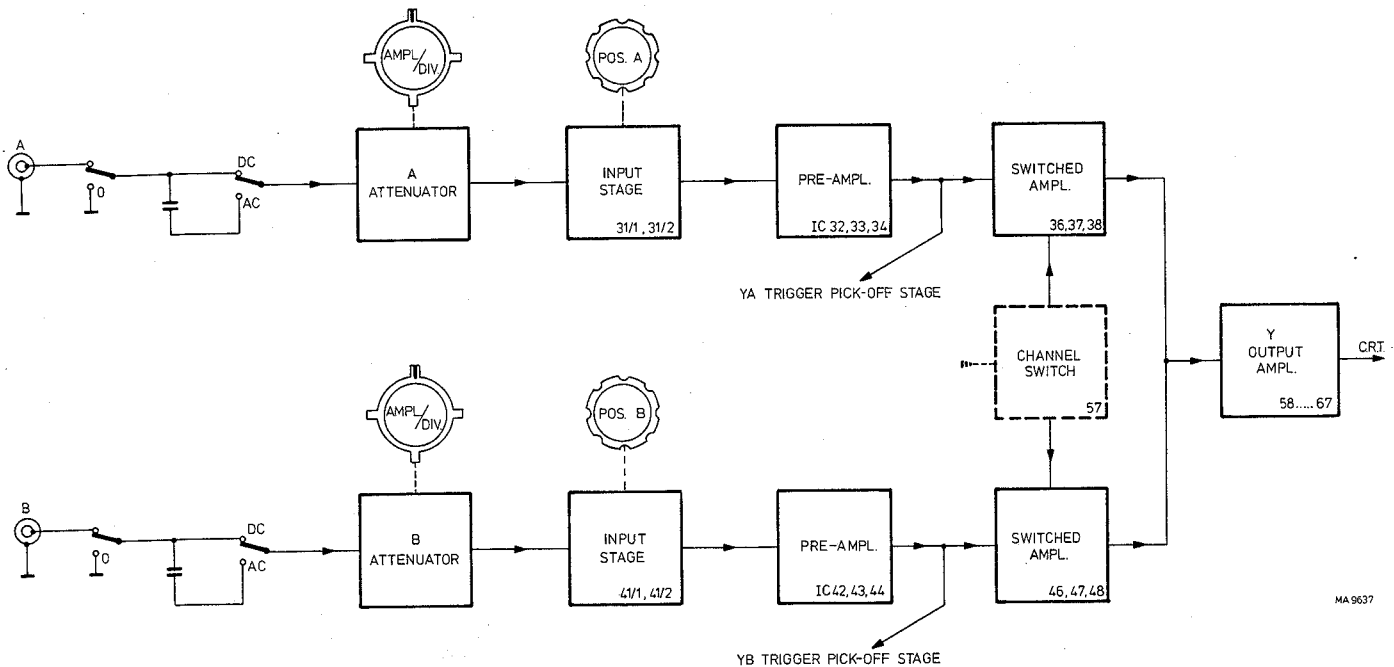


Fig. 3.1. Vertical deflection system

The PM 3226 uses two separate electronically switched vertical deflection channels A and B to provide the dual-trace facility, which combine in the final Y amplifier stage. As these channels are identical, only the A channel is described. Each vertical channel (see Fig. 3.1.) feeds the Y input signal via a coupling mode switch, an attenuator, an input stage, a preamplifier and a switched amplifier to a combined output amplifier that feeds the Y deflection plates of the cathode-ray tube. The individual stages of the vertical deflection system are now described in some detail with reference to the overall circuit diagram (Fig. 3.39).

##### 3.1.1.1. Input attenuator

The A vertical channel input at socket 851 is fed via the coupling mode components to two high-ohmic divider stages in cascade, which can be switched in circuit, if necessary, to provide the required amount of signal attenuation.

By means of the front-panel pushbutton 861/2 (AC/DC) the input signal is applied either via capacitor 241 or direct. Pushbutton 861/3 (0) isolates the Y input signal and earths the channel input for reference purposes; e.g. for calibration or centring the trace.

The overall attenuation of the stage is determined by the combination of the selected sections of both voltage dividers. The various combinations are selected by the 12 positions of the front-panel AMPL/DIV attenuator switch 862.

The first divider stage incorporates a through-switching position, and two resistance-capacity pi-networks that attenuate by factors of x2.5 and x5. The second divider stage also incorporates a through-switching position, and three resistance-capacity pi-networks that attenuate by factors of x10, x100, x1000. In combination, the two step-attenuator stages provide twelve Y deflection coefficients from 2 mV/div to 10 V/div in a 2-5-10 sequence.

Equalisation of the input capacitance for the five attenuator networks is achieved by trimmers 243, 248, 252, 257 and 262.

The voltage divider sections are made independent of the input frequency range of the oscilloscope (15 MHz) by means of trimmers 246, 251, 252, 256 and 261.

### 3.1.1.2. Input stage

The input stage comprises two balanced field-effect transistors 31/1, 31/2 in an impedance converter circuit. Diode 120 protects the input source follower against excessive negative input voltage swings; the input resistive network protects against excessive positive voltages.

Vertical movement of the trace is provided by front-panel Y POSITION potentiometer 436 connected to the gate of field-effect transistor 31/2. Preset potentiometer 446 serves to adjust the range of the POSITION potentiometer 436 to compensate for differences in the field-effect characteristics of 31/1 and 31/2. In addition, these transistors share the same integrated circuit block to aid stabilisation.

### 3.1.1.3. Preamplifier

*Note: Transistors forming part of integrated circuits are referred to by their collector points.*

The balanced preamplifier stage, formed by transistors 32/1, 32/2, 32/3, 32/4, 33 and 34 is of the series-shunt feedback type. Since both halves of the amplifier are contained in the same integrated circuit block, the gain is independent of frequency and drift; i.e. two signals in the same phase cancel out. The Darlington pair input stages are fed from a constant-current source transistor 32/5 and direct coupling is employed throughout.

The voltage gain at the 33, 34 collectors is independent of the active components and is approximately equal to the ratio of the feedback resistance to the emitter resistance;

$$\text{i.e. } \frac{R_f}{R_e} = \frac{455}{456}$$

$$\text{Gain} = \frac{\text{Shunt feedback resistance}}{\text{Series feedback resistance}} = \frac{R_f}{R_e} = \frac{455 + 458}{456 + 457 + \text{mutual conductance}}$$

Most of the amplifier stages used in the PM 3226 are amplifiers with series and shunt feedback (Cherry-Hooper). A typical example of such an amplifier is shown below.

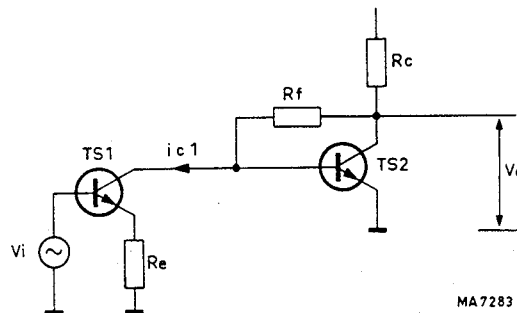


Fig. 3.2. Amplifier with series and shunt feedback

If we neglect the base current of TS2, it will be clear that the current through  $R_e$  also flows through  $R_f$ .

The transfer ratio  $\frac{i_C}{V_i}$  in a series feedback amplifier stage is approximately  $\frac{1}{R_e}$ .

The transfer ratio  $\frac{V_O}{i_C}$  in a shunt feedback amplifier stage is approximately  $R_f$ .

Thus, the voltage gain of the whole amplifier  $A_v = \frac{V_O}{V_i}$  is approximately  $\frac{R_f}{R_e}$  and depends only on the passive elements  $R_f$  and  $R_e$ .

### 3.1.1.4. Switched amplifier

The output signals of the A channel preamplifier are applied to the switched amplifier formed by transistors 36, 37 and 38. The emitter source current of the differential stage 37 and 38, is controlled by switching transistor 36 which, in turn, is controlled by the channel switch (3.1.2.). The switched amplifier and Y output

amplifier together form a shunt-series amplifier as previously described. The differential stage 37, 38 forms the series feedback part of the overall final amplifier. By varying the series feedback of the amplifier with preset 472, the overall gain of the Y amplifier can be set. The RC network 474, 274 gives gain correction at high frequencies.

The output from the switched amplifier is coupled via diodes 122, 123 to the combined Y output amplifier.

### 3.1.1.5. Y output amplifier

The output signals are applied to the combined Y output amplifier formed by transistors 58, 59, 61, 62, balanced by 63, 64, 66, 67. These single-ended push-pull sections form the shunt feedback part of the overall final amplifier.

From the emitters of 59 and 66, the signal is applied via resistors 577 and 581 to the Y deflection plates. Transistors 58, 59 and similarly 66, 67 permit high voltage working and also provide fast switching to compensate for stray capacitance effects, thus improving the response at high frequencies (e.g. improving the rise-time on the leading edges of squarewave signals).

Resistors 577 and 581 in the output feed to the vertical deflection plates of the c.r.t. damp any parasitic oscillations, due to capacitive effects, that may occur at certain frequencies.

Although this has a limiting effect on the bandwidth, the bandwidth of the final Y amplifier is inherently better than required.

The gain of the final Y amplifier, as likewise that of the X final amplifier, is mainly determined by the ratio of the shunt-feedback resistors to the series feedback resistors.

The theoretical value of the gain is found by the following approximations:

$$\text{Gain} = \frac{\text{Shunt feedback resistance}}{\text{Series feedback resistance}} = \frac{R563 + R564 + R567 + R568}{\text{Emitter resistance of 37 and 38}}$$

Capacitors C322 to C326 across the shunt feedback resistors provide high frequency compensation.

### 3.1.1.6. Trigger pick-off

For internal triggering, a signal is taken from one side of the A channel preamplifier stage, collector of transistor 34 (connection P) and applied to the base of transistor 68: likewise, for the B channel, from the collector of transistor 44 (connection Q) to the base of transistor 69. When the internal trigger mode is selected (pushbutton A or B depressed) a 12 V supply is coupled via emitter resistors 603 or 592 of transistors 69 or 68 respectively.

The resulting positive going edge at the collector of 69 (or 68) is coupled via C341 to the trigger amplifier.

## 3.1.2. Channel switching

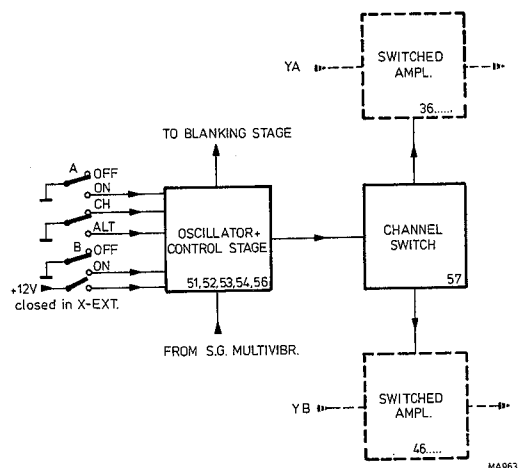


Fig. 3.3. Channel switching

The channel switching comprises:

- a free-running emitter-coupled multivibrator 51, 52 with stable frequency characteristics; for use in the CHOP mode;
- switching control transistors 53, 54, for the CHOP and ALT mode respectively.
- logic gates 56/1, 56/2, 56/3, 56/4, for controlling the flip-flop and providing blanking pulses.
- JK flip-flop 57 for channel switching.

The above functions are controlled by the front-panel mode selection pushbuttons. The simplified functional diagram, Fig. 3.4. indicates the switching principles for each of the modes.

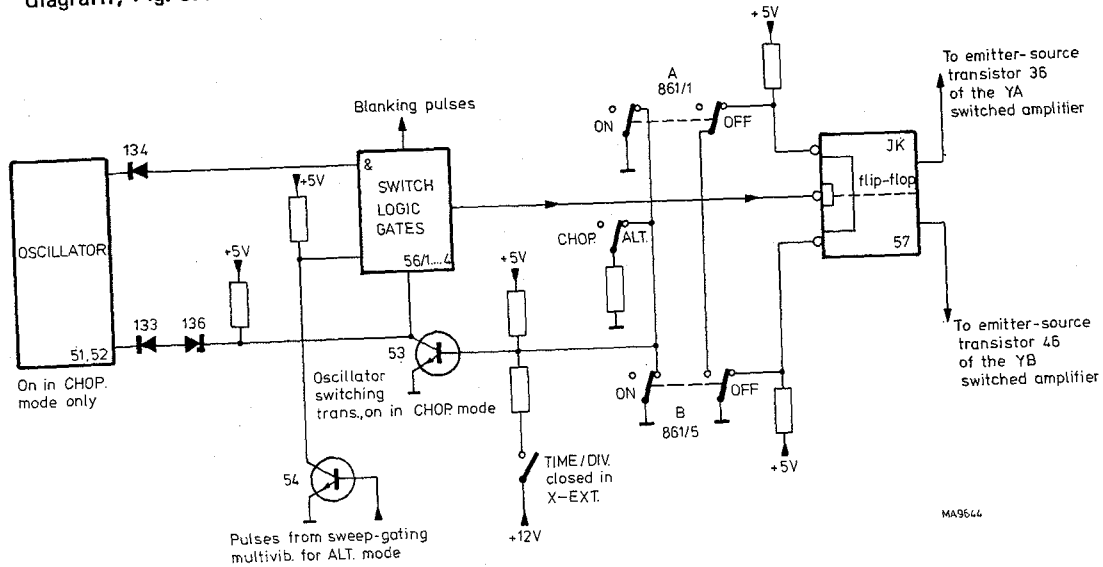


Fig. 3.4. Vertical channel switching principles

- A selected
  - 861/1 contact provides positive switching voltage for flip-flop to allow channel A via emitter source transistor 36.
  - Earth contact is removed to allow oscillation if CHOP mode selected.
- B selected
  - 861/5 contact provides positive switching voltage for flip-flop to allow channel B via emitter source transistor 46.
  - Earth contact is removed to allow oscillator if CHOP mode selected.
- ALT selected (CHOP/ALT pushbutton 861/4 released)
  - A pulse from the sweep-gating multivibrator at the end of each sweep is applied to the base of transistor 54. The output of 54 is applied to input 13 of logic NAND gate 56/4. One output of 56/4 is fed via NAND gates 56/1 and 56/3, and via inverter 56/2 to switch the flip-flop, thus allowing the A and B channels for alternate sweeps. Another output of 56/4 is routed to the blanking stage for blanking.
  - In this mode, switching transistor 53 is not conducting because of the earth potential at its base.
  - During the time that transistor 53 is not conducting the CHOP oscillator is switched off (see Fig. 3.5).

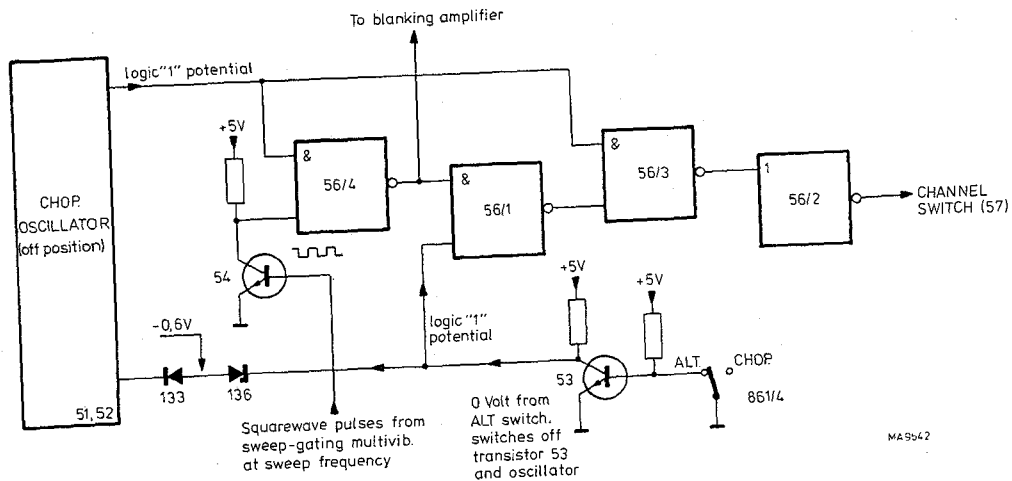


Fig. 3.5. Vertical channel switching - ALT mode

CHOP selected  
(CHOP/ALT  
pushbutton 861/4  
depressed)

- The CHOP pushbutton 861/4 disconnects the earth from the base of switching transistor 53, which then conducts. The collector voltage drops from 5 V to 0 V and, consequently, because of the zener diode voltage, the anode of diode 133 drops from  $-0.6$  V to  $-5.6$  V and switches on the CHOP oscillator 51, 52. The square wave voltage at the output of the CHOP oscillator (collector of transistor 52) operates the NAND gates to produce 400 kHz clock pulses for the channel switching flip-flop 57 (see Fig. 3.6).

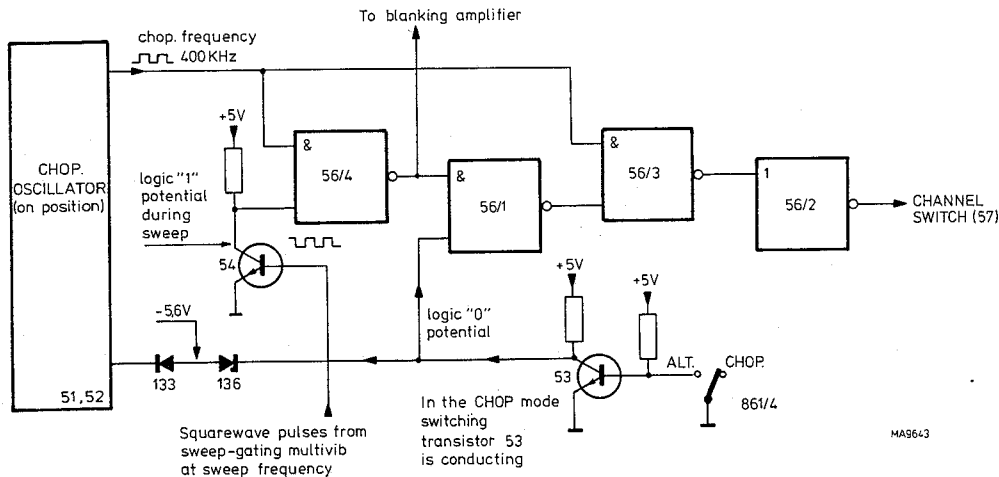


Fig. 3.6. Vertical channel switching – CHOP mode

### 3.1.3. Triggering

The trigger source switches for triggering the time-base generator can select any of the following input sources:

- an internal signal from the vertical A channel
- an internal signal from the vertical B channel
- an external signal from the front-panel socket via the X and trigger preamplifier
- a signal derived from the mains supply.

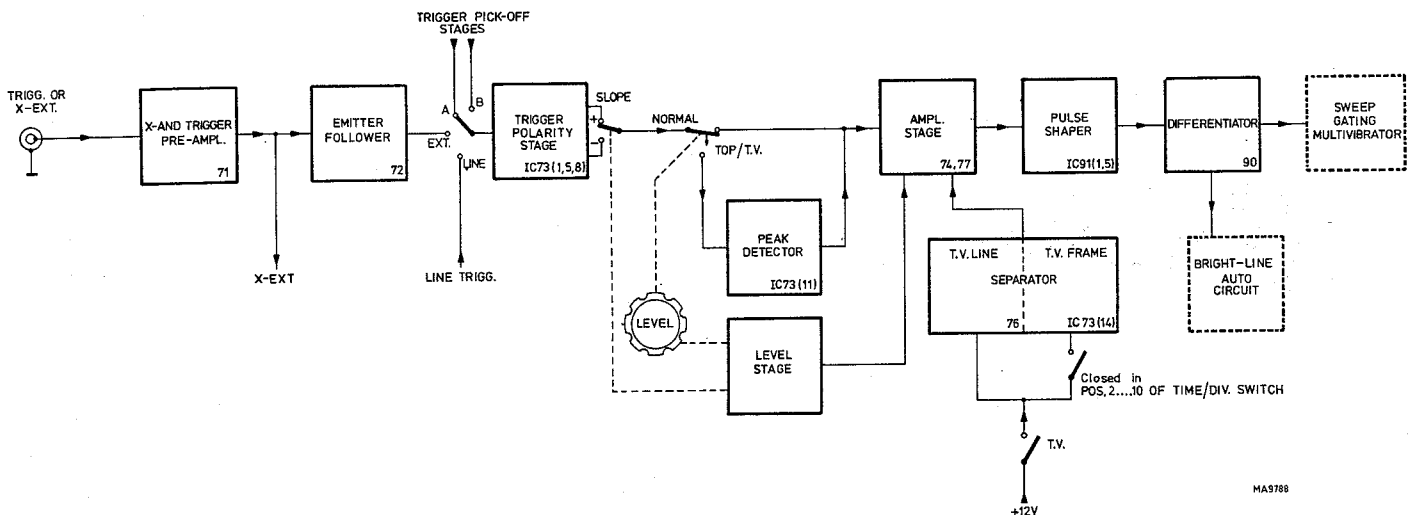


Fig. 3.7. Trigger unit

Source selection is achieved by means of pushbutton switches 861/8 (A), 861/9 (B), and 861/10 (EXT). Simultaneous selection of A and B (LINE) provides triggering from the mains supply utilising an internal source. If TV is selected (861/12 depressed), a peak detector and sync separator stage facilitate triggering from TV line and frame signals. The peak detector is also switched into circuit when the LEVEL control is in the TOP position. Sources applied to the front-panel TRIG or X EXT socket can be used for either triggering or X deflection purposes.



3.1.3.1. *X and trigger preamplifier*

External input sources applied to the TRIG or X-EXT front-panel socket are coupled via a frequency compensated voltage divider (x10) 594, 598 to the base of emitter-follower 71, which is protected against excessive positive signals by diode 142.

In the X-EXT mode (i.e. position 1 of TIME/DIV switch) the output signals of emitter-follower 71 are fed via diode 143 (signal line U) to the X-final amplifier. When external signals are used for triggering purposes, these signals are a.c.-coupled via capacitor 339 to the base of a second emitter-follower 72. The output from the emitter is fed to the EXT trigger source selector switch 861/10.

3.1.3.2. *Trigger polarity stage*

The trigger polarity stage comprises a trigger slope amplifier, transistors 73/2 and 73/1, which feeds an emitter-follower, 73/3.

The trigger slope amplifier consists of two shunt-feedback amplifiers, the gain of which is mainly determined by the values of resistors 616 and 629. The amplifying stage 73/1 is used for phase inversion when the positive slope is selected. The collector voltages of transistors 73/2 and 73/1 are equal in amplitude and opposite in phase. These collector voltages are diode-switched by means of the +12 V supply according to the position of the — selection pushbutton 861/11. This selection switch enables triggering on either the positive-going or the negative-going edge of the triggering signal.

Depending on the position of the ± switch 861/11, diodes 148, 149 or 151, 152 will conduct and the respective collector voltages will be applied to the base of emitter-follower 73/3. Figs. 3.8 and 3.9.

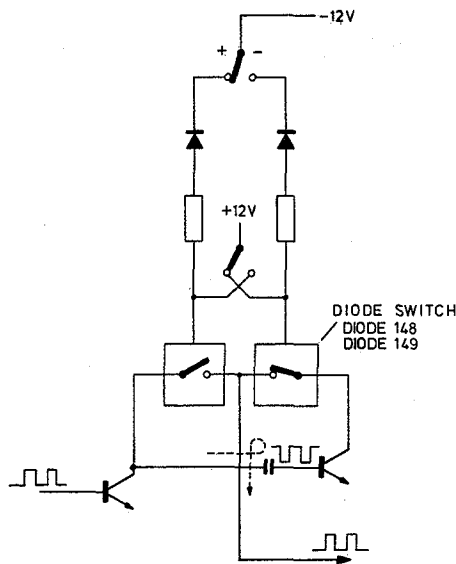


Fig. 3.8. Triggering on +ve going edge

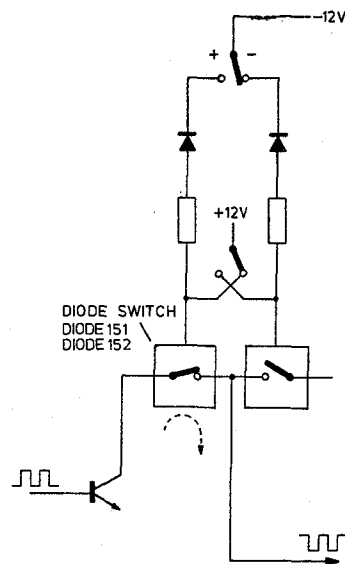


Fig. 3.9. Triggering on -ve going edge

MA9789

### 3.1.3.3. Peak detector and amplifier stage

The NORMAL mode permits two kinds of triggering:

- NORMAL/LEVEL mode, which permits triggering at any point (level) on the chosen trigger input signal;
- NORMAL/TOP mode, in which triggering occurs at approximately the top of the chosen trigger input signal.

In the NORMAL/LEVEL mode, the trigger signal output from emitter-follower 73/3 is a.c.-coupled via capacitor 353 to the junction of resistors 638, 636, where it is summed with the d.c. level from the wiper of potentiometer 623 (LEVEL) via resistor 634. Thus, for each setting of the LEVEL potentiometer a different part of the trigger signal can be amplified by transistor 74.

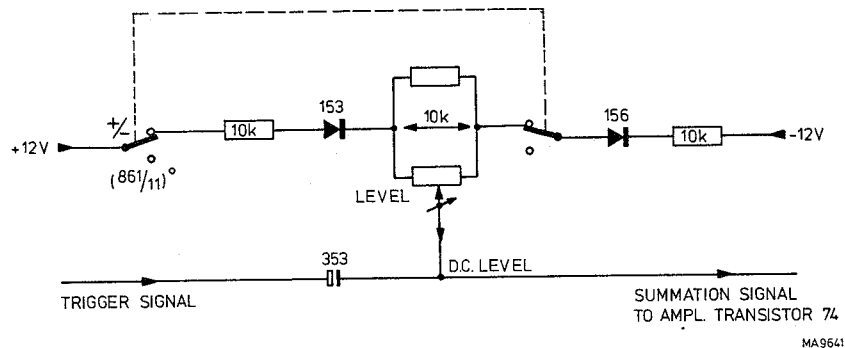


Fig. 3.10. Simplified diagram of the level circuit

As can be seen from the simplified diagram, Fig. 3.10. the LEVEL control lies at the midpoint of a balanced potential divider network between +12 V and -12 V. The wiper can swing nominally between +4 V and -4 V.

In the NORMAL/TOP mode, a +12 V supply via the TOP switch is fed to the base of the switching transistor 73/4, thus causing it to conduct. As a result, the peak detector diode 157, diode 158, cap. 353, cap. 354 and resistor 633 is activated, which clamps the base of transistor 74 to conduct on signal peaks. In this mode, the emitter of 74 is biased by voltage divider resistor 642 and resistor 643 between the -12 V supply and the 0 V rail via the switching diodes 163 and 164.

In the TV mode, the switching transistor 73/4 conducts to provide peak-detection of the synchronising pulses of a video signal. To achieve this, a +12 V supply is fed via the TV/NORMAL switch 861/12 and diode 156 to the base of switching transistor 73/4. In this mode, the emitter of transistor 74 is biased via the switching diodes 161 and 162 from a preset potentiometer 651 which provides the appropriate TV trigger adjustment.

The amplified signal at the collector of 74 is matched to the pulse shaper circuit by means of emitter-follower 77. The amplified level of the signal is such that it exceeds the hysteresis gap of the Schmitt trigger pulse shaper formed by 91/1 and 91/2 (see Fig. 3.11). In this way, switchover of the Schmitt trigger occurs on both positive and negative-going excursions of the input trigger signal and the fast switching action results in square wave outputs.

### 3.1.3.4. Sync separator

When the TV mode is selected, triggering occurs on the line or frame sync pulses of a video signal, the appropriate trigger signals being coupled by means of the TIME/DIV switch. In the switch positions 200 ms to 0.5 ms, frame triggering takes place, a +12 V supply being switched via 861/12 to the bases of both 76 and 73/5. Sync separation occurs via the low-pass filter formed by 644//645 and 356//357//358.

In the positions 0.2 ms to 0.5  $\mu$ s of the TIME/DIV switch, only 76 conducts and brings the low-pass filter 644//645 and 356 into circuit.

The reduced capacitance enables line triggering to take place.

The switching transistor 76 is controlled via 861/12 from the +12 V rail.

### 3.1.3.5. Trigger pulse shaper and differentiator

The trigger pulse shaper consists of transistors 91/1 and 91/2 in Schmitt trigger configuration. This pulse shaper circuit transforms the emitter output voltage of emitter-follower 77 into a square-wave voltage of constant amplitude and width, having the same frequency as its input signal. Inset Fig.3.11 shows how the output signal is applied.

From this figure it is evident that the input signal should be of sufficient magnitude to exceed both limits of the hysteresis gap (switchover points) in order to obtain a square-wave output voltage.

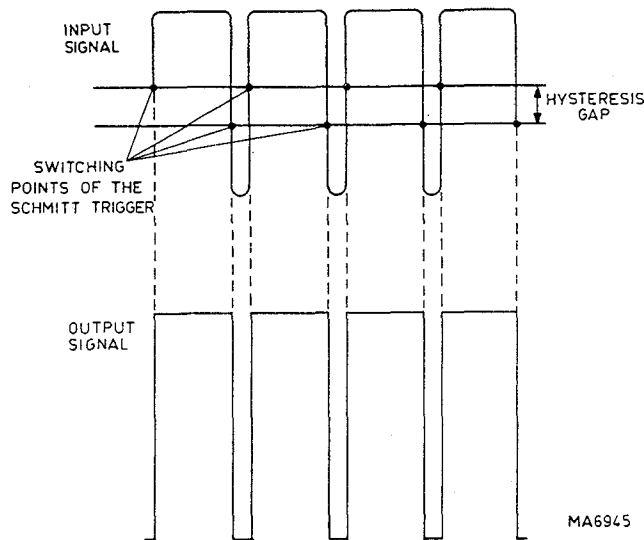


Fig. 3.11. Pulse shaper operation on receipt of trigger input signal

This square-wave is differentiated by capacitor 368 and the resistance of  $\frac{714//715}{HFE(91/5)}$  (i.e. the transform of base resistance to emitter resistance of 91/5) into narrow positive and negative pulses. The negative-going spikes cause 91/5 to conduct and initiate the sweep of the sawtooth generator. The positive-going spikes serve as control pulses for the BRIGHT-LINE AUTO circuit.

#### 3.1.4. Time-base generator

The time-base generator comprises a sweep-gating multivibrator, a sawtooth generator, a hold-off circuit, a bright-line auto circuit and an X-final amplifier.

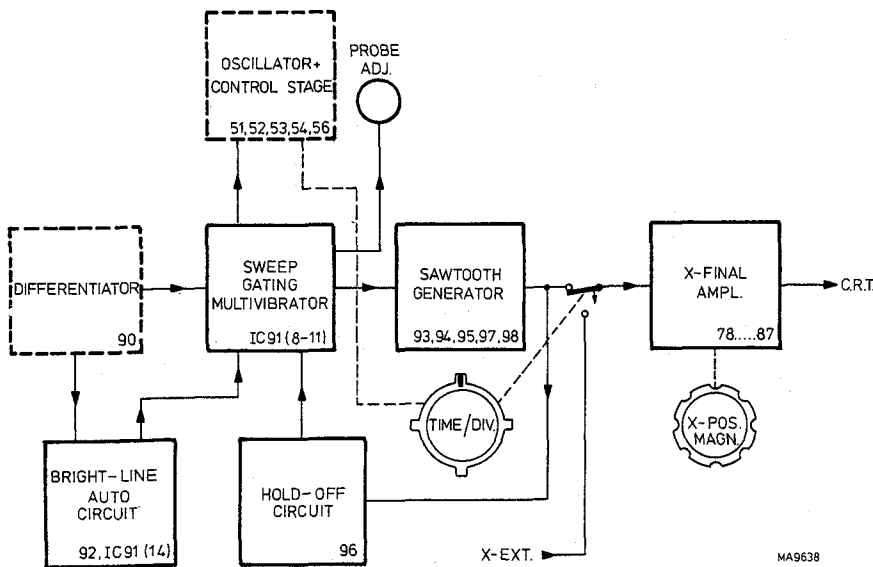


Fig. 3.12. Time-base generator



Before considering these stages in detail, the general principle is briefly described. Basically, the sweep-gating multivibrator, under the control of trigger pulses from the differentiator and also feedback pulses from the hold-off circuit, supplies square-wave pulses to the switching transistor 94 of the sawtooth generator.

The time-base capacitors (effectively in parallel with the switching transistor) are charged linearly through a constant-current source to provide the forward sweep, and are discharged rapidly by the switching transistor to provide the flyback period. The resulting sawtooth output is taken from two transistors in Darlington pair configuration and fed to the X-final amplifier.

### 3.1.4.1. Sweep-gating multivibrator and sawtooth generator

The sweep-gating multivibrator comprises transistors 91/3 and 91/4 connected in Schmitt trigger configuration. In the state when transistor 91/3 is cut off and transistor 91/4 is conducting, switching transistor 94 is cut off. While 94 remains cut off, current source transistor 93 charges capacitors 376 or, depending on the position of the TIME/DIV switch, capacitors 376 and 377 with a constant current. This results in a linearly increasing voltage across these capacitors, which constitutes the forward sweep.

When switching transistor 94 conducts, the time-base capacitors discharge rapidly (i.e. the flyback period). The sawtooth voltage thus produced is taken off by a cascade Darlington pair circuit consisting of emitter-followers 97, 98 and applied to both the horizontal final amplifier, and via feedback components 189, 186, 721 and hold-off circuit 96 to the sweep-gating multivibrator.

The time-base output sawtooth and the feedback sawtooth waveforms are shown in graphs  and  respectively on the overall circuit diagram, Fig. 3.39.

The input voltage of the sweep-gating multivibrator is controlled by:

- a d.c. voltage derived from the stability potentiometer 734
- trigger pulses derived from the pulse shaper
- a bias voltage supplied by the auto circuit
- the sweep feedback voltage via the hold-off circuit.

When this input voltage reaches a pre-determined level, the sweep-gating multivibrator switches over. In this condition, transistor 91/4 is cut off. Switching transistor 94 then starts to conduct and the time-base capacitance is discharged via this transistor.

On arrival of the next trigger pulse this cycle is repeated.

The magnitude of the charging current of the time base capacitors, and thus the time coefficient, is determined by resistors 831 to 841. Preset potentiometers 746 and 748 permit adjustment of the time coefficients in the ranges 200 ms/div to 0.5 ms/div, and the range 0.2 ms/div to 0.5  $\mu$ s/div respectively, by controlling the base current of transistor 92.

Timebase capacitor 377 is switched into the circuit by means of transistor 95 which is switched by a positive voltage applied to its base in certain positions of the TIME/DIV switch.

Blanking pulses are provided by the collector circuit of 91/4 via 716 and capacitor 321 for the beam blanking stage. In addition, a rectified output is provided via 176 for the front-panel PROBE ADJUST socket.

### 3.1.4.2. Hold-off circuit

The hold-off circuit consists of transistor 96, capacitors 376, 378 and diode 186; the circuit establishes a time interval at the end of the sweep to inhibit the sweep-gating multivibrator for a period. Due to the blocking effect of diode 186, the charged hold-off capacitance 376 (and 378 if switched) is unable to follow the decay of the sawtooth voltage. The capacitor voltage therefore decays at an RC time that is sufficiently large to permit total discharge of the time base capacitors and to enable all circuits to return to their quiescent states before the next sweep is produced. During this RC time, the input level of the sweep-gating multivibrator is so high that incoming trigger pulses are ineffective.

The hold-off capacitance is charged by the TIME/DIV switch for the various sweep rates to allow the correct hold-off time.

Capacitor 376 is permanently in circuit, while 378 is switched in circuit by means of transistor 96 in the 20 ms/div to 0.5 ms/div positions of the TIME/DIV switch.

### 3.1.4.3. Bright-line auto circuit

Basically, the bright-line auto circuit comprises electrolytic capacitor 371 effectively in parallel with the complementary transistors 92 and 91/5. The complementary pair can be considered as a thyristor. Positive-going trigger pulses at the base of 91/5, cause it to start conducting. In turn, 92 starts to conduct and capacitor 371 discharges via resistor 722. Diode 178 is therefore blocked as its anode goes negative and the hysteresis levels of the sweep-gating multivibrator are such that it is driven by the negative-going trigger pulses received via 90.

However, when no trigger pulses are available, the complementary transistors are non-conducting and capacitor 371 charges towards the +12 V rail via 724, 722.

Hence, diode 178 conducts and the sweep-gating multivibrator hysteresis levels are set to that the initiation of the sweep is dependent only on the sweep feedback voltage. The time base generator is therefore free-running and a bright horizontal line will be displayed.

When triggered at frequencies above about 10 Hz, the average output voltage of the auto circuit is low, therefore diode 178 is cut off. Consequently, the sweep-gating multivibrator hysteresis levels are returned to the normal triggered condition.

### 3.1.4.4. X-Final amplifier

The output of the timebase sawtooth generator, or the output of the TRIG or X-EXT preamplifier are selected by a diode-switching network to provide an input for the X-final amplifier.

The diode-switching network is controlled by the position of the TIME/DIV switch and comprises the diodes 167, 168, 169, 171.

In the X-EXT position of the TIME/DIV switch, the +12 V supply permits diodes 169 and 171 to conduct, thus passing the signal employed for external X deflection to the base of transistor 78.

In the other positions of the TIME/DIV switch, the +12 V supply via diodes 187 or 188 permits diodes 167 and 168 to conduct, thus passing the timebase sawtooth signal to the base of transistor 78.

The X-final amplifier consists of two differential amplifier stages. The first stage, transistors 78 and 79, is stabilised by series-feedback. One input of this amplifier is driven by the signal passed by the diode-switching network; the other input is driven by a d.c. voltage derived from the X-POSITION potentiometer, which allows horizontal shift of the trace. Transistor 80 in the emitter circuit of transistors 78 and 79 provides a constant-current source.

The second differential amplifier consists of two single-ended push-pull sections 82, 83 and 84, 86, with shunt feedback, and is supplied with constant current from current source 81, 87. This final stage is supplied from the +200 V rail because the X plates of the c.r.t. are mechanically displaced such that they are less sensitive than the Y plates. The fast switching currents of this output circuit allow faster charge and discharge of stray capacitances, thus enlarging the bandwidth of the X-amplifier. The deflection signal is fed to the X plates of the c.r.t. via resistors 693 and 698.

The gain of the X-final amplifier is mainly determined by the ratio of the shunt-feedback resistors 683 and 687 and the common emitter resistor (i.e. the series feedback) of transistors 78 and 79.

The theoretical value of the gain can be found by the following approximation formula:

$$\text{Gain} = \frac{\text{Shunt feedback resistance}}{\text{Series feedback resistance}} = \frac{683 + 687}{673 + 674 \text{ mutual conductance}}$$

The practical gain value obtained is slightly lower than the theoretical gain.

When the front-panel X-MAGN switch is operative for 5 times magnification, the series-feedback resistance is shunted by resistor 669 thus reducing its value by a factor of five.

Consequently, the gain of the stage is correspondingly increased by the same factor. Capacitors 360 and 361 across the feedback resistors 683 and 687 respectively provide high frequency compensation.

### 3.1.5. Cathode-ray tube circuit

The cathode-ray tube circuit comprises the high-voltage and low-voltage power supply, the c.r.t. itself and the brightness, focus and astigmatism controls, and the beam-blanking amplifier.

A block diagram of the c.r.t. circuit is given in Fig. 3.13.

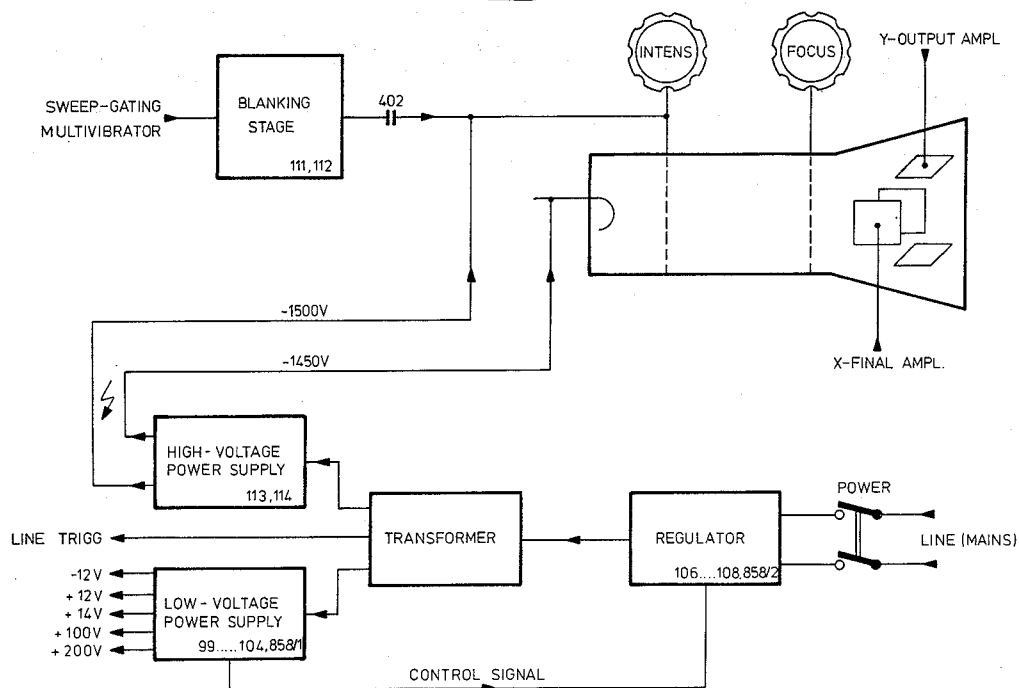


Fig. 3.13. Cathode-ray tube circuit

### 3.1.5.1. C.R.T. Controls

By means of the INTENS potentiometer 823, the brightness of the display can be continuously controlled. The display can be focused by means of the FOCUS potentiometer 824. Both of these front panel controls are shown in the c.r.t. circuit, Fig. 3.13.

The average output voltage of the Y-final amplifier is applied to the 'astigmatism' control grid (pin 9) via resistors 821 and 822. This obviates the necessity for astigmatism correction or adjustment by a manual control.

Both the FOCUS and INTENS controls form part of a potential divider network across the 1.5 kV output that is derived from a voltage multiplier in the high-voltage power supply. The slider of the INTENS control provides the cathode potential for the c.r.t. that regulates the beam current. The slider of 824, the FOCUS control, is connected direct to the focus grid (pin 8).

### 3.1.5.2. Blanking amplifier

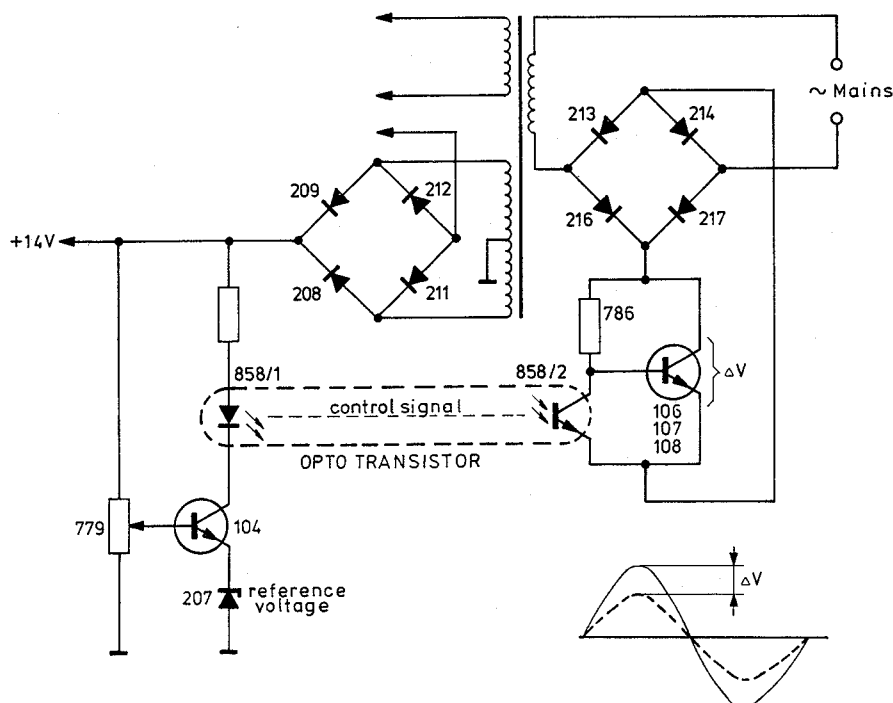
The blanking amplifier blanks the c.r.t. during the fly-back period of the time base and unblanks the c.r.t. during the sweep period; if the TIME/DIV switch occupies the X-EXT position the c.r.t. is continuously unblanked. During the time base flyback period, the Wehnelt cylinder (pin 3) must receive a negative-going pulse for blanking. This pulse is derived from the sweep-gating multivibrator and is amplified by a single-ended push-pull amplifier consisting of transistors 111 and 112. The blanking signal is fed to the Wehnelt cylinder via resistor 802 and capacitor 402, after which d.c. restoration takes place in conjunction with diode 223. Diode 222 clips the output signal during the unblanking period.

If the top of the unblanking pulse is not flat, uneven illumination of the trace will result.

### 3.1.5.3. Input regulator and low-voltage power supplies

The low-voltage power supply circuit basically consists of a voltage-regulated input circuit under the control of a light-emitting diode in the rectified +14 V circuit, a mains transformer and the low-voltage rectified supplies for the oscilloscope circuits (see Fig. 3.14). The incoming mains voltage is fed via the power ON/OFF switch, the thermal fuse, the voltage selector 866 and the regulating network to the appropriate primary windings on the mains transformer 868.

The input regulator network comprises bridge rectifier 213 ... 217, series regulator transistors 106, 107 and an opto-transistor 858/2.



MA9694

Fig. 3.14. Low-voltage power supply with regulator

In principle, the power supply regulator operates as follows.

As shown in the functional block diagram, Fig. 3.14, after transforming and rectifying, the +14 V supply is applied to the preset potentiometer 779, the slider voltage of which is compared with the reference voltage of zener diode 206 by transistor 104. Assuming that the slider voltage, and thus the base voltage of 104 tends to rise, this results in a collector current increase of this transistor with a corresponding increase in the light emission in the l.e.d. (858/1) part of the opto-transistor. Since the output signal of an opto-transistor is proportional to its input signal, its collector current is also increased. As a result, less base current is applied to transistor 107; consequently its collector-emitter voltage rises (i.e.  $\Delta V$  in Fig. 3.14). As the mains transformer primary voltage is in series with the collector-emitter voltages of transistors 106 and 107, the voltage across the mains transformer primary drops.

This voltage drop counteracts any tendency for the secondary voltage to rise, and maintains a state of equilibrium.

Zener diodes 219 and 220 provide a measure of protection for the regulating network against excessive input voltages.

The mains transformer has four secondary windings:

- a heater winding for the c.r.t.
- a winding for the high-voltage power supply
- a winding for the +200 V/+100 V supply
- a winding for the  $\pm 12$  V/ $\pm 14$  V supply

The  $\pm 12$  V/ $\pm 14$  V d.c. supply is derived from a full-wave bridge rectifier 208, 209, 211, 212 and smoothed by electrolytics 396 and 398. The +12 V stabilised supply is derived from the +14 V supply via the series transistor 99. The base of 101 is controlled by a potential divider 771, 772 across the +14 V supply. Any tendency for the potential to change is amplified by 101 and the resulting collector current controls the base of the series transistor 99 accordingly. The series transistor can be compared to a variable resistor that can be changed to control the output current.

Similarly, the stabilised -12 V supply is derived from the -14 V supply via series stabilising transistor 103.

If the supply current of any of the power supplies becomes excessive, for example, due to a short-circuit, the reference voltage of zener diode 206 will drop, resulting in more light emission from the l.e.d. and thus a reduction of the transformer primary voltage.

The type and properties of the X and Y final amplifiers obviate the need for stabilised supplies for the +100 V and +200 V rails.

For these voltages the primary-regulation is sufficient.

#### 3.1.5.4. High-voltage power supply

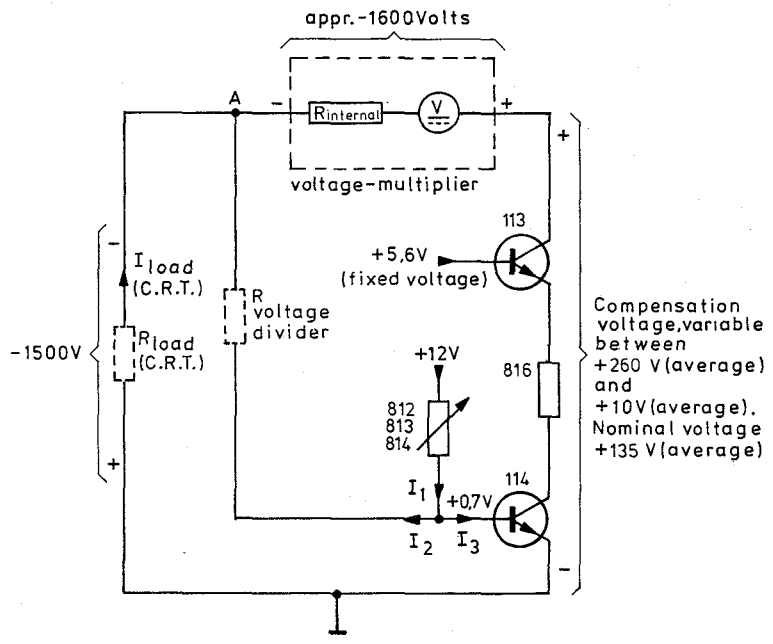
The high-voltage power supply consists of a quadruple voltage divider that produces cathode, control grid and focus potentials for the c.r.t., and a compensation circuit (113, 114) to compensate h.t. voltage ripple and variations (see Fig. 3.15.). The -1500 V is derived by applying the secondary mains transformer voltage to a diode voltage-quadrupler network where it is multiplied by four.

The compensation circuit operates as follows:

Assume that the -1500 V output of the voltage multiplier network (point A in Fig. 3.15.) tends to rise (i.e. go more negative) with a decrease in ripple or load through the c.r.t.

Since  $I_1$  is constant because of the stabilised +12 V and the fixed base-emitter voltage of +0.7 V, and  $I_2$  will increase (because of the voltage increase across the voltage divider), then  $I_3$  will drop. This means that less base current is applied to transistor 114 causing a decrease in current through transistors 113 and 124. Their collector-emitter voltages will therefore rise, this rise thus compensating for the negative-going rise of the -1500 V supply. In other words, the algebraic sum of the potential across the voltage multiplier and the potential across the compensation network is equal to -1500 V.

Preset potentiometer 794 (part of voltage divider R) controls the c.r.t. current. Adjustment of the -1500 V is obtained by controlling the base current of 114 by preset potentiometer 812.



MA9595

Fig. 3.15. High-voltage power supply



## 3.2 CHECKING AND ADJUSTING

### 3.2.1 General information

The following information provides the complete checking and adjusting procedure for the PM 3226 oscilloscope. As some of the circuits are interdependent, the given order of checking is advised. The procedures are, therefore, presented in a sequence that is best suited to this order and, for convenience, the adjusting elements and their functions are tabulated in the Condensed Adjusting Procedure (page 85). Prior to checking and adjusting a particular circuit, care must be taken to ensure the accuracy of all associated circuits.

Only skilled personnel aware of the hazards involved should perform those adjustments which necessitate the removal of covers from an oscilloscope that is connected to the mains supply. In all other circumstances, covers should remain fitted as long as the instrument is live (see also chapter 2, "DIRECTIONS FOR USE").

The tolerances stated in the checking and adjusting procedures apply only to instruments which are completely set up, and may differ from the data given in the specification chapter i.e. 1.2 TECHNICAL DATA.

### 3.2.2 Test equipment and tools required

For a complete checking and adjusting procedure, you will need the tools and test equipment listed in the following table.

TEST EQUIPMENT

<i>Description of the test instrument</i>	<i>Specification of the test instrument</i>	<i>Suitable test instrument</i>	<i>Usage</i>
Digital multimeter.	AC/DC instrument, accuracy within 0.1%.	Philips PM2421 or equivalent.	C.R.T. circuit. Trouble shooting.
Time-mark generator.	Providing markers of 1 ms to 0.5 $\mu$ s, accuracy within 0.5%.	—	Time-base timing checks.
T.V. pattern generator or T.V. source.	Providing frame and line sync pulse output. Ampl. at least 100 mV.	Philips PM5504 or equivalent.	Time-base, T.V. triggering.
Squarewave generator or amplitude calibrator.	Providing output voltages variable from 10 mV to 30 V (accuracy within 0.5 %), frequency range 1 KHz ... 100 kHz, rise time <5ns.	—	Attenuator response, vertical gain and response checks.
Sinewave generator.	Providing output voltages variable from 10 mV to 10 V frequency range 1 kHz ... 15 MHz.	Philips PM5145 suitable for most purposes.	Vertical amplifier bandwidth and triggering checks. Trouble shooting.
Monitor oscilloscope.	0 ... 15 MHz bandwidth	Philips PM3225 or equivalent.	Trouble shooting. Adjusting.
Amp.-meter.	Moving-iron meter.	—	Mains current consumption.
Variable mains transformer.	Well insulated for safe checking.	Philips 2422 529 00005.	Trouble shooting.
Probe 10x attenuat.	Suitable for input capacities of 20 to 30 pF.	Philips PM9336 or equivalent.	Trouble shooting.
2:1 Dummy probe.	1 M $\Omega$ // trimmer 3-60 pF.	See Fig. 3.16	Attenuator reponse.
Trimming tool kit.	Low capacitance trimming tool.	Philips. See Fig. 3.30.	Adjusting and maintenance.

### 3.2.3. Starting positions of the controls

All preset potentiometers and trimming capacitors are indicated on the drawings of the printed-wiring boards (see Figs. 3.36, 3.37, 3.38), in addition they have been listed in the heading of the various sections.

All controls mentioned without item numbers in the 'checking and adjusting' procedure are located on the front panel. Unless otherwise stated, the front-panel controls must be set to the following positions:

- Trigger switches of the time-base to positions: A, +, and NORMAL
- AMPL/DIV switches to 50 mV
- TIME/DIV switch to .5 ms and CAL position
- AC/DC switches to AC
- ON/OFF switches to ON
- 0 switches to 0
- CHOP/ALT switch to ALT
- FOCUS control to mid-position
- Y POSITION controls to mid-position
- X POSITION control to mid-position
- X MAGN switch depressed (x1)
- LEVEL switch fully clockwise (TOP)
- INTENS control to normal intensity
- POWER switch to ON

*Note: In general, a warm-up period of at least 30 minutes is recommended.*

### 3.2.4. Mains current

- Check that the mains voltage adapter (866) has been set to 220 V and connect the instrument to such a voltage, frequency 46 to 400 Hz.
- Switch the oscilloscope on and check that the pilot lamp lights up.
- Check that the current consumption does not exceed 75 mA (measured with a moving-iron meter).

### 3.2.5. Cathode-ray tube circuit


The trimming potentiometers for adjusting the +12 V (–12 V) and the intensity are located on the printed-wiring boards unit 2 (+12 V) and Unit 3 (intensity).

With the front-panel controls set as stated under section 3.2.3., make the following adjustments.

#### 3.2.5.1. +12 V supply (779/U2)


- Set switch NORMAL/TV to TV.
- Check that the voltage between the collector of TS99/U2 (i.e. point K/U1 Fig. 3.17.) and the 0 V rail is +12 V, + or – 30 mV; if necessary, readjust potentiometer 779/U2.
- Vary the a.c. voltage to which the instrument is connected between 190 V and 242 V.
- Check that the +12 V do not vary more than 40 mV.

#### 3.2.5.2. INTENS or –1500 V (812/U3)

- Set switch NORMAL/TV to TV.
- Turn potentiometer INTENS to its anti-clockwise stop.
- Set preset potentiometer 794/U3 to mid-range.
- Connect a measuring oscilloscope between the collector of TS113/U3 (i.e. point 3/U3, Fig. 3.17.) and the 0 V rail.
- Check that the top level of the displayed wave-form is  $+190\text{ V} \pm 10\text{ V}$  (see diagram  in Fig. 3.39.); if necessary, adjust preset potentiometer 812/U3.
- If this adjustment was necessary, also carry out the next one (3.2.5.3.).

#### 3.2.5.3. INTENS minimum (794/U3)

- Set switch NORMAL/TV to NORMAL.
- Turn potentiometer INTENS entirely clockwise.
- Turn potentiometer LEVEL entirely anti-clockwise.
- Select LINE mode.
- Set TIME/DIV switch to .2 ms.
- Connect a measuring oscilloscope between the collector of TS113/U3 (i.e. point 3/U3, Fig. 3.17.) and 0 V rail.

- Check that the bottom level of the displayed wave-form is  $+50\text{ V} \pm 10\text{ V}$  (see diagram  in Fig. 3.39). If necessary, adjust preset potentiometer 794/U3.

### 3.2.6. Time-base generator

The trimming potentiometers for adjusting the stability, time coefficients and the TV trigger of the time-base generator are located on the printed-wiring boards Unit 1 (TV trigger) and Unit 2 (stability, time coefficients). With the front-panel controls set as stated under section 3.2.3., make the following adjustments.

#### 3.2.6.1. Stability (734/U2)

- Adjust FOCUS and INTENS controls for a normal display (i.e. approx. at their mid-stroke position).
- Set CHOP/ALT switch to CHOP.
- Switch the LEVEL control to TOP position.
- Set the wiper of potentiometer R522,  $20^{\circ}$  (+ or  $-5^{\circ}$ ) from the point where triggering commences.

#### 3.2.6.2. Time coefficients 200 ms ... 0.5 ms (746/U2)

- Set TIME/DIV switch to .5 ms
- Release 0 pushbutton (YA).
- Set CHOP/ALT switch to ALT.
- Apply a time marker voltage of 200 mV with a repetition time of .5 ms to  $Y_A$  input socket.
- Check that the 8 centre periods have a total width of  $8\text{ div} \pm 2$  sub-divisions; if necessary, readjust potentiometer 746/U2.
- Set the X POSITION control as necessary.

#### 3.2.6.3. Time coefficients 0.2 ms ... 0.5 $\mu$ s (744/U2)

- Set TIME/DIV switch to .5  $\mu$ s.
- Release 0 pushbutton (YA).
- Change the repetition time of the input signal to 0.5  $\mu$ s.
- Check that the 8 centre periods have a total width of  $8\text{ div} \pm 2$  sub-divisions; if necessary, readjust potentiometer 744/U2.
- Set the X POSITION control as necessary.

#### 3.2.6.4. TV trigger adjustment (651/U1)

- Set AMPL/DIV switch to .1 V (YA).
- Set TIME/DIV switch to 5 ms.
- Set TV/NORMAL switch to TV.
- Depress +/- switch to  $-$ .
- Release 0 pushbutton.
- Apply a television signal of 240 mV, positive video (French system) to  $Y_A$  input socket.
- Check that the display starts with a frame sync pulse; if necessary, readjust potentiometer 651/U1.
- Set TIME/DIV switch to 20  $\mu$ s.
- Check that the display starts with a line sync pulse.

### 3.2.7. Vertical amplifier

The trimming potentiometer and capacitors for trace position adjustment, sensitivity and square-wave response are all located on the printed-wiring board unit 1.

With the front panel controls set as stated under section 3.2.3., make the following adjustments:

*Note: Prior to adjusting the vertical amplifier, ensure that the cathode-ray tube circuit and the time-base generator are operating correctly, i.e. that they meet their specifications.*

*When one or more transistors or other components have been replaced in the vertical amplifier, it is advisable that the following adjustments are checked.*

#### 3.2.7.1. Range adjustment of Y POSITION Control (446, 506)

- Set 0 switches to 0.
- Set  $Y_A$  (B) AMPL/DIV switch to .1 V.
- Set TIME/DIV switch to 5 ms.

- Set YA (B) POSITION potentiometer to mid-range; if necessary, adjust potentiometer 446 (506) for display of trace on the centre graticule line. The range of the Y POSITION potentiometer is so adjusted for equal swing either side of the centre horizontal line.

### 3.2.7.2. Sensitivity (472, 532)

- Set YA (B) AMPL/DIV switch to 2 mV.
- Set TIME/DIV switch to 50  $\mu$ s.
- Release 0 pushbutton YA (B).
- Apply a voltage of exactly 12 mV p-p, 10 kHz, to YA (B) input socket.
- Check that the vertical display height is exactly 6 divisions; if necessary, readjust potentiometer 472 (532).
- Adjust the Y POSITION control as necessary.

### 3.2.7.3. Attenuator response (243 ... 267 and 283 ... 307)

- Set YA (B) AMPL/DIV switch to 2 mV.
- Set TIME/DIV switch to 50  $\mu$ s.
- Release the 0 pushbutton YA (B).
- To equalize the input capacitance in all positions of the AMPL/DIV (i.e. attenuator) switch, for some adjustments, a 2:1 dummy measuring probe is connected in series with YA (B) input socket. The dummy probe consists of the parallel circuit of a 1 M $\Omega$  resistor and a 3-60 pF trimmer (Fig. 3.16.) and is adjusted as indicated in the following table.
- Connect a square-wave voltage with an amplitude as indicated in the following table, a repetition rate of 10 kHz and a rise time not exceeding 100 ns to YA (B) input socket.
- Check that neither overshoot nor rounding is visible (maximum pulse top errors 2%) and also check the trace height; if necessary, correct the pulse top errors with the aid of the trimmers (Fig. 3.17.) mentioned in the following table.

Position of the A (B) AMPL/DIV switch	Signal to Y <sub>A</sub> (B) socket or Signal to 2:1 dummy	Adjusting element		Square-wave with a trace height
		Y <sub>A</sub>	Y <sub>B</sub>	
2 mV/div	12 mV	267	307	6 div + or -2 %
2 mV/div	24 mV	trimmer in dummy		6 div + or -2 %
5 mV/div	30 mV	246	286	6 div + or -2 %
5 mV/div	60 mV via dummy	243	283	6 div + or -2 %
10 mV/div	60 mV	251	291	6 div + or -2 %
10 mV/div	120 mV via dummy	248	288	6 div + or -2 %
20 mV/div	120 mV	252	292	6 div + or -2 %
50 mV/div	300 mV	253	293	6 div + or -2 %
.2 V/div	1.2 V	256	296	6 div + or -2 %
.5 V/div	3 V	257	297	6 div + or -2 %
2 V/div	12 V	261	301	6 div + or -2 %
5 V/div	30 V	262	302	6 div + or -2 %

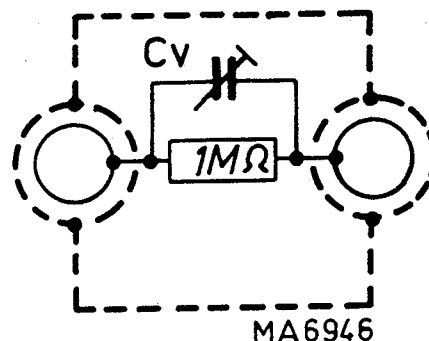


Fig. 3.16. 2:1 Dummy probe

#### 3.2.7.4. H.F. Response (274, 314)

- Set  $Y_A$  (B) AMPL/DIV switch to 2 mV.
- Set TIME/DIV switch to .5  $\mu$ s.
- Pull X-MAGN switch to x5.
- Apply a square-wave signal of 12 mV, 100 kHz rise time  $< 5$  ns, at the  $Y_A$  (B) input socket and adjust, if necessary, trimmer 274 (314) of the vertical amplifier(s) for a flat-top response with minimum overshoot (0.5 sub-div is acceptable).

#### 3.2.7.5. Bandwidth of the vertical amplifier

- Depress X-MAGN switch to x1.
- Set TIME/DIV switch to 5  $\mu$ s.
- Set  $Y_A$  (B) AMPL/DIV switch to 2 mV/div.
- Check the bandwidth at a trace height of 6 div in accordance with the following table:

<i>Input sine wave on <math>Y_A</math> (B) socket</i>	<i>Frequency</i>	<i>Required trace height</i>
12 mVp-p	100 kHz	6 div
12 mVp-p	15 MHz	at least 4.2 div

### Notes:

Series of horizontal lines for taking notes.

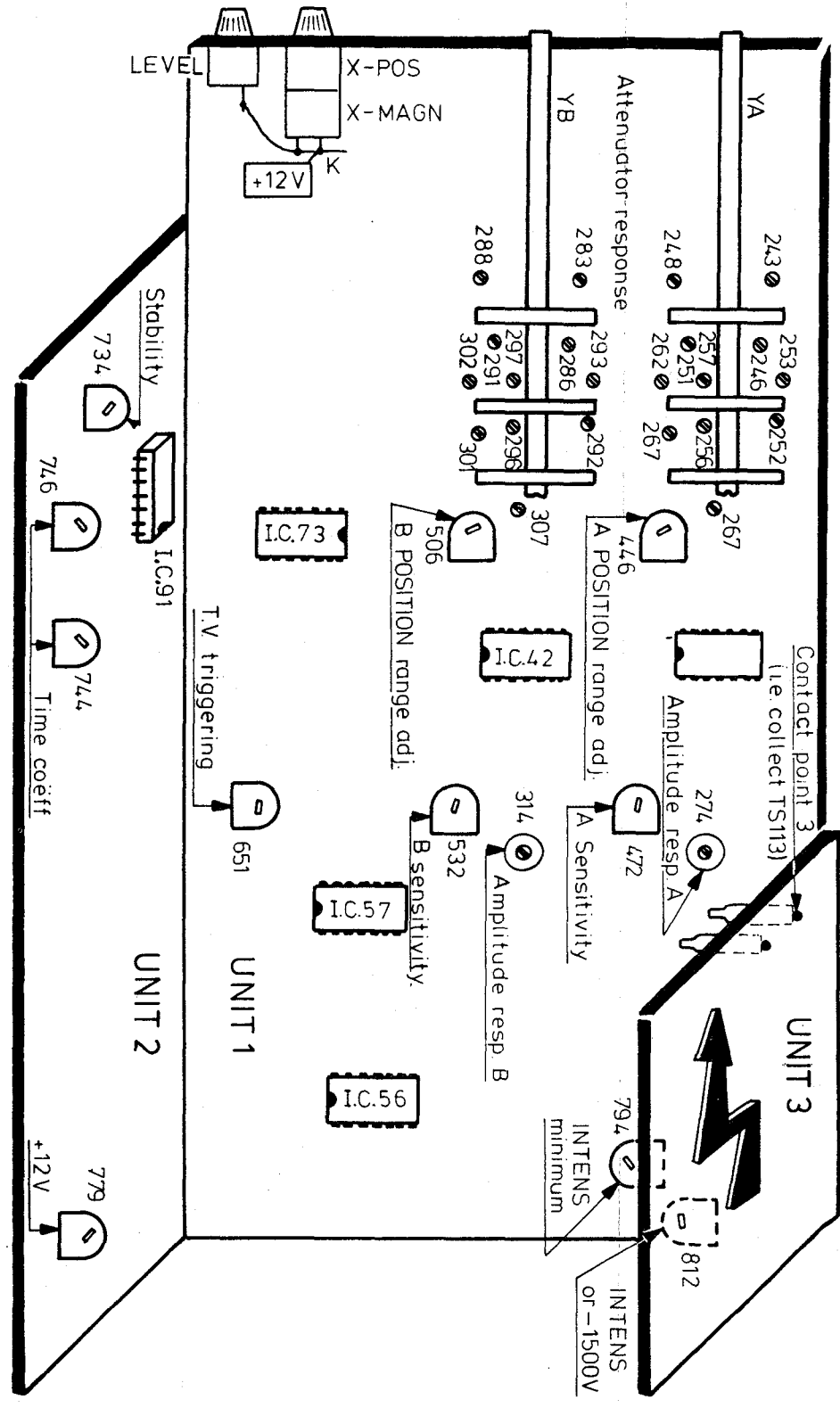


Fig. 3.17. Printed-wiring boards with adjusting references

Notes:

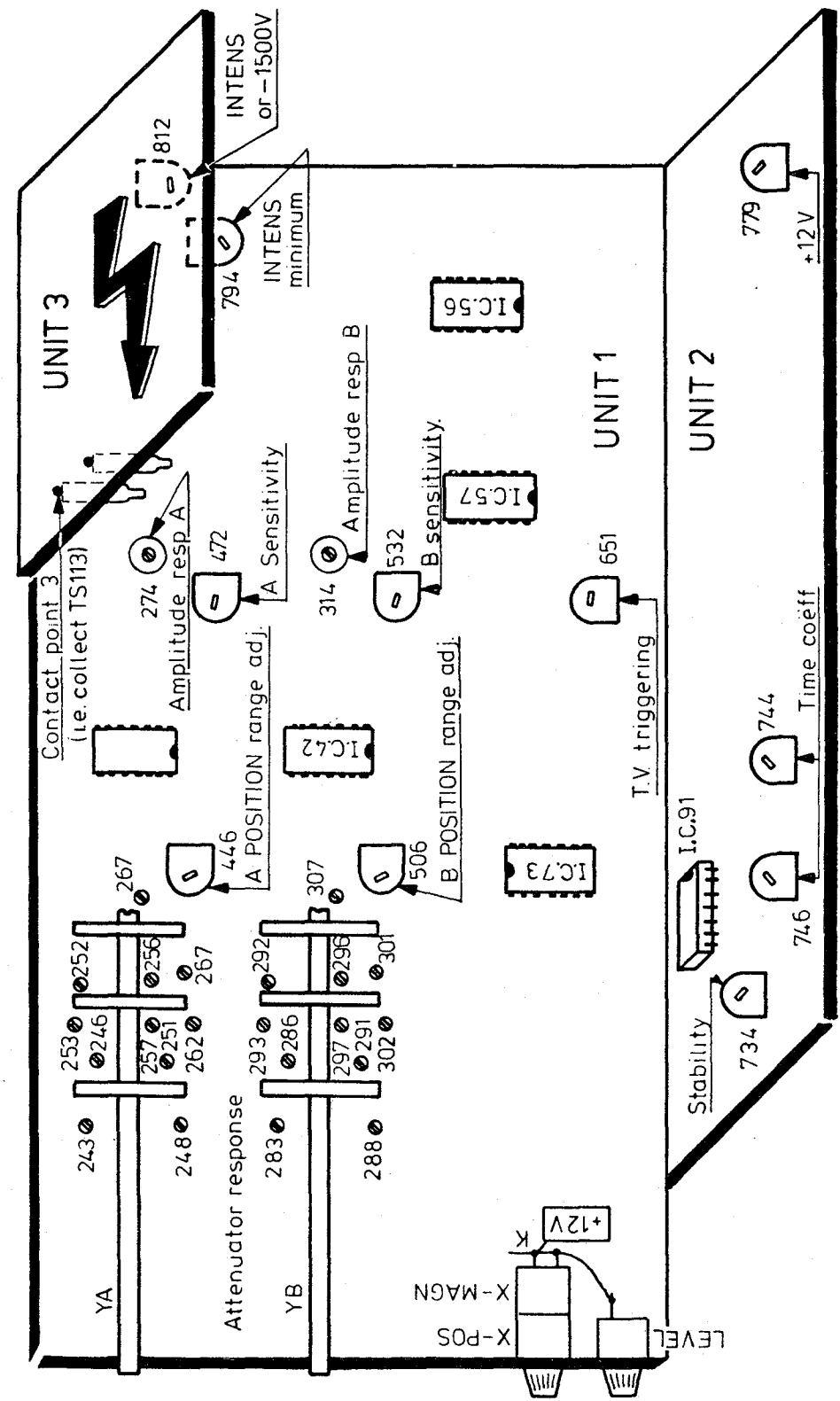


Fig. 3.17. Printed-wiring boards with adjusting references

### 3.4. INFORMATION FOR ASSISTANCE IN FAULT-FINDING

#### 3.4.1. Mains transformer data

The available unloaded voltage tapings and the number of turns per winding are listed in the circuit diagram (Fig. 3.39.) in the form of a table.

#### 3.4.2. Voltages and waveforms in the instrument

The d.c. voltage levels at the electrodes of the transistors and the voltage waveforms in the time-base generator and Y-amplifier are shown at the relevant points on the circuit diagram (Fig.3.39).

The waveforms have been measured under the following conditions:

- Input signal on Y input socket: 5 V<sub>p-p</sub> sine-wave voltage, frequency 1 kHz,
- Level potentiometer in TOP position.
- Trigger switches at INTERN, +, and NORMAL.
- Y-POSITION and X-POSITION controls at mid-range.
- AMPL/DIV switch to 1 Volt.
- TIME/DIV switch to .5 ms.

The voltage values are typical and may slightly differ per instrument.

#### 3.4.3. Remark

In case of a defect, it is always possible to apply to the world wide PHILIPS Service Organization.

When the instrument is to be sent to a PHILIPS Service Workshop for repair, the following points should be observed:

- Attach a label with your name and address to the instrument.
- Give a complete description of the faults found, or the service required.
- Use the original packing, or, if this is no longer available, carefully pack the instrument in a wooden crate or box.
- Send the instrument to the address obtained after consultation with the local PHILIPS Organization.



		SETTINGS OF CONTROLS OF THE INSTRUMENT UNDER TEST (elements pertaining to channel B are indicated in brackets after those for channel A)																	
ADJUSTING ELEMENTS AND THEIR FUNCTIONS		V/div. A (B)	T/div. Cal.	ON/OFF A (B)	AC/DC A (B)	0 A (B)	CHOP/ALT	A	B	EXT.	+	TV/NORM	Focus	POS.-A (POS.-B)	X-POS. MAGN.	Level TOP	Power-ON INTENS.	MEASURING	
Adjustment and adjusting sequence	Adjusting element	50 mV	.5ms cal.	ON	AC	0	ALT	A	released	released	+	TV				TOP	INTENS. at normal	Explanation + values	
CATH.-RAY TUBE CIRCUIT																			
+12 V, -12 V supply voltages	Potmeter 799	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Adjust +12 V (+ or -30 mV)
Intens (-1500 Volt)	Potmeter 812	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"		"	Adjust with potm. 812 collect. voltage TS113 for  ± 190 V ± 10 V
Intens (dark current)	Potmeter 794	"	.2ms cal.	"	"	"	"	A + B	"	"	"	NORM	"	"	"			"	Adjust with potm. 794 collect. voltage TS113 for  ± 50 V ± 10 V
TIME-BASE GENERATOR																			
Stability	Potmeter 734	"	"	"	"	"	CHOP	"	B released	"	"	"	Norm. FOCUS	"	"	TOP	INTENS. at normal	"	Set wiper R522, +20° clockwise from point of just no triggering
Time coeff. 200 ms → 0,5 ms	Potmeter 746	"	.5ms cal.	"	"	0 released	ALT	"	"	"	"	"	"	"	Adjust	"	"	"	8 periods = 8 div. (± .2 s.d) { Measured across the centre 8 div.
Time coeff. 0,2 ms → 0,5 μs	Potmeter 744	"	.5μs cal.	"	"	"	"	"	"	"	"	"	"	"	Adjust	"	"	"	8 periods = 8 div. (± .2 s.d) { Measured across the centre 8 div.
T.V. trigger-adjustment	Potmeter 651	.1V	5ms cal.	"	"	"	"	"	"	"	-	TV	"	"	"	"	"	"	Adjust at frame pulses (apply a positive video signal)
VERTICAL AMPLIFIERS A AND B																			
Range adjustment of POSITION	Potmeter 446 (506)	"	"	"	"	0	"	"	(B)	"	+	NORM	"	"	"	"	"	"	Set POSITION potm. (A&B) at mid-range adjust 446 (506) for display at centre graticule line
Sensitivity (overall-gain)	Potmeter 472 (532)	2mV	50 μs cal.	"	"	0 released	"	"	"	"	"	"	"		"	"	"	"	Apply 12 mV frequency 10 kHz } adjust for  H = 6 div.
Square-wave response, attenuator	Cap. 267 (307)	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 12 mV, adjust for square-wave response
"	Use a dummy probe	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 24 mV, adjust dummy for square-wave response
"	Cap. 246 (286)	5mV	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 30 mV, adjust for square-wave response
"	Cap. 243 (283)-Use dummy	5mV	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 60 mV, adjust for square-wave response
"	Cap. 251 (291)	10mV	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 60 mV, adjust for square-wave response
"	Cap. 248 (288)-Use dummy	10mV	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 120 mV, adjust for square-wave response
"	Cap. 252 (292)	20mV	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 120 mV, adjust for square-wave response
"	Cap. 253 (293)	50mV	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 300 mV, adjust for square-wave response
"	Cap. 256 (296)	.2V	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 1,2 V, adjust for square-wave response
"	Cap. 257 (297)	.5V	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 3 V, adjust for square-wave response
"	Cap. 261 (301)	2V	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 12 V, adjust for square-wave response
"	Cap. 262 (302)	5V	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Apply 30 V, adjust for square-wave response
Square-wave response, amplifier	Cap. 274 (314)	2mV	.5 μs cal.	"	"	"	"	"	"	"	"	"	"	"	x5	"	"	"	Apply square-wave voltage 12 mV, 100 kHz adjust for that top and min. overshoot

**3.4. INFORMATION FOR ASSISTANCE IN FAULT-FINDING****3.4.1. Mains transformer data**

The available unloaded voltage tapings and the number of turns per winding are listed in the circuit diagram (Fig. 3.39.) in the form of a table.

**3.4.2. Voltages and waveforms in the instrument**

The d.c. voltage levels at the electrodes of the transistors and the voltage waveforms in the time-base generator and Y-amplifier are shown at the relevant points on the circuit diagram (Fig.3.39).

The waveforms have been measured under the following conditions:

- Input signal on Y input socket: 5 V<sub>p-p</sub> sine-wave voltage, frequency 1 kHz,
- Level potentiometer in TOP position.
- Trigger switches at INTERN, +, and NORMAL.
- Y-POSITION and X-POSITION controls at mid-range.
- AMPL/DIV switch to 1 Volt.
- TIME/DIV switch to .5 ms.

The voltage values are typical and may slightly differ per instrument.

**3.4.3. Remark**

In case of a defect, it is always possible to apply to the world wide PHILIPS Service Organization.

When the instrument is to be sent to a PHILIPS Service Workshop for repair, the following points should be observed:

- Attach a label with your name and address to the instrument.
- Give a complete description of the faults found, or the service required.
- Use the original packing, or, if this is no longer available, carefully pack the instrument in a wooden crate or box.
- Send the instrument to the address obtained after consultation with the local PHILIPS Organization.

### 3.5. INFORMATION CONCERNING ACCESSORIES

#### 3.5.1. Attenuator probe sets PM 9326 and PM 9327 (Fig. 3.18)

These passive probe sets are equal but for the length of the probe cable, which is 1.15 m for the PM 9326 and 2 m for the PM 9327.

The sets consist of:

1 probe cable	Fig. 3.18, item 1
1 earth lead 15 cm	Fig. 3.18, item 2
1 earth lead 30 cm	Fig. 3.18, item 3
1 measuring probe 1:1 (black)	Fig. 3.18, item 4
1 test pin	Fig. 3.18, item 5
1 test hook	Fig. 3.18, item 6
1 attenuator probe 1:10 (grey)	Fig. 3.18, item 7
1 test clip	Fig. 3.18, item 8
1 box	Fig. 3.18, item 9

The measuring probe and the earth lead can be simply pulled from the cable. The test clip, test pin and test hook are screwed on to the measuring probe.

For ordering numbers of these parts, see list 3.6.4.1.

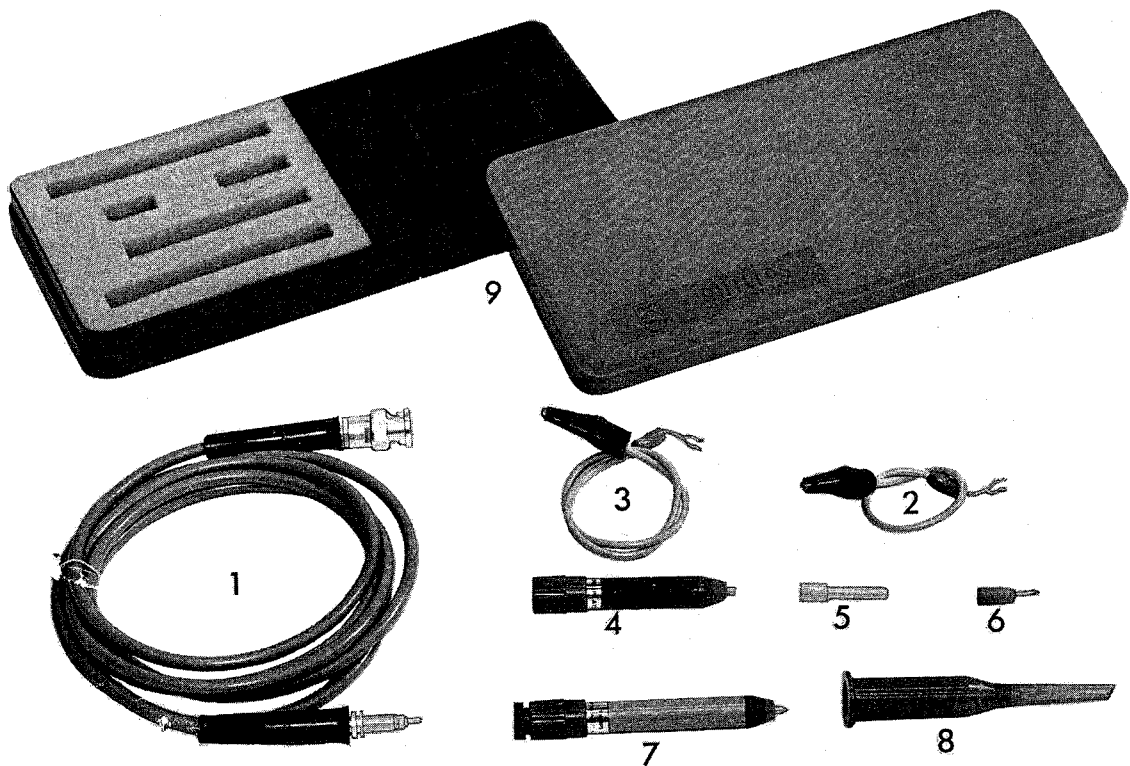


Fig. 3.18. Attenuator probe set PM9326 (PM 9327)

3.5.1.1 *Technical data*

Attenuation	1:10 ± 3%
Input impedance	10 MOhm//10 pF
Max. permissible input voltage	1000 V <sub>p-p</sub>
Maximum d.c. component 500 V with the blocking capacitor included into the circuit.	

3.5.1.2 *Adjustment (Fig. 3.19.)*

- Unscrew the probe locking nut by turning it anti-clockwise.
- Connect the measuring pin to socket PROBE ADJ of the oscilloscope
- Rotate the probe body to change the capacitance while watching the display for the desired waveform.
- When compensation is completed, carefully turn the locking nut clockwise, to lock it without disturbing the adjustment.

The attenuator probe causes distortion if it has not been properly adjusted.

See the following examples:

*Note:* For settings of the instrument controls, see Section 3.2.3.:

Adjustment of attenuator probes, page 19

Abgleich der Spannungsteiler-Messköpfe, Seite 36

Réglage des sondes atténuatrices, page 55

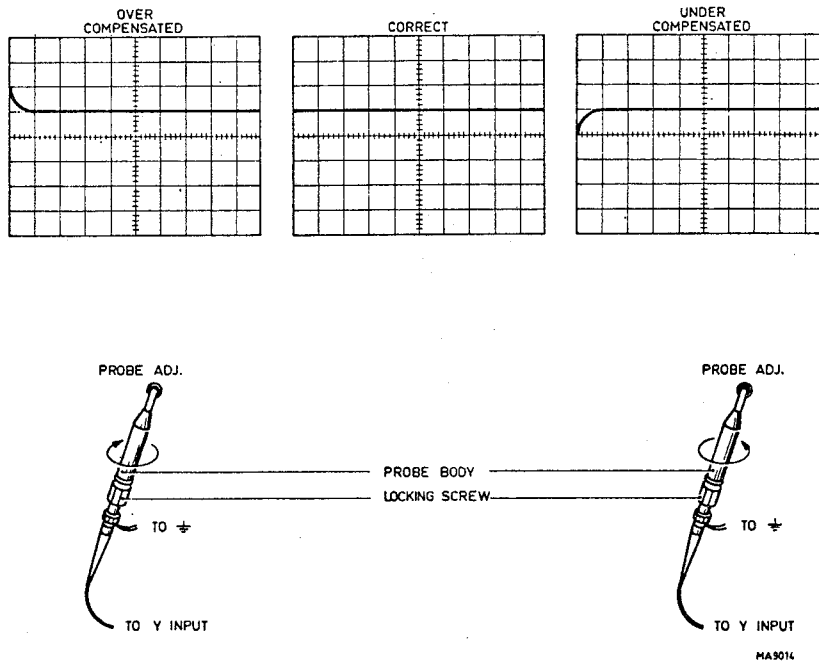


Fig. 3.19. Attenuator probe compensation

### 3.5.2. Attenuator probe sets PM 9336 and PM 9336L

The PM 9336 is a 10x attenuator probe, designed for oscilloscopes up to 25 MHz, having a BNC input jack and 10 to 35 pF input capacitance, paralleled by 1 M $\Omega$ . The PM 9336L is a similar probe with a cable length of 2.5 m.

The set consists of:

1 probe assembly	Fig. 3.20, item 1
5 soldering terminals	Fig. 3.20, item 2
1 test hook	Fig. 3.20, item 3
2 spare test hook sleeves	Fig. 3.20, item 4
1 protective cap	Fig. 3.20, item 5
1 probe holder	Fig. 3.20, item 6
2 probe tips	Fig. 3.20, item 7
1 earthing cord	Fig. 3.20, item 8
1 box	

For ordering numbers of these parts, see list 3.6.4.2.

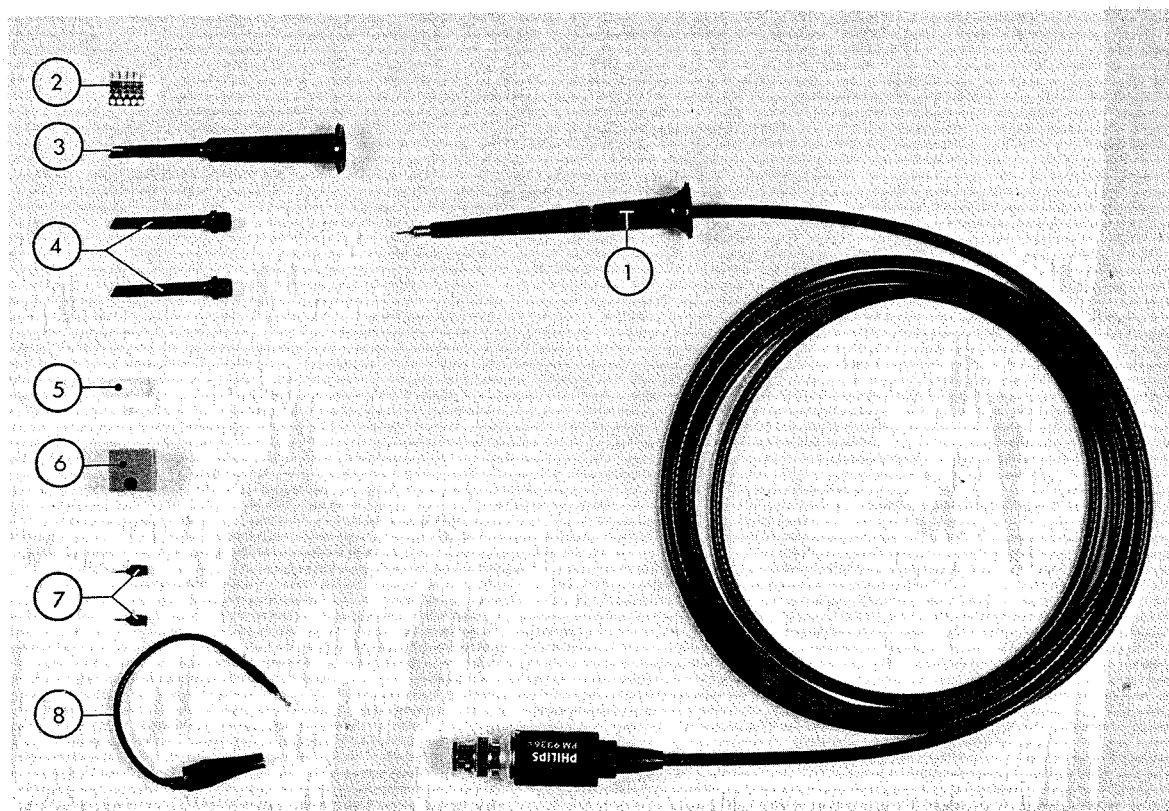


Fig. 3.20. Attenuator probe set PM 9336 (PM 9336L)

### 3.5.2.1 Technical data

Attenuation	1:10 $\pm$ 3%		
Input resistance	PM 9336	10 MOhm	$\pm$ 2%
	PM 9336L	10 MOhm	$\pm$ 2%
Input capacitance	PM 9336	11 pF	$\pm$ 1 pF
	PM 9336L	14 pF	$\pm$ 1 pF
Maximum allowable input voltage	500 V (D.C. + A.C. peak)		

### 3.5.2.2 Adjustment

The measuring probe has been adjusted and checked by the factory. However, to match the probe to your oscilloscope, the following manipulation is necessary.

Connect the measuring pin to socket PROBE ADJ of the oscilloscope.

A trimmer can be adjusted through a hole in the compensation box to obtain optimum square-wave response.

*Note:* For settings of the instrument controls, see Section 3.2.3.:

Adjustment of attenuator probes, page 20

Abgleich der Spannungsteiler-Messköpfe, Seite 37

Réglage des sondes atténuatrices, page 56

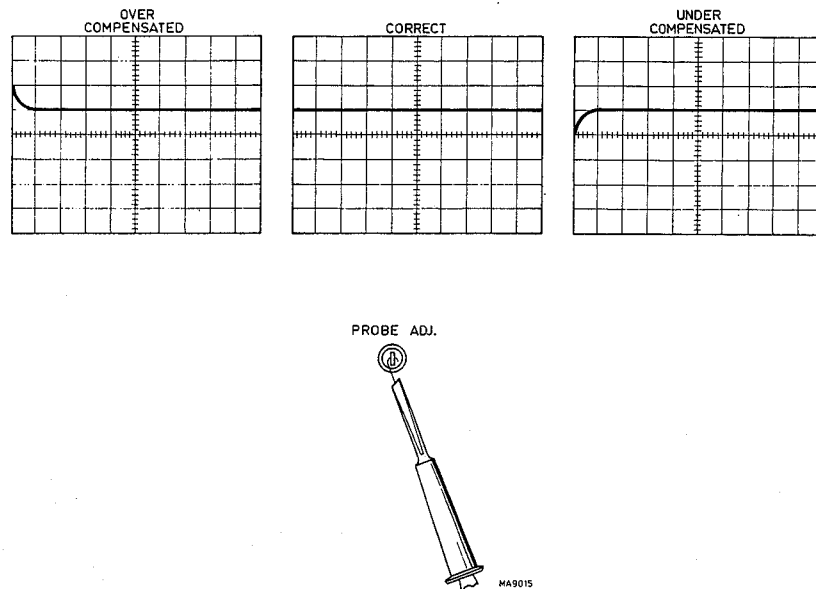


Fig. 3.21. Probe compensation.

### 3.5.3. 1:1 Probe sets PM 9335 and PM 9335L

The PM 9335 is a passive probe without signal attenuation for use with oscilloscope, counters and voltmeters having a high input impedance and a BNC input socket.

The cable design is such that the reflections due to the instrument's capacitive load are absorbed.

The useful range of this probe is restricted to d.c. and l.f. applications (up to 10 MHz).

The PM 9335L is a similar probe with a cable length of 2.5 m.

The set consists of:

1 test hook	Fig. 3.22, item 1
2 spare test hook sleeves	Fig. 3.22, item 2
2 spare probe tips	Fig. 3.22, item 3
1 protective cap	Fig. 3.22, item 4
1 earthing lead	Fig. 3.22, item 5
1 probe holder	Fig. 3.22, item 6
1 probe assembly	Fig. 3.22, item 7
1 box	

For ordering numbers of these parts, see list 3.6.4.3.

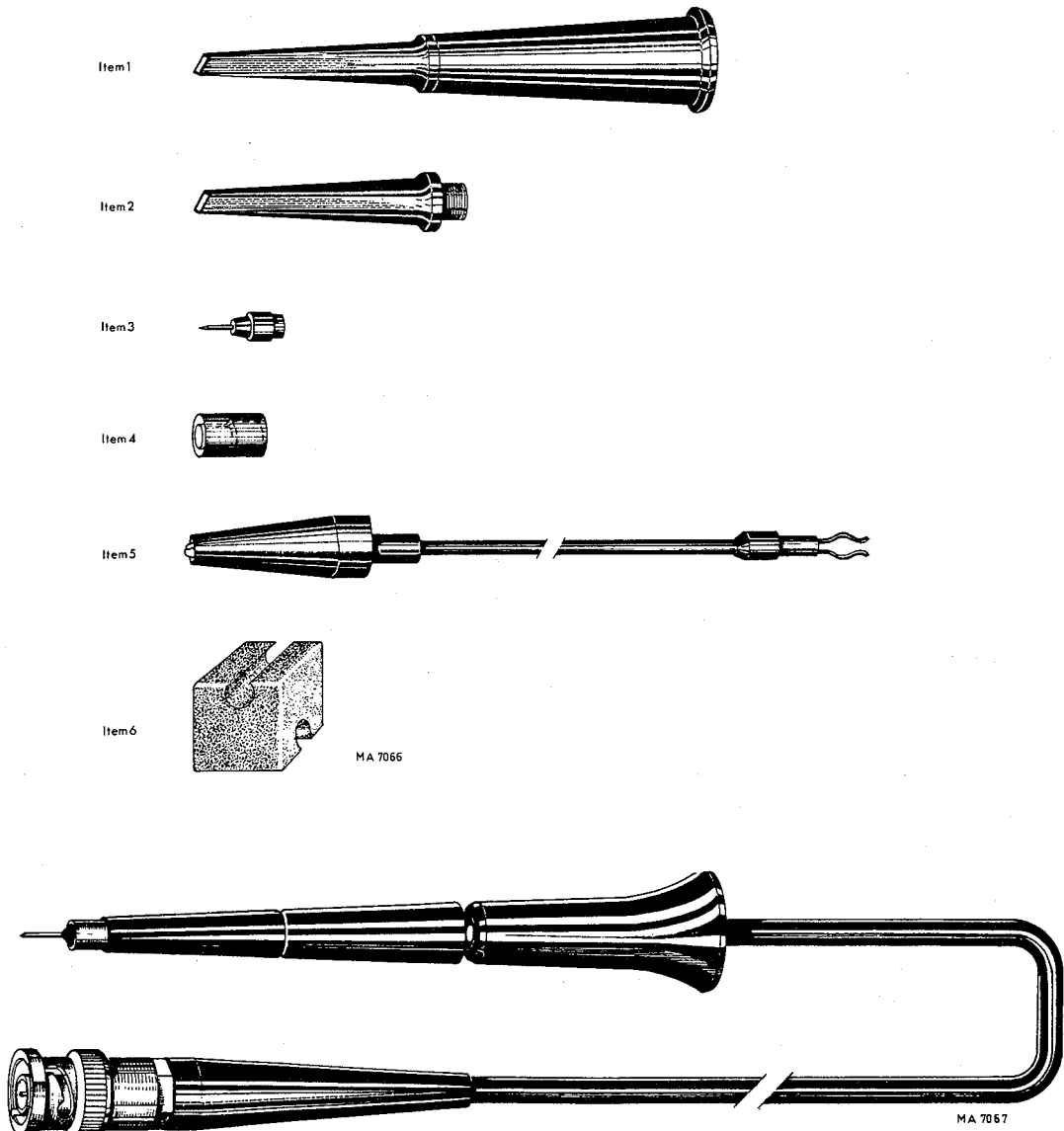


Fig. 3.22. Probe set PM 9335 (PM 9335L)

**3.5.3.1 Technical data**

Attenuation	1:1		
Input resistance	1 MOhm		
Input capacitance	45 ± 5 pF + input cap. of measuring instrument		
<i>Max. allowable input voltage</i>			
D.C.	500 V		
A.C. peak-to-peak	500 V derating at higher frequencies with $\frac{500 \text{ V}}{\text{MHz}}$		
A.C. peak + D.C.	500 V		
<i>Dimensions</i>			
Probe body	<i>L</i>	<i>W</i>	<i>H</i> mm
Cable	1.5		m
Box	230	104	24 mm



### 3.5.4. 2 kV Attenuator set PM 9358

The PM 9358 is a 100x attenuator probe which can handle signals up to 2 kVrms. The probe has been designed for use with oscilloscopes having a bandwidth up to 150 MHz, a BNC input jack and an input impedance of  $1\text{ M}\Omega$  paralleled by 10 to 30 pF.

The set consists of:

1 probe assembly	Fig. 3.23, item 1
5 soldering terminals	Fig. 3.23, item 2
1 test hook	Fig. 3.23, item 3
1 spare test hook sleeve	Fig. 3.23, item 4
1 protective cap	Fig. 3.23, item 5
1 insulating cap	Fig. 3.23, item 6
1 probe holder	Fig. 3.23, item 7
2 spare test pins	Fig. 3.23, item 8
1 earthing cord	Fig. 3.23, item 9
1 box	

For ordering numbers of these parts, see list 3.6.4.4.

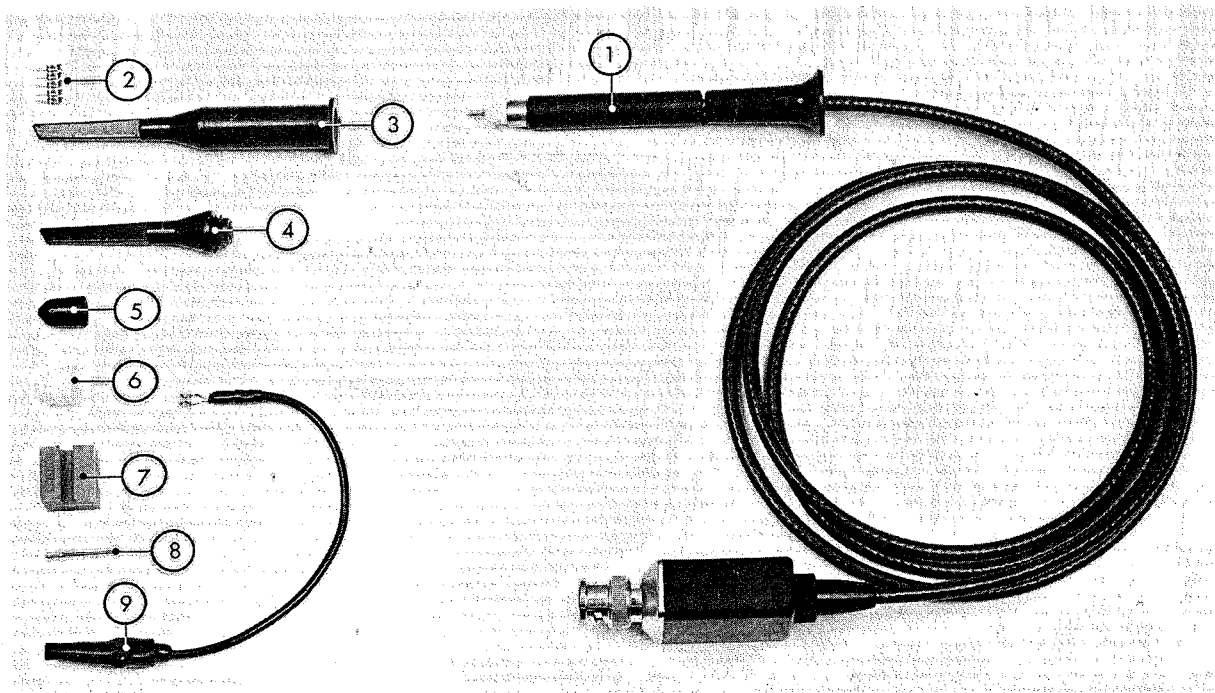


Fig. 3.23. Attenuator probe set PM 9358

3.5.4.1 *Technical data*

Attenuation		1:100 ± 2%
Input resistance		20 MOhm ± 3%
Input capacitance		2 pF ± 0.3 pF
Max. allowable voltage DC or AC <sub>rms</sub>		
Continuous	2 kV	
Under pulsed conditions	2 kV	{ Duty cycle 50–100% dv/dt ≤ 1000 V/ns Pulse rep. frequency ≤ 1 MHz
	3 kV	
	4 kV	{ Duty cycle 25–50% dv/dt ≤ 500 V/ns Pulse rep. frequency ≤ 1 MHz Max. pulse duration 100 ms
	5.6 kV <sub>p-p</sub>	
Sinewaves continuous	5.6 kV <sub>p-p</sub>	{ Duty cycle 0–25% dv/dt ≤ 200 V/ns Pulse rep. frequency ≤ 1 MHz Max. pulse duration 20 ms
		For frequencies up to 1 MHz

3.5.4.2 *Adjustment*

The measuring probe has been adjusted and checked by the factory. However, to match the probe to your oscilloscope, the following manipulation is necessary. Connect the measuring pin to socket PROBE ADJ of the oscilloscope. A trimmer can be adjusted through a hole in the compensation box to obtain optimum square-wave response.

See the following examples:

*Note:* For settings of the instrument controls, see Section 3.2.3.

- Adjustment of attenuator probes, page 19
- Ableich der Spannungsteiler-Messköpfe, Seite 37
- Réglage des sondes atténuatrices, page 55

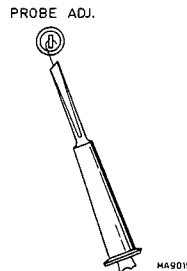
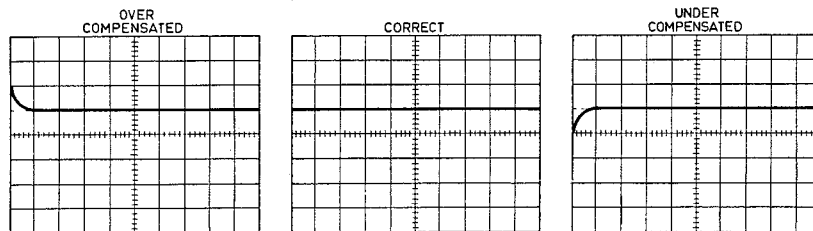
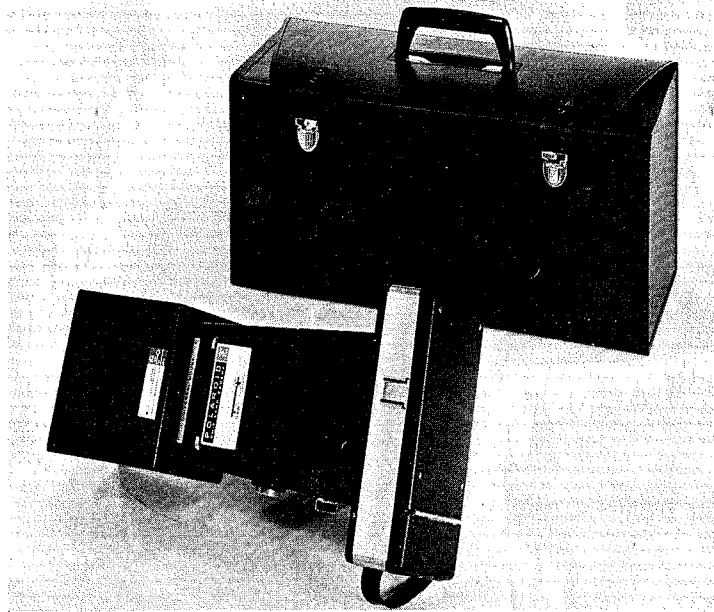


Fig. 3.24. Probe compensation

### 3.5.5 Multi-purpose camera PM 9380

Camera PM 9380 has been designed to photograph oscilloscope displays in a quick and simple way. It incorporates the Polaroid instant photographic process which has the advantage that you can see the picture a few moments after you took it.

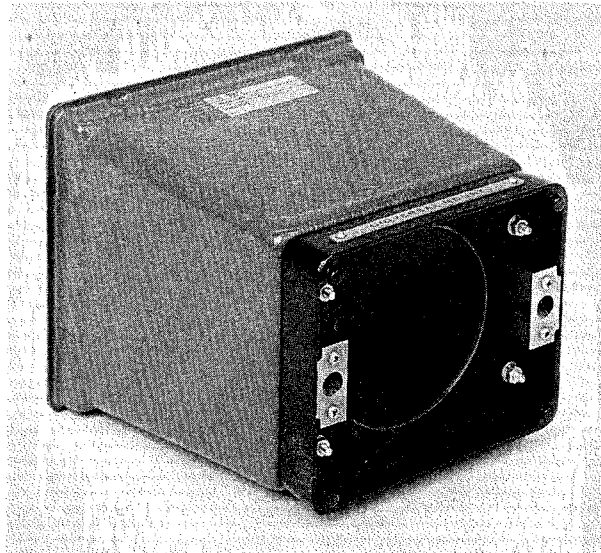


*Fig. 3.25. Multi-purpose camera PM 9380*

### 3.5.6 Adapter PM 8971

This adapter forms the connection between camera PM 9380 and oscilloscope PM 3226. The dimensions of the adapter are such, that the camera automatically focussed when the camera-adapter combination is held against the front of the oscilloscope.

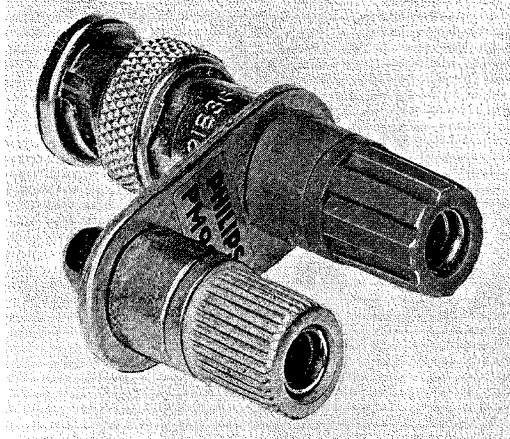
*Note: Cover the POWER ON lamp, when taking a photograph.*



*Fig. 3.26. Adapter PM 8971*

### 3.5.7 Adapter PM 9051

This is an adapter to make a BNC socket suitable for the connection of two 4 mm banana plugs.



*Fig. 3.27. Adapter PM 9051*

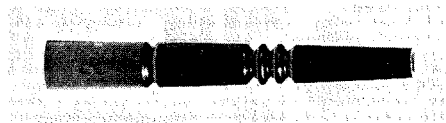
### 3.5.8. Wrap pin adapter

This adapter is especially designed to connect a measuring probe to a wrapped wiring system. The adapter, which is pushed over the probe tip, can be used in wrapped systems with pins of up to 1 mm dia.

The wrap pin adapter fits the following (attenuator) probes:

PM 9336 and PM 9336L
PM 9335 and PM 9335L
PM 9358

Ordering number 5322 264 24018.



*Fig. 3.28. Wrap pin adapter*

### 3.5.9. Anti-static spray (Type 815/ASS)

Anti-static 815/ASS is a special product for prevention of dust caused by static electricity. It can be used on all plastics and highly polished wooden surfaces. This spray gives a long-lasting protection against static charges and dust.

Application areas: – TV Screens – Masks – Picture Tubes  
– Cabinets and Instrument Panels, etc.

Ordering number: 4822 390 80021 (English/Spanish text)  
4822 389 50017 (Dutch/French text)  
4822 389 50018 (German/Italian text)



Fig. 3.29. Anti-static spray

### 3.5.10. Trimming Tool Kit (Type 800/NTX)

This useful kit contains 3 twin-coloured holders, 2 extension holders and 21 interchangeable trimming pins. The wide variety of pins allows almost every type of trimming function to be carried out in instruments to be calibrated (e.g. measuring instruments, radio and T.V. sets).

Ordering number: 4822 310 50015.

(A spare set containing the 8 most commonly used pins is available under the Ordering number: 4822 310 50016.).

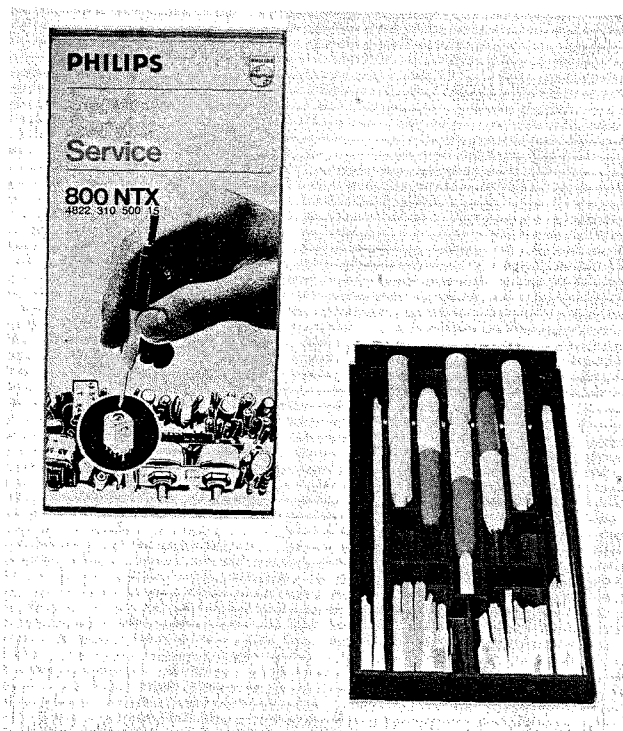
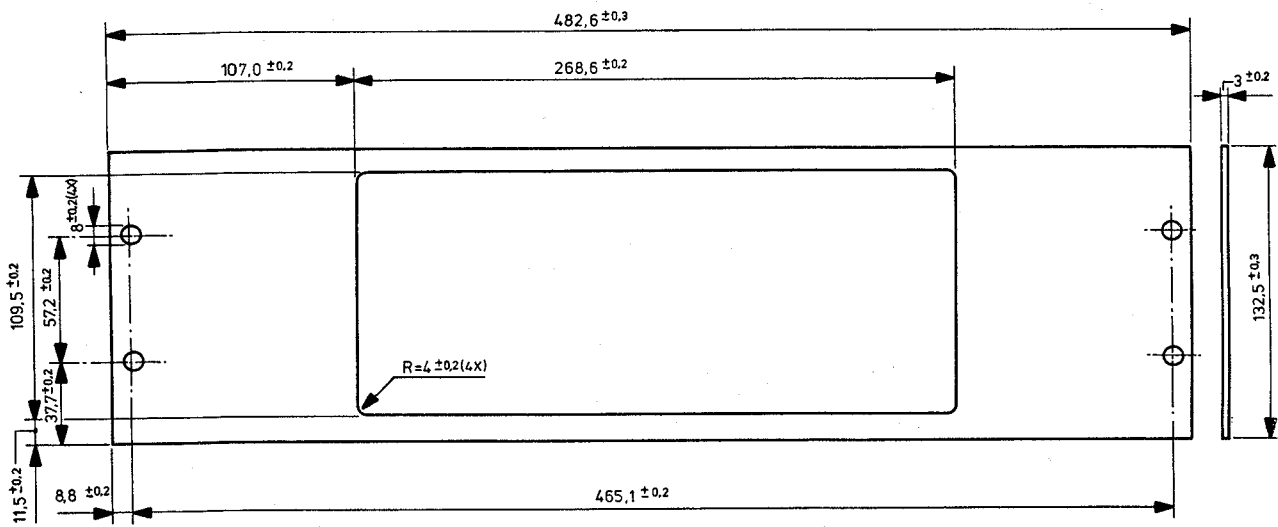


Fig. 3.30. Trimming tool kit

**3.5.11 Dimensional drawing of a 19" rack adapter**

This adapter makes the PM 3226 oscilloscope suitable for mounting in a 19" rack or cabinet.

*Note: The dimensions are expressed in mm.*



MA9458

*Fig. 3.31. Dimensioned sketch for 19" Rackmount PM 3226  
 Masszeichnung für 19" Gestelleinbau für PM 3226  
 Croquis coté pour montage en rack 19" du PM 3226*



### 3.6. PARTS LISTS AND DIAGRAMS (Subject to alteration without notice)

#### 3.6.1. Mechanical parts

<i>Item</i>	<i>Fig.</i>	<i>Qty.</i>	<i>Ordering number</i>	<i>Description</i>
1	3.32	1	5322 447 94188	Cast-aluminium rear frame
2	3.32	1	5322 447 94324	Cover (without carrying handle)
3	3.32	1	5322 447 94187	Cast-aluminium front frame
4	3.32	1	5322 451 34005	Bezel
5a	3.32	1	5322 480 34084	Contrast filter (blue)
5b	3.32	1	5322 480 34049	Contrast filter (grey)
6	3.32	1	5322 480 34051	Graticule
7	3.32	6	5322 414 34134	Control knob (436, 496, 623, 823, 824, 842)
8	3.32	6	5322 492 64337	Clamping spring (knob 436, 496, 623, 823, 824, 864)
9	3.32	6	5322 414 74015	Cover for knob (436, 496, 623, 666, 823, 824)
10	3.32	3	5322 414 34079	Switch knob (862, 863, 864)
11	3.32	3	5322 505 14228	Nut for switch knob (862, 863, 864)
12	3.32	2	5322 414 74019	Cover for switch knob (862, 863)
13	3.32	1	5322 414 34091	Control knob (666)
14	3.32	1	5322 414 74029	Cover for knob (842)
15	3.32	1	5322 455 84039	Text plate
16	3.32	3	5322 276 14101	Push-button switch (861/8-9-10)
17	3.32	9	5322 276 14117	Push-button switch (861/1-2-3-4-5-6-7-11-12)
18a	3.32	5	5322 414 14011	Knob for push-button switch (grey)
18b	3.32	7	5322 414 25613	Knob for push-button switch (green-grey)
19	3.32	3	5322 267 10004	BNC socket (851, 852, 853)
20	3.32	3	5322 506 14001	Nut for BNC socket
21	3.32	1	5322 535 84346	Earthing terminal (856)
22	3.32	1	5322 505 14178	Knurled nut for 856
23	3.32	1	5322 506 14005	Hexagonal nut for 856
24	3.32	1	5322 264 24015	Calibration terminal (854)
25	3.32	1	5322 325 84013	Grommet for 854
26	3.32	1	5322 255 44161	Holder for LED
27	3.32	4	5322 462 44174	Foot (bottom side)
28	3.32-33	2	5322 498 54048	Arm for carrying handle
29	3.32-33	1	5322 498 54051	Carrying handle
30	3.32-33	2	5322 520 34164	Bearing bush
31	3.32-33	2	5322 528 34101	Ratchet
32	3.32-33	2	5322 530 84075	Spring
33	3.32-33	2	5322 414 64053	Knob
34	3.33	4	5322 462 44176	Foot (rear side)
35	3.33	1	5322 502 24525	Coin-slot screw
36	3.33	1	4822 530 70124	Locking washer for item 35
37	3.33	1	4822 272 10079	Voltage adaptor (866)
*38	3.33	1	5322 321 14001	Mains cable
*39	3.33	1	5322 325 60119	Mains cable cleat
40	3.33	1	5322 325 64068	Mains cable grommet
41	3.34	1	5322 401 14166	Retaining brace for C.R.T.
42	3.34	1	5322 532 64186	Rubber sleeve for C.R.T.
43	3.34	1	5322 158 14004	Coil 15 $\mu$ H (867)
44	3.34	1	5322 280 24047	Relay contact (881)
45	3.34	1	5322 256 94075	Nylon bracket for C.R.T.
46	3.34	1	5322 405 94116	Clamp for item 45
47	3.34	1	5322 255 70159	Valve socket for C.R.T.

\* For Q version, order these items with the following ordering numbers: Mains cable 5322 321 14021  
Mains cable cleat 5322 401 14038



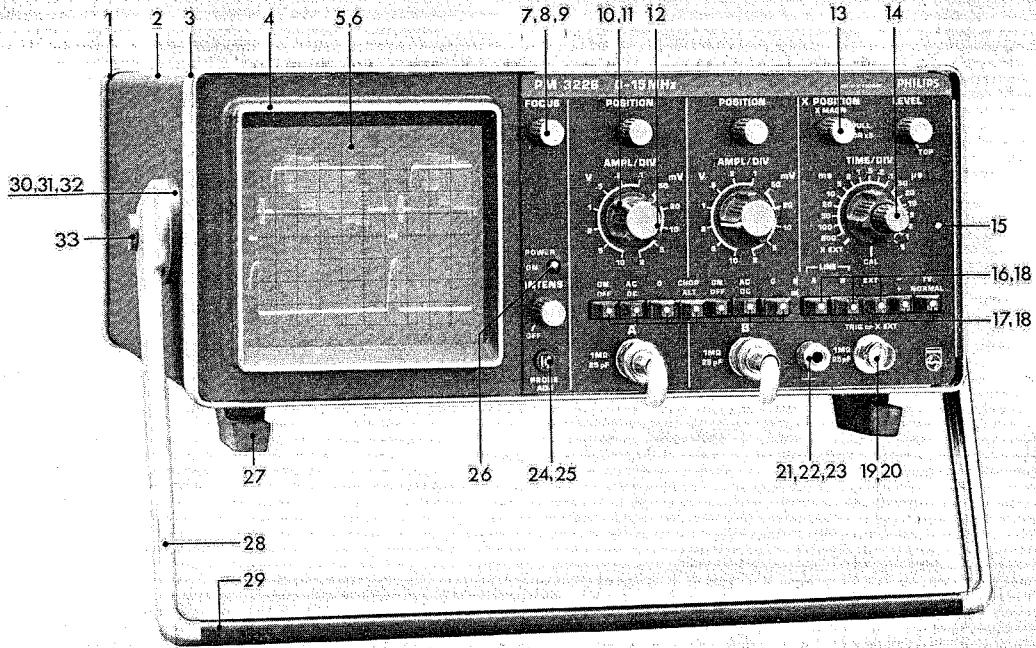


Fig. 3.32. Front view showing item numbers

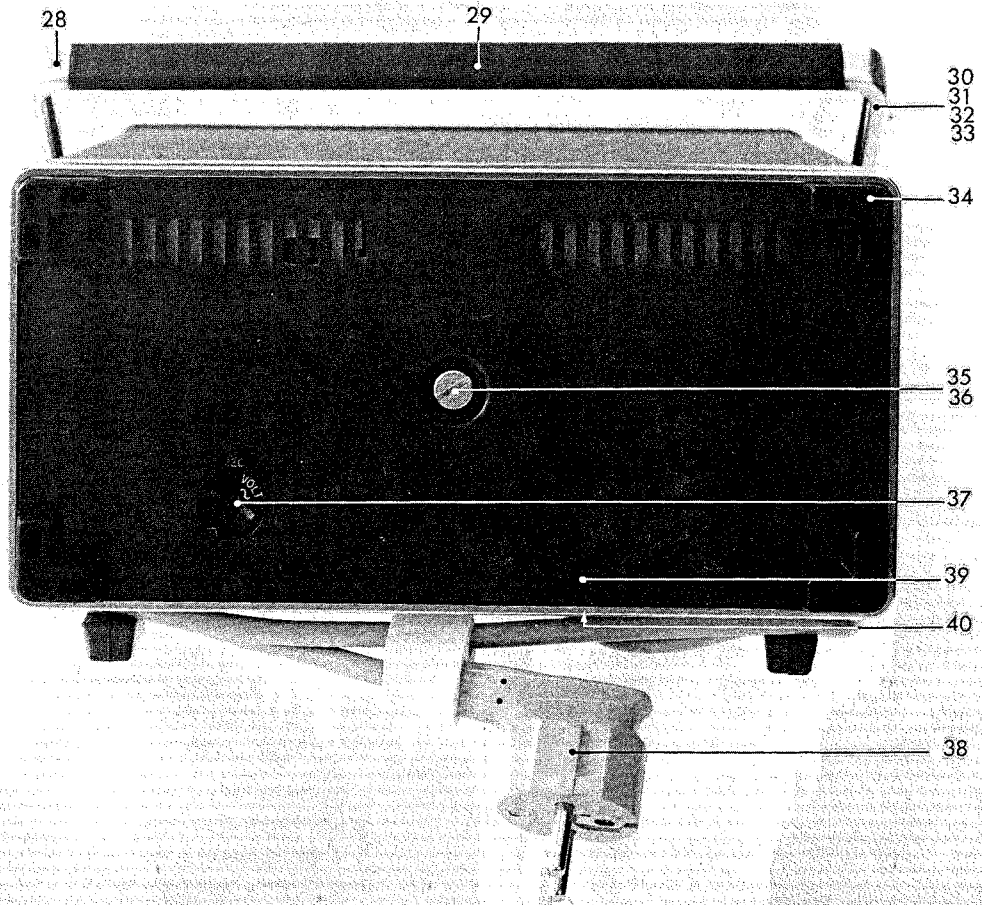


Fig. 3.33. Rear view showing item numbers

Item	Fig.	Qty.	Ordering number	Description
48	3.34	2	5322 405 94084	Nylon bracket for potentiometers (823, 824)
49	3.34	2	5322 535 74413	Nylon spindle for potentiometers (823, 824)
50	3.34	1	5322 466 94447	Transparent protective cover
51	3.34	1	5322 146 34064	Mains transformer (868)
52	3.34	1	4822 252 20007	Thermal fuse
53	3.34	2	5322 255 44129	Heat sink for transistor 106/U2 and 107/U2
54	3.34	4	5322 526 14018	Attenuation bead
55	3.34	1	5322 216 54138	Unit 3 (p.c. board complete)
56	3.34	1	5322 216 54137	Unit 2 (p.c. board complete)
57	3.34	1	5322 216 54136	Unit 1 (p.c. board complete)
58	3.34	1	5322 532 24427	Coupling piece for potentiometer 842
59	3.34	1	5322 273 64039	Attenuator switch (without components)
60	3.34	1	5322 273 44055	Time-base switch (unit 4, without components)
61	3.34	1	5322 105 34033	Time-base switch (unit 4, with components)

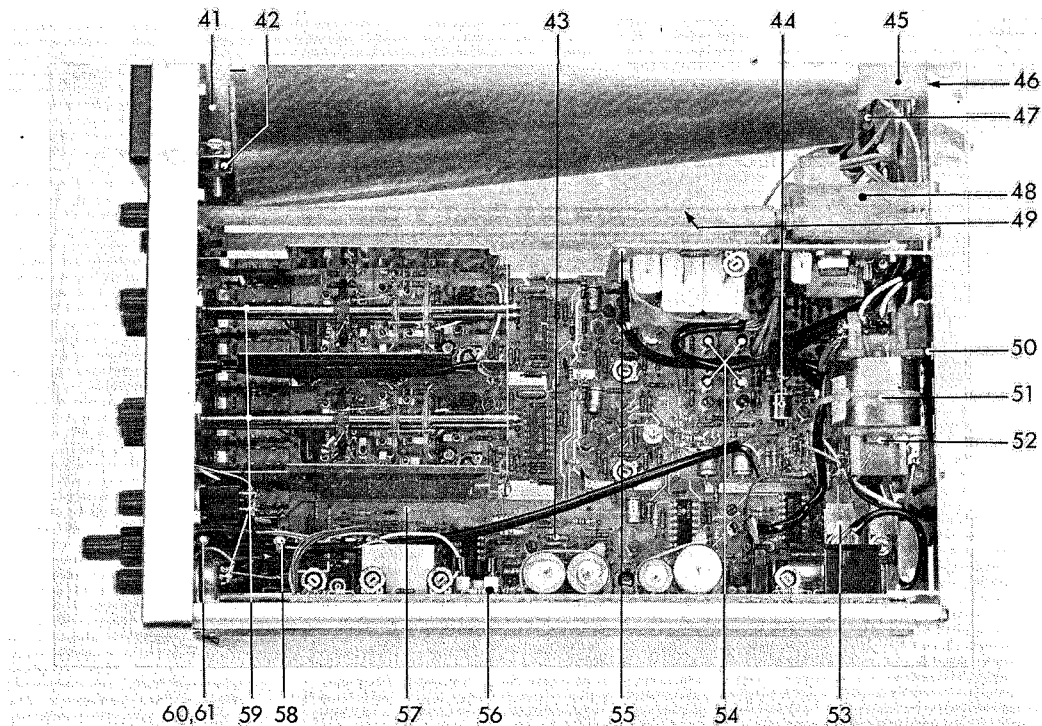


Fig. 3.34. Top view showing item numbers

### 3.6.2. Miscellaneous parts

Item	Ordering number	Type/Description
1	5322 447 94323	Protective front cover
2	5322 263 24005	Adapter (BNC-4 mm banana)
3a	5322 131 20022	C.R.T. D10-160 GH
3b	5322 131 20024	C.R.T. D10-160 GM
4	4822 130 30885	LED (Type CQY)
5	5322 255 44122	I.C. socket (6x)
6	5322 255 40089	Transistor socket (55x)
7	5322 255 44069	Transistor spacer (2x)
8	5322 255 44108	Transistor spacer (2x)
9	5322 255 44053	Transistor S-clip (TS26)
10	4822 266 30071	3-pole plug (Stocko MKF 803-1-0-303)
11	4822 265 30121	3-pole socket (Stocko MKS 823-1-0-303)
12	4822 266 30072	4-pole plug (Stocko MKF 804-1-0-404)
13	4822 265 30119	4-pole socket (Stocko MKS 824-1-0-404)
14	4822 266 30073	6-pole plug (Stocko MKF 806-1-0-606)
15	4822 265 30117	6-pole socket (Stocko MKS 826-1-0-606)

## 3.6.3. ELECTRICAL PARTS

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
3.6.3.1. CAPACITORS					
240	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
241	4822 121 40145	100N	10	630	POLYESTER FOIL
242	4822 122 31195	10P	2	500	CERAMIC PLATE
243	5322 125 54026	0,5-3P		400	TRIMMER
244	4822 122 31187	2,7P	0,25P	500	CERAMIC PLATE
246	5322 125 54026	0,5-3P		400	TRIMMER
247	4822 122 31187	2,7P	0,25P	500	CERAMIC PLATE
248	5322 125 54027	1-5,5P		400	TRIMMER
249	4822 122 31191	5,6P	0,25P	500	CERAMIC PLATE
251-253	5322 125 54026	0,5-3P		400	TRIMMER
254	4822 122 31199	22P	2	500	CERAMIC PLATE
255	4822 122 31182	1,0P	0,25P	500	CERAMIC PLATE
256,257	5322 125 54026	0,5-3P		400	TRIMMER
258	4822 122 31182	1,0P	0,25P	500	CERAMIC PLATE
259	4822 122 30055	330P	2	100	CERAMIC PLATE
261,262	5322 125 54026	0,5-3P		400	TRIMMER
263	4822 122 31186	2,2P	0,25P	500	CERAMIC PLATE
264	4822 121 50415	2,2N	1	63	POLYSTYRENE FOIL
266	4822 122 31201	27P	2	500	CERAMIC PLATE
267	5322 125 54026	0,5-3P		400	TRIMMER
268	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
269	4822 124 20453	68MU		6,3	ELECTROLYTIC
271	4822 122 31199	22P	2	500	CERAMIC PLATE
272	4822 122 31178	680P	10	100	CERAMIC PLATE
273	4822 122 31199	22P	2	500	CERAMIC PLATE
274	5322 125 54013	2-22P		100	TRIMMER
275	4822 121 40427	220N	10	100	POLYESTER FOIL
281	4822 121 40145	100N	10	630	POLYESTER FOIL
282	4822 122 31195	10P	2	500	CERAMIC PLATE
283	5322 125 54026	0,5-3P		400	TRIMMER
284	4822 122 31187	2,7P	0,25P	500	CERAMIC PLATE
286	5322 125 54026	0,5-3P		400	TRIMMER
287	4822 122 31187	2,7P	0,25P	500	CERAMIC PLATE
288	5322 125 54027	1-5,5P		400	TRIMMER
289	4822 122 31191	5,6P	0,25P	500	CERAMIC PLATE
291-293	5322 125 54026	0,5-3P		400	TRIMMER
294	4822 122 31199	22P	2	500	CERAMIC PLATE
295	4822 122 31182	1,0P	0,25P	500	CERAMIC PLATE
296,297	5322 125 54026	0,5-3P		400	TRIMMER
298	4822 122 31182	1,0P	0,25P	500	CERAMIC PLATE
299	4822 122 30055	330P	2	100	CERAMIC PLATE
301,302	5322 125 54026	0,5-3P		400	TRIMMER
303	4822 122 31186	2,2P	0,25P	500	CERAMIC PLATE
304	4822 121 50415	2,2N	1	63	POLYSTYRENE FOIL
306	4822 122 31201	27P	2	500	CERAMIC PLATE
307	5322 125 54026	0,5-3P		400	TRIMMER
308	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
309	4822 124 20453	68MU		6,3	ELECTROLYTIC
311	4822 122 31199	22P	2	500	CERAMIC PLATE
312	4822 122 31178	680P	10	100	CERAMIC PLATE
313	4822 122 31199	22P	2	500	CERAMIC PLATE
314	5322 125 54013	2-22P		100	TRIMMER
315	4822 121 40427	220N	10	100	POLYESTER FOIL
316	4822 124 20461	47MU		10	ELECTROLYTIC
317	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
318	4822 122 31175	1,0N	10	100	CERAMIC PLATE
319,320	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
321	4822 122 31195	10P	2	500	CERAMIC PLATE
322	4822 122 30105	1,5P	0,25P	100	CERAMIC PLATE
323,324	4822 122 31213	0,68P	0,25P	500	CERAMIC PLATE
325	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
326	4822 122 30105	1,5P	0,25P	100	CERAMIC PLATE
327	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOI (%)	VOLTS	REMARKS
328	4822 121 40239	47N	10	250	POLYESTER FOIL
329	4822 124 20469	68MU		16	ELECTROLYTIC
330	4822 122 31175	1,0N	10	100	CERAMIC PLATE
331	4822 124 20469	68MU		16	ELECTROLYTIC
332	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
333, 334	4822 122 31198	18P	2	500	CERAMIC PLATE
	336				
337	4822 122 31085	150P	2	100	CERAMIC PLATE
338	4822 122 31061	18P	2	100	CERAMIC PLATE
339	4822 121 40427	220N	10	100	POLYESTER FOIL
341	4822 124 20468	33MU		16	ELECTROLYTIC
342	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
343	4822 122 31198	18P	2	500	CERAMIC PLATE
344	4822 124 20476	22MU		25	ELECTROLYTIC
346	4822 124 20469	68MU		16	ELECTROLYTIC
347	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
348	4822 122 31186	2,2P	0,25P	500	CERAMIC PLATE
349	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
350	4822 122 30103	22N	-20/+80		CERAMIC PLATE
351	4822 122 31186	2,2P	0,25P	500	CERAMIC PLATE
352	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
353	4822 124 20583	1,0MU		63	ELECTROLYTIC
354, 355	4822 124 20476	22MU		25	ELECTROLYTIC
356	4822 122 30034	470P	2	100	CERAMIC PLATE
357, 358	4822 121 50272	6,2N	1	63	POLYSTYRENE FOIL
359	4822 122 30034	470P	2	100	CERAMIC PLATE
360, 361	4822 122 31182	1,0P	0,25P	500	CERAMIC PLATE
362	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
363	4822 124 20494	4,7MU		63	ELECTROLYTIC
366	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
367	4822 122 31067	33P	2	100	CERAMIC PLATE
368, 369	4822 122 31199	22P	2	500	CERAMIC PLATE
371	4822 124 20494	4,7MU		63	ELECTROLYTIC
372	4822 122 31081	100P	2	100	CERAMIC PLATE
373	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
374	4822 121 50415	2,2N	1	63	POLYSTYRENE FOIL
376	4822 122 31175	1,0N	10	100	CERAMIC PLATE
377	5322 121 40256	2,2MU	10	100	POLYESTER FOIL
378	4822 124 20605	1,5MU		63	ELECTROLYTIC
379	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
381	4822 122 31175	1,0N	10	100	CERAMIC PLATE
382-384	4822 124 20468	33MU		16	ELECTROLYTIC
386	5322 124 24152	47MU		250	ELECTROLYTIC
387	5322 124 24153	220MU		100	ELECTROLYTIC
388, 389	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE
390	4822 122 31175	1,0N	10	100	CERAMIC PLATE
391	4822 124 20523	680MU		16	ELECTROLYTIC
392	4822 124 20494	4,7MU		63	ELECTROLYTIC
393	4822 124 20473	220MU		16	ELECTROLYTIC
394	4822 124 20582	47MU		4	ELECTROLYTIC
395	4822 121 41156	68N	10	250	POLYESTER FOIL
396	4822 124 20524	1000MU		16	ELECTROLYTIC
397	4822 121 41161	100N	10	100	POLYESTER FOIL
398	4822 124 20524	1000MU		16	ELECTROLYTIC
399	4822 122 30103	22N	-20/+80		CERAMIC PLATE
401	4822 122 31067	33P	2	100	CERAMIC PLATE
402	4822 121 40123	15N	10	1600	POLYESTER FOIL
403	4822 121 41161	100N	10	100	POLYESTER FOIL
404	4822 121 40407	22N	10	250	POLYESTER FOIL
406-408	4822 121 40178	150N	10	1000	POLYESTER FOIL
409	4822 121 40393	150N	10	630	POLYESTER FOIL
411	4822 121 41161	100N	10	250	POLYESTER FOIL
412	4822 121 40363	10N	10	1600	POLYESTER FOIL
413	4822 122 30043	10N	-20/+80	63	CERAMIC PLATE
415	5322 121 34613	0,1MU(X)+ 2X4000PF(Y)			PAPER FOIL
416	4822 122 30103	22N	-20/+80	63	CERAMIC PLATE

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
3.6.3.2. RESISTORS					
421	5322 116 54012	6,81K	1	MR25	METAL FILM
422	5322 116 51033	604K	1	MR30	METAL FILM
423	5322 116 50021	665K	1	MR30	METAL FILM
424	5322 116 54323	800K	1	MR30	METAL FILM
426	5322 116 54734	249K	1	MR25	METAL FILM
427	5322 116 54408	909K	1	MR30	METAL FILM
428	5322 116 54702	113K	1	MR25	METAL FILM
429	5322 116 55153	992K	1	MR30	METAL FILM
430	4822 110 63043	3,9	5	CR25	CARBON
431	5322 116 54211	10,1K	1	MR25	METAL FILM
432	5322 116 54188	1,0M	1	MR30	METAL FILM
433	5322 116 54549	1,0K	1	MR25	METAL FILM
434	5322 116 54892	200K	1	MR30	METAL FILM
436	5322 101 24073	4,7K	20	0,1W	CARBON POTM LIN
437	5322 116 54323	800K	1	MR30	METAL FILM
438	5322 116 54716	162K	1	MR25	METAL FILM
439	5322 116 54469	100	1	MR25	METAL FILM
441	5322 116 50483	38,3K	1	MR25	METAL FILM
442	5322 116 54426	121	1	MR25	METAL FILM
443	5322 116 54469	100	1	MR25	METAL FILM
444	5322 116 50522	13,0K	1	MR25	METAL FILM
446	4822 100 10037	1,0K	20	0,1W	TRIMMING POTM
447	5322 116 50572	12,1K	1	MR25	METAL FILM
448,449	5322 116 54644	21K	1	MR25	METAL FILM
450,451	5322 116 54442	51,1	1	MR25	METAL FILM
452	5322 116 54576	2,37K	1	MR25	METAL FILM
453,454	5322 116 54571	1,96K	1	MR25	METAL FILM
455	5322 116 54587	3,65K	1	MR25	METAL FILM
456,457	5322 116 54431	16,2	1	MR25	METAL FILM
458	5322 116 54587	3,65K	1	MR25	METAL FILM
459	5322 116 54545	90°	1	MR25	METAL FILM
461,462	5322 116 54536	750	1	MR25	METAL FILM
463	5322 116 54701	110K	1	MR25	METAL FILM
464	5322 116 54558	8,25K	1	MR25	METAL FILM
466	4822 110 60117	2,4K	5	CR25	CARBON
467	5322 116 54426	121	1	MR25	METAL FILM
468,469	5322 116 50417	162	1	MR25	METAL FILM
471	5322 116 50766	147	1	MR25	METAL FILM
472	4822 100 10038	470	20	0,1W	TRIMMING POTM
473	5322 116 50482	33,2K	1	MR25	METAL FILM
474	5322 116 50876	26,1	1	MR25	METAL FILM
481	5322 116 54012	6,81K	1	MR25	METAL FILM
482	5322 116 51033	604K	1	MR30	METAL FILM
483	5322 116 50021	665K	1	MR30	METAL FILM
484	5322 116 54323	800K	1	MR30	METAL FILM
486	5322 116 54734	249K	1	MR25	METAL FILM
487	5322 116 54408	909K	1	MR25	METAL FILM
488	5322 116 54702	113K	1	MR25	METAL FILM
489	5322 116 55153	992K	1	MR30	METAL FILM
490	4822 110 63043	3,9	5	CR25	CARBON
491	5322 116 54211	10,1K	1	MR25	METAL FILM
492	5322 116 54188	1,0M	1	MR30	METAL FILM
493	5322 116 54549	1,0K	1	MR25	METAL FILM
494	5322 116 54892	200K	1	MR30	METAL FILM
496	5322 101 24073	4,7K	20	0,1W	CARBON POTM LIN
497	5322 116 54323	800K	1	MR30	METAL FILM
498	5322 116 54716	162K	1	MR25	METAL FILM
499,503	5322 116 54469	100	1	MR25	METAL FILM
504	5322 116 50522	13,0K	1	MR25	METAL FILM
506	4822 100 10037	1,0K	20	0,1W	TRIMMING POTM
507	5322 116 50572	12,1K	1	MR25	METAL FILM
508,509	5322 116 54644	21K	1	MR25	METAL FILM
510,511	5322 116 54442	51,1	1	MR25	METAL FILM
512	5322 116 54576	2,37K	1	MR25	METAL FILM
513,514	5322 116 54571	1,96K	1	MR25	METAL FILM
515	5322 116 54587	3,65K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
516,517	5322 116 54431	16,2	1	MR25	METAL FILM
518	5322 116 54587	3,65K	1	MR25	METAL FILM
519	5322 116 54545	909	1	MR25	METAL FILM
521,522	5322 116 54536	750	1	MR25	METAL FILM
523	5322 116 54701	110K	1	MR25	METAL FILM
524	5322 116 54558	8,25K	1	MR25	METAL FILM
526	4822 110 60117	2,4K	5	CR25	CARBON
527	5322 116 54426	121	1	MR25	METAL FILM
528,529	5322 116 50417	162	1	MR25	METAL FILM
531	5322 116 50766	147	1	MR25	METAL FILM
532	4822 100 10038	470	20	0,1W	TRIMMING POTM
533	5322 116 50482	33,2K	1	MR25	METAL FILM
534	5322 116 50876	26,1	1	MR25	METAL FILM
536	5322 116 50515	1,78K	1	MR25	METAL FILM
537	4822 110 60122	3,6K	5	R25	CARBON
538	5322 116 50679	237	1	MR25	METAL FILM
539	4822 110 63127	5,6K	5	CR25	CARBON
541	4822 110 63107	1,0K	5	CR25	CARBON
542	5322 116 54589	3,83K	1	MR25	METAL FILM
543	5322 116 54608	7,5K	1	MR25	METAL FILM
544	5322 116 54529	619	1	MR25	METAL FILM
546	5322 116 54585	3,48K	1	MR25	METAL FILM
547	4822 110 60124	4,3K	5	CR25	CARBON
548	5322 116 50479	15,4K	1	MR25	METAL FILM
549	4822 110 60162	110K	5	CR25	CARBON
551	4822 110 63143	22K	5	CR25	CARBON
552	5322 116 54701	110K	1	MR25	METAL FILM
553	4822 110 60111	1,3K	5	CR25	CARBON
554	5322 116 54595	5,11K	1	MR25	METAL FILM
556	5322 116 54576	2,37K	1	MR25	METAL FILM
557	5322 116 54623	11K	1	MR25	METAL FILM
558,559	5322 116 54595	5,11K	1	MR25	METAL FILM
561,562	5322 116 50482	33,2K	1	MR25	METAL FILM
563,564	5322 116 54011	5162K	1	MR25	METAL FILM
566	5322 116 54549	1,0K	1	MR25	METAL FILM
567,568	5322 116 54011	5,62K	1	MR25	METAL FILM
569,571	5322 116 54012	6,81K	1	MR25	METAL FILM
572,573	4822 116 20063				VDR
574,576	5322 116 54012	6,81K	1	MR25	METAL FILM
577	4822 110 60102	620	5	CR25	CARBON
578,579	5322 116 54426	121	1	MR25	METAL FILM
581	4822 110 60102	620	5	CR25	CARBON
582	5322 116 50676	196	1	MR25	METAL FILM
583	4822 110 63027	1,0	5	CR25	CARBON
584,586,587	4822 110 63063	22	5	CR25	CARBON
588	5322 116 54655	30,1K	1	MR25	METAL FILM
589	5322 116 54532	649	1	MR25	METAL FILM
591	5322 116 50679	237	1	MR25	METAL FILM
592	5322 116 54536	750	1	MR25	METAL FILM
593	5322 116 54708	133K	1	MR25	METAL FILM
594	5322 116 54408	909K	1	MR30	METAL FILM
596	5322 116 50669	205	1	MR25	METAL FILM
597	4822 110 60108	1,1K	5	CR25	CARBON
598	5322 116 54701	110K	1	MR25	METAL FILM
599	4822 110 63194	1,8M	10	CR25	CARBON
601	4822 110 60073	51	5	CR25	CARBON
602	5322 116 50669	205	1	MR25	METAL FILM
603	5322 116 54536	750	1	MR25	METAL FILM
604	5322 116 54708	133K	1	MR25	METAL FILM
606	4822 110 63127	5,6K	5	CR25	CARBON
607	5322 116 54701	110K	1	MR25	METAL FILM
608	5322 116 54442	51,1	1	MR25	METAL FILM
609	5322 116 54595	5,11K	1	MR25	METAL FILM
611	4822 110 60111	1,3K	5	CR25	CARBON
612	5322 116 54655	30,1K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
613	5322 116 54504	274	1	MR25	METAL FILM
614	5322 116 54549	1,0K	1	MR25	METAL FILM
616	5322 116 54615	9,09K	1	MR25	METAL FILM
617	5322 116 54692	86,6K	1	MR25	METAL FILM
618	5322 116 54619	10K	1	MR25	METAL FILM
619	5322 116 54576	2,37K	1	MR25	METAL FILM
621	5322 116 54619	10K	1	MR25	METAL FILM
622	5322 116 54627	13,3K	1	MR25	METAL FILM
623	5322 101 44019	47K	20	0,1W	CARBON POTM LIN + SWITCH
624	5322 116 50522	13K	1	MR25	METAL FILM
626	5322 116 54637	17,8K	1	MR25	METAL FILM
627	5322 116 54576	2,37K	1	MR25	METAL FILM
628	5322 116 54558	8,25K	1	MR25	METAL FILM
629	5322 116 54624	11,5K	1	MR25	METAL FILM
631	5322 116 54619	10K	1	MR25	METAL FILM
632	5322 116 50415	1,15K	1	MR25	METAL FILM
633	5322 116 54696	100K	1	MR25	METAL FILM
634	5322 116 50481	22,6K	1	MR25	METAL FILM
635	5322 116 54442	51,1	1	MR25	METAL FILM
636	4822 110 60073	51	5	CR25	CARBON
638	4822 110 63178	470K	5	CR25	CARBON
639	4822 110 60126	5,1K	5	CR25	CARBON
641	5322 116 54508	301	1	MR25	METAL FILM
642	5322 116 50669	205	1	MR25	METAL FILM
643	5322 116 54011	5,62K	1	MR25	METAL FILM
644	5322 116 50555	1,27K	1	MR25	METAL FILM
645	5322 116 54595	5,11K	1	MR25	METAL FILM
646,647	5322 116 50524	3,01K	1	MR25	METAL FILM
648	5322 116 54619	10K	1	MR25	METAL FILM
649	4822 110 60128	6,2K	5	CR25	CARBON
651	4822 100 10075	100	20	0,1W	TRIMMING POTM
652	5322 116 54011	5,62K	1	MR25	METAL FILM
653	5322 116 54655	30,1K	1	MR25	METAL FILM
654	5322 116 50593	16,2K	1	MR25	METAL FILM
656	5322 116 54011	5,62K	1	MR25	METAL FILM
657	4822 110 60073	51	5	CR25	CARBON
658	5322 116 54655	30,1K	1	MR25	METAL FILM
659	5322 116 50593	16,2K	1	MR25	METAL FILM
661	4822 110 60139	16K	5	CR25	CARBON
662	4822 110 60133	9,1K	5	CR25	CARBON
663	4822 110 63125	4,7K	5	CR25	CARBON
664	4822 110 63145	27K	5	CR25	CARBON
666	5322 101 64012	47K	20	0,1W	CARBON POTM LIN + SWITCH
667	4822 110 63134	10K	5	CR25	CARBON
668	5322 116 54442	51,1	1	MR25	METAL FILM
669	5322 116 54532	649	1	MR25	METAL FILM
672	4822 110 63125	4,7K	5	CR25	CARBON
673,674	5322 116 50635	1,47K	1	MR25	METAL FILM
676	4822 110 63143	22K	5	CR25	CARBON
677	5322 116 50515	1,78K	1	MR25	METAL FILM
678	5322 116 54615	9,09K	1	MR25	METAL FILM
679	5322 116 54632	14,7K	1	MR25	METAL FILM
681,682	5322 116 54552	1,05K	1	MR25	METAL FILM
683	5322 116 54689	82,5K	1	MR25	METAL FILM
684	5322 116 50583	5,9K	1	MR25	METAL FILM
686	5322 116 50414	2,87K	1	MR25	METAL FILM
687,688	5322 116 54689	82,5K	1	MR25	METAL FILM
689,691	4822 116 20063				VDR
692	5322 116 54689	82,5K	1	MR25	METAL FILM
693	5322 116 54595	5,11K	1	MR25	METAL FILM
694	5322 116 54009	562	1	MR25	METAL FILM
696	5322 116 54518	383	1	MR25	METAL FILM
697	5322 116 54009	562	1	MR25	METAL FILM
698	5322 116 54595	5,11K	1	MR25	METAL FILM
701	4822 110 60073	51	5	CR25	CARBON
702	4822 110 63123	3,9K	5	CR25	CARBON
703	5322 116 54426	121	1	MR25	METAL FILM
704	5322 116 54557	1,21K	1	MR25	METAL FILM
706	5322 116 50579	3,16K	1	MR25	METAL FILM
707	5322 116 50479	15,4K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	DHM	TOL (%)	TYPE	REMARKS
708	5322 116 54558	8,25K	1	MR25	METAL FILM
709	5322 116 54554	1,1K	1	MR25	METAL FILM
711	5322 116 54608	7,5K	1	MR25	METAL FILM
712	4822 110 60073	51	5	CR25	CARBON
713	5322 116 54519	402	1	MR25	METAL FILM
714	5322 116 50559	27,4K	1	MR25	METAL FILM
715	5322 116 54554	1,1K	1	MR25	METAL FILM
716	5322 116 54549	1,0K	1	MR25	METAL FILM
717	5322 116 54529	619	1	MR25	METAL FILM
718	5322 116 54565	1,62K	1	MR25	METAL FILM
719	5322 116 50581	2,49K	1	MR25	METAL FILM
721	5322 116 50669	205	1	MR25	METAL FILM
722	4822 110 60108	1,1K	5	CR25	CARBON
723	5322 116 54619	10K	1	MR25	METAL FILM
724	4822 110 63147	33K	5	CR25	CARBON
726	4822 110 63081	100	5	CR25	CARBON
729	5322 116 50484	4,64K	1	MR25	METAL FILM
731	5322 116 50664	2,05K	1	MR25	METAL FILM
732	4822 110 60153	51K	5	CR25	CARBON
733	5322 116 50515	1,78K	1	MR25	METAL FILM
734	4822 100 10021	1,0K	20	0,1W	TRIMMING POTM
735	5322 116 54615	9,09K	1	MR25	METAL FILM
736	4822 110 63116	2,2K	5	CR25	CARBON
737	5322 116 54005	3,32K	1	MR25	METAL FILM
738	5322 116 50726	36,5K	1	MR25	METAL FILM
739	4822 110 63067	33	5	CR25	CARBON
740	4822 116 30062	15K	10	0,6W	NTC
741	4822 110 60075	62	5	CR25	CARBON
742	4822 110 60146	30K	5	CR25	CARBON
743	5322 116 50479	15,4K	1	MR25	METAL FILM
744	4822 100 10027	2,2K	20	0,1W	TRIMMING POTM
746	4822 100 10025	4,7K	20	0,1W	TRIMMING POTM
747	5322 116 54549	1,0K	1	MR25	METAL FILM
748	4822 110 63089	220	5	CR25	CARBON
749	4822 110 63127	5,6K	5	CR25	CARBON
751	4822 110 60135	11K	5	CR25	CARBON
752	4822 110 63147	33K	5	CR25	CARBON
753	4822 110 63132	8,2K	5	CR25	CARBON
754	4822 110 60137	13K	5	CR25	CARBON
756	5322 116 50524	3,01K	1	MR25	METAL FILM
757-759	4822 110 63063	22	5	CR25	CARBON
761,762	4822 110 63107	1,0K	5	CR25	CARBON
763	4822 110 63125	4,7K	5	CR25	CARBON
764,766	4822 110 63132	8,2K	5	CR25	CARBON
767	4822 110 63125	4,7K	5	CR25	CARBON
768,769	4822 110 63065	27	5	CR25	CARBON
771	5322 116 54571	1,96K	1	MR25	METAL FILM
772	5322 116 50572	12,1K	1	MR25	METAL FILM
773,774	4822 110 63107	1,0K	5	CR25	CARBON
776	4822 110 63125	4,7K	5	CR25	CARBON
777	4822 110 63121	3,3K	5	CR25	CARBON
778	4822 110 60131	7,5K	5	CR25	CARBON
779	4822 100 10021	1,0K	20	0,1W	TRIMMING POTM
781	4822 110 63127	5,6K	5	CR25	CARBON
782	4822 110 60146	30K	5	CR25	CARBON
783,784	5322 116 55096	820	5	PR52	METAL FILM
786	4822 110 60131	7,5K	5	CR25	CARBON
791	5322 116 50414	2,87K	1	MR25	METAL FILM
792	4822 110 42223	22M	5	VR37	CARBON
793	4822 110 53107	1,0K	5	CR37	CARBON
794	4822 100 10022	220K	20	0,1W	TRIMMING POTM
797	4822 110 60186	910K	5	CR25	CARBON
798	4822 110 63187	1,0M	5	CR25	CARBON
799	5322 116 64027	7,5M	5	VR37	METAL OXIDE
801	4822 116 51099	10K	5	PR37	METAL FILM
802	4822 110 63114	1,8K	5	CR25	CARBON
803	4822 110 60151	43K	5	CR25	CARBON
803	5322 116 54669	45,3	1	MR25	METAL FILM
804	5322 116 54558	8,25K	1	MR25	METAL FILM
806	4822 110 60151	43K	5	CR25	CARBON



ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
807	4822 116 20063				VDR
808	5322 116 54595	5,11K	1	MR25	METAL FILM
809	4822 110 60093	300	5	CR25	CARBON
811	4822 110 63063	22	5	CR25	CARBON
812	4822 100 10076	47K	20	0,1W	TRIMMING POTM
813	4822 110 60166	160K	5	CR25	CARBON
814	4822 110 60159	91K	5	CR25	CARBON
816	4822 110 63125	4,7K	5	CR25	CARBON
817,818	4822 110 63072	47	5	CR25	CARBON
821,822	5322 116 54696	100K	1	MR25	METAL FILM
823	4822 101 20304	220K	20	0,25W	CARBON POTM LIN
824	5322 101 24111	4,7M	20	0,25W	CARBON POTM LIN
826	5322 116 54538	787	1	MR25	METAL FILM
831	5322 116 50642	845K	1	MR30	METAL FILM
832	5322 116 50196	422K	1	MR30	METAL FILM
833	5322 116 54208	210K	1	MR25	METAL FILM
834	5322 116 54691	84,5K	1	MR25	METAL FILM
836	5322 116 50474	42,2K	1	MR25	METAL FILM
837	5322 116 54644	21K	1	MR25	METAL FILM
838	5322 116 54558	8,25K	1	MR25	METAL FILM
839	5322 116 54593	4,12K	1	MR25	METAL FILM
841	5322 116 50664	2,05K	1	MR25	METAL FILM
842	5322 101 44018	10K	20	0,1W	CARBON POTM LIN + SWITCH

## 3.6.3.4. Diodes

Type	Ordering number
AAZ15	5322 130 30229
BAV21	4822 130 30842
BAV45	5322 130 34037
BAW62	5322 130 30613
BAX17	5322 130 30605
BY179	5322 130 30521
BY184	5322 130 30668
BY206	4822 130 30839
BYX10	5322 130 30195
BZX75-C2V1	5322 130 34049
BZX75-C2V8	5322 130 34048
BZX79-B5V6	5322 130 34173
BZX79-B10	5322 130 34297
BZX79-C5V6	5322 130 34173
BZX79-C6V8	5322 130 34278
BZX79-C8V2	5322 130 34382
BZX79-C30	5322 130 30652
BZX79-C56	5322 130 34258
BZX79-C62	5322 130 34384
BZX79-C68	4822 130 30864
BZX79-B75	5322 130 34685
CQY24A	5322 130 30922

## 3.1.2.5. Integrated circuits

Type	Ordering number
CA3086	5322 209 84111
CNY43	5322 130 44395
SG 3823N	5322 209 84862
N74LS00A or	5322 209 84823
SN74LS00N	5322 209 84983
N7472A or	5322 209 84166
SN7472N-00	5322 209 84166

## 3.1.2.4. Transistors

Type	Ordering number
BF422	4822 130 41084
BC328	5322 130 44104
BC338	5322 130 44121
BC547	5322 130 44257
BC548	4822 130 40938
BC548C	5322 130 44196
BC557	5322 130 44256
BC558	4822 130 40941
BC558B	5322 130 44197
BD263A	5322 130 44389
BD237	5322 130 44235
BF199	5322 130 44154
BF240	4822 130 40902
BF450	5322 130 44237
BF458	5322 130 44403
BF459	5322 130 44413
BF494	5322 130 44195
BSS38	4822 130 40968
BSX20	5322 130 40417
*ON561	5322 130 44302

\*) ON561 is a matched FET pair.

The ON561 pair can be replaced by matched FET pair BFW11.

Ordering number: 5322 130 44643.

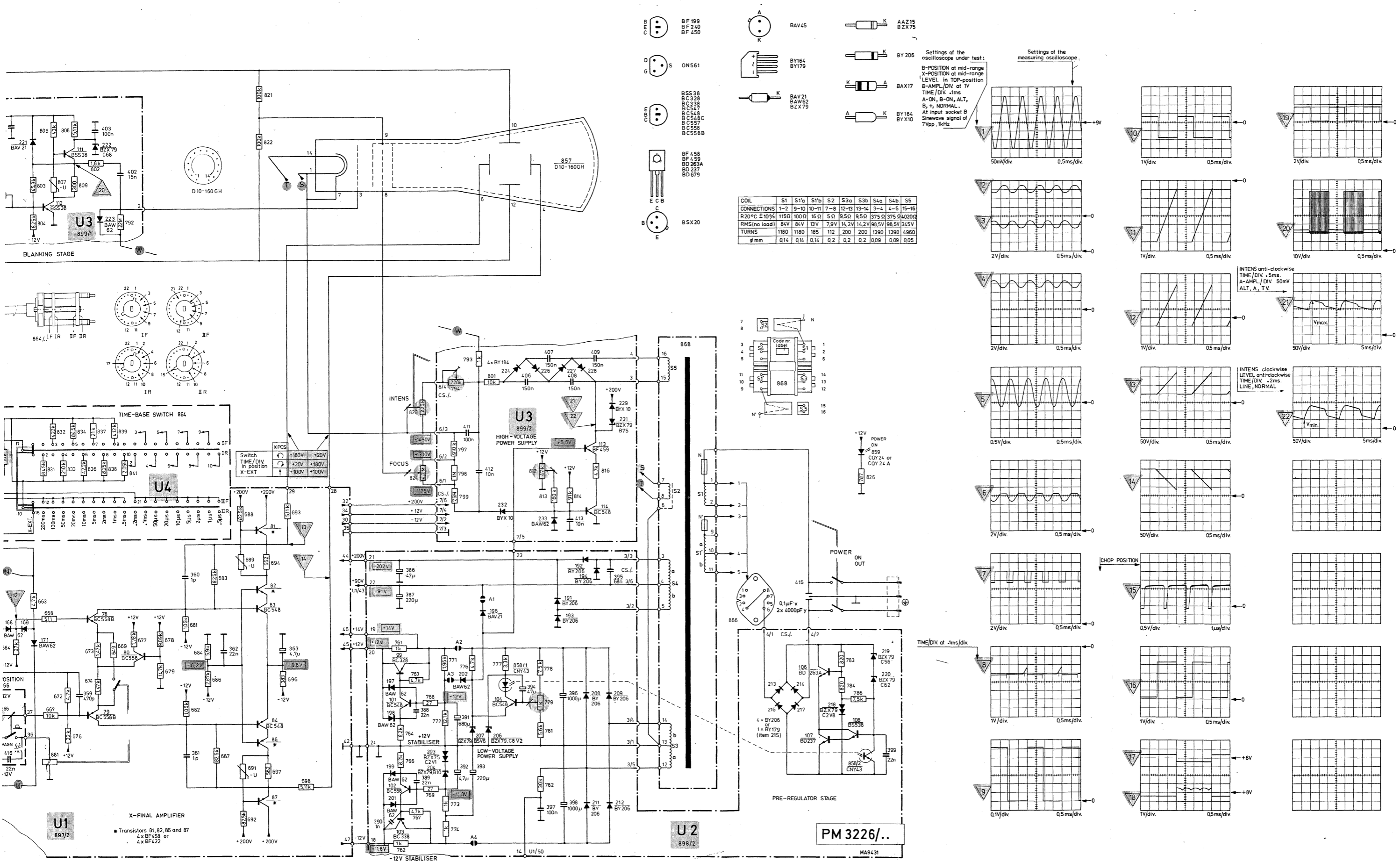


Fig. 3.39. Overall circuit diagram PM 3226

**CODING SYSTEM OF FAILURE REPORTING FOR QUALITY  
ASSESSMENT OF T & M INSTRUMENTS  
(excl. potentiometric recorders)**

The information contents of the coded failure description is necessary for our computerized processing of quality data.

Since the reporting of repair and maintenance routines must be complete and exact, we give you an example of a correctly filled-out PHILIPS SERVICE Job sheet.

①	②	③	④																								
Country	Day Month Year	Typenumber /Version	Factory/Serial no.																								
<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 15px; height: 15px; text-align: center;">3</td><td style="width: 15px; height: 15px; text-align: center;">2</td></tr> </table>	3	2	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 15px; height: 15px; text-align: center;">1</td><td style="width: 15px; height: 15px; text-align: center;">5</td><td style="width: 15px; height: 15px; text-align: center;">0</td><td style="width: 15px; height: 15px; text-align: center;">4</td><td style="width: 15px; height: 15px; text-align: center;">7</td><td style="width: 15px; height: 15px; text-align: center;">5</td></tr> </table>	1	5	0	4	7	5	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 15px; height: 15px; text-align: center;">O</td><td style="width: 15px; height: 15px; text-align: center;">P</td><td style="width: 15px; height: 15px; text-align: center;">M</td><td style="width: 15px; height: 15px; text-align: center;">3</td><td style="width: 15px; height: 15px; text-align: center;">2</td><td style="width: 15px; height: 15px; text-align: center;">6</td><td style="width: 15px; height: 15px; text-align: center;">0</td><td style="width: 15px; height: 15px; text-align: center;">0</td><td style="width: 15px; height: 15px; text-align: center;">2</td></tr> </table>	O	P	M	3	2	6	0	0	2	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr><td style="width: 15px; height: 15px; text-align: center;">D</td><td style="width: 15px; height: 15px; text-align: center;">O</td><td style="width: 15px; height: 15px; text-align: center;">0</td><td style="width: 15px; height: 15px; text-align: center;">0</td><td style="width: 15px; height: 15px; text-align: center;">7</td><td style="width: 15px; height: 15px; text-align: center;">8</td><td style="width: 15px; height: 15px; text-align: center;">3</td></tr> </table>	D	O	0	0	7	8	3
3	2																										
1	5	0	4	7	5																						
O	P	M	3	2	6	0	0	2																			
D	O	0	0	7	8	3																					

**CODED FAILURE DESCRIPTION**

⑤	⑥	⑦	⑧																																																																	
Nature of call	Location	Component/sequence no.	Category																																																																	
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Detailed description of the information to be entered in the various boxes:

①Country: 

3	2
---	---

 = Switzerland

②Day Month Year 

1	5	0	4	7	5
---	---	---	---	---	---

 = 15 April 1975

③Type number/Version 

O	P	M	3	2	6	0	0	2
---	---	---	---	---	---	---	---	---

 = Oscilloscope PM 3260, version 02 (in later oscilloscopes this number is placed in front of the serial no)

④Factory/Serial number 

D	O	0	0	7	8	3
---	---	---	---	---	---	---

 = DO 783 These data are mentioned on the type plate of the instrument

⑤ Nature of call: Enter a cross in the relevant box

⑥ Coded failure description

**Location**

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These four boxes are used to isolate the problem area. Write the code of the part in which the fault occurs, e.g. unit no or mechanical item no of this part (refer to 'PARTS LISTS' in the manual).  
Example: 0001 for Unit 1  
          000A for Unit A  
          0075 for item 75  
If units are not numbered, do not fill in the four boxes; see Example Job sheet.

**Component/sequence no.**

--	--	--	--	--	--

These six boxes are intended to pinpoint the faulty component.  
A. Enter the component designation as used in the circuit diagram. If the designation is alfa-numeric, the letters must be written (starting from the left) in the two left-hand boxes and the figures must be written (in such a way that the last digit occupies the right-most box) in the four right-hand boxes.  
B. Parts not identified in the circuit diagram:  
990000 Unknown/Not applicable  
990001 Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)  
990002 Knob (incl. dial knob, cap, etc.)  
990003 Probe (only if attached to instrument)  
990004 Leads and associated plugs  
990005 Holder (valve, transistor, fuse, board, etc.)  
990006 Complete unit (p.w. board, h.t. unit, etc.)  
990007 Accessory (only those without type number)  
990008 Documentation (manual, supplement, etc.)  
990009 Foreign object  
990099 Miscellaneous

**Category**

--

- 0 Unknown, not applicable (fault not present, intermittent or disappeared)
- 1 Software error
- 2 Readjustment
- 3 Electrical repair (wiring, solder joint, etc.)
- 4 Mechanical repair (polishing, filing, remachining, etc.)
- 5 Replacement (of transistor, resistor, etc.)
- 6 Cleaning and/or lubrication
- 7 Operator error
- 8 Missing items (on pre-sale test)
- 9 Environmental requirements are not met

⑦ Job completed: Enter a cross when the job has been completed.

⑧ Working time: Enter the total number of working hours spent in connection with the job (excluding travelling, waiting time, etc.), using the last box for tenths of hours.

	1	2
--	---	---

 = 1,2 working hours (1 h 12 min.)

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