



**2438**

**520 MHz**

**UNIVERSAL COUNTER TIMER**

**Operating Manual**



## 520 MHz Universal Counter Timer 2438

Code Nos. 52438-302L and -303J  
which includes UCT Set 52438-304F

### HAZARD WARNING SYMBOLS

The following symbols appear on the equipment

<i>Symbol</i>	<i>Type of hazard</i>	<i>Reference in manual</i>
⚠	RF input limit	Chap. 1, page 5 and Chap. 3, page 5
⚠	AC supply setting	Chap. 2, page 3 and Chap. 3, page 6
⚠	Static sensitive component	See service manual

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ST. ALBANS HERTFORDSHIRE ENGLAND.



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### PRELIMINARIES

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### CHAPTERS

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#### Note...

Each page bears the date of the original issue or the code number and date of the latest amendment (Am. 1, Am. 2 etc.). New or amended material of technical importance introduced by the latest amendment is indicated by triangles positioned thus  .....  to show the extent of the change. When a chapter is reissued the triangles do not appear.

Any changes subsequent to the latest amendment state of the manual are included on inserted sheets coded C1, C2 etc.

## NOTES AND CAUTIONS

### ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

#### Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

#### Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, short together the L (live) and N (neutral) pins of the mains plug.

#### Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective



action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

### Fuses

Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

## Chapter 1

# GENERAL INFORMATION

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## INTRODUCTION

1. Marconi Instruments Universal Counter Timer type 2438 provides measurement of frequency, frequency ratio, period, time interval and total count. Multiple period and time interval averaging measurement modes allow increased accuracy for period and time interval measurements. 2438 can measure frequency from 0 to 520 MHz and period or time interval from 100 ns to 1 ks. It can handle amplitudes from 30 mV to 250 V r.m.s. Frequency measurements can be resolved to 0.1 Hz, time interval to 3.3 ns and period to 100 ps.





Fig. 1 520 MHz Universal Counter Timer type 2438

2. There are two input channels, each with its own triggering controls. The triggering controls provide a.c. or d.c. coupling, x1 or x10 attenuation, positive or negative trigger slope and trigger level which is variable between -25 V and +25 V, with a 0 V preset position. A flashing l.e.d. indicates when the input signal is within triggering range and a monitor output provides a signal with which to trigger an oscilloscope display for accurate measurement of trigger point. False triggering due to contact bounce can be eliminated by the use of the delay time control. When the rear panel delay control is switched on, a delay circuit is triggered by the first input signal and locks out further triggering for a time determined by the setting of the delay control. The delay time is variable between 150  $\mu$ s and 8 ms.

3. Measurement modes and ranges are selected by front panel push button switches. In the total count mode, a front panel push button is used to manually start and stop the count, and another front panel push button is used to reset the counter. Alternatively, an input to channel A can start or stop the count. Frequency and frequency ratio measurements both use the channel B input, but frequency ratio measurements also use

a rear panel input socket for the lower of the two input frequencies. Period measurements use the channel A input, and time interval measurements require a start signal on channel A and a stop signal on channel B. The counter timer uses multiple period or time interval averaging when any of the three highest resolution ranges and period or time interval have been selected.

4. 2438 is fitted with a temperature compensated crystal oscillator frequency standard that has less than 1.5 parts per million variation over its operating temperature range. An optional version of 2438 is fitted with an oven controlled crystal oscillator frequency standard that has less than 0.1 parts per million variation over its temperature range. Alternatively, an external frequency standard can be used which is plugged into a rear panel socket on the 2438. Should the external standard fail the 2438 automatically switches back to its internal reference.

5. The display panel has an eight digit l.e.d. display with self check facility. Leading zeros are suppressed. Also on the display panel, lamps indicate whether the display has overflowed, whether an external frequency standard has been accepted and whether the counter gate is open. The numerical display is latched so that it is updated only at the end of each measurement sequence, except in the total count mode. The time between measurement sequences, which can be from 100 ms to 10 s, is set by a display time control. When the delay control is switched on, the decimal point flashes, and if required, a display of the delay time may be selected.

6. A data interface kit is available as an optional accessory, which allows the counter timer to be used with a printer or as part of an instrumentation system. External control signals set the required mode and range, and trigger the measurement sequence. The result is multiplexed through the interface by external synchronizing signals. See para. 12 and Chap. 2, para. 9 for further details.



PERFORMANCE DATA

Characteristic

Performance

Characteristic

Performance

7. Inputs

Two inputs are provided, channel A and channel B. Also, the external standard input may be used for ratio measurements.

Input channel A

Frequency range : DC coupled : 0 to 10 MHz.  
AC coupled : 10 Hz to 10 MHz.

Sensitivity : 30 mV r.m.s. (sine wave) from 0 to 1 MHz.

50 mV r.m.s. (sine wave) from 1 MHz to 10 MHz.

Input channel B

Frequency range : DC coupled : 0 to 10 MHz.  
AC coupled : 10 Hz to 10 MHz.  
AC coupled, FREQ mode : 10 Hz to 50 MHz.  
AC coupled, UHF mode : 50 MHz to 520 MHz.

Sensitivity : 30 mV r.m.s. (sine wave) from 0 to 1 MHz.

50 mV r.m.s. (sine wave) from 1 MHz to 10 MHz.

FREQ mode : 10 mV r.m.s. (sine wave) from 10 Hz to 20 MHz.

15 mV r.m.s. (sine wave) from 20 MHz to 50 MHz.

UHF mode : -19 dBm (25 mV r.m.s. p.d. into 50  $\Omega$ ) from 50 MHz to 520 MHz.

Channels A & B

Input impedance : Approx. 1 M $\Omega$  in parallel with less than 45 pF except for

$\triangle$  Maximum input :

Controls :

Trigger level :

Monitor outputs :

Trigger indication:

channel B UHF mode, 50  $\Omega$  nominal.

DC coupled : 250 V d.c.  
AC coupled : 250 V r.m.s. (sine wave) at 50 Hz decreasing to 5 V r.m.s. (sine wave) at 50 MHz except for channel B UHF mode +27 dBm (5 V r.m.s. p.d. into 50  $\Omega$ ) from 50 MHz to 520 MHz.

Separate push buttons for each channel provide :

Coupling - a.c. or d.c.

Attenuator - attenuates input by x10 nominal except channel B, UHF frequency mode = 10 dB nominal.

Slope - selects +ve or -ve trigger.

A single push button commons both channels.

Separate controls adjust trigger level from :

0 V to  $\pm 2.5$  V (attenuator x1),  
0 V to  $\pm 25$  V (attenuator x10).

Front panel outputs allow monitoring of trigger points. +ve edge of output waveform corresponds to trigger point.

Separate lamps indicate trigger level :

Lamp on - trigger level above signal threshold.

Lamp off - trigger level below signal threshold.

Lamp flashing - triggering in range.



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Ratio input Rear panel switch enables external standard input to be used for ratio measurements.

Frequency range : 10 kHz to 10 MHz.

Sensitivity : 180 mV r.m.s. (sine wave).

Maximum input : 1.8 V r.m.s. (sine wave).

Input impedance : 10 kΩ nominal.

Period and time : 100 ns minimum, to 1 ks maximum without overflow.

Count : Up to 10<sup>7</sup> events per second.

Range selection :

Five push buttons select the following ranges and indicate readout units :

8. Modes of operation

Functions :

Seven push buttons select the following functions :

- (1) Freq. B - channel B is used for frequency measurements.
- (2) UHF - selects u.h.f. mode on channel B for frequency measurement only.
- (3) Per. A - channel A is used for period measurements.
- (4) Count B - channel B input is counted.
- (5) Start/stop - momentary action button is used to start and stop count function. The count function is also started and stopped by an input to channel A.
- (6) Reset - resets memory and display (for use mainly in count mode).
- (7) T int. A-B - a time interval measurement is started by a pulse on channel A and stopped by a pulse on channel B. The number of intervals averaged depends on the range selected.

Simultaneous selection of Per. A and UHF functions causes delay time to be displayed.

Range of operation :

Frequency : 0 to 520 MHz (see channel B specification).

Readout units	Frequency mode			Period or time interval mode		
	Gate time	UHF	Resolution	No. periods averaged	Resolution	
(1) MHz, s	1ms	10ms	1kHz	1	10μs	
(2) MHz, ms	10ms	100ms	100Hz	1	100ns	
(3) kHz, μs	100ms	1s	10Hz	10	10ns	32ns
(4) kHz, μs	1s	10s	1Hz	100	1ns	10ns
(5) Hz, ns	10s	100s	0.1Hz	1000	100ps	3.3ns

In the time interval averaging mode,

$$\text{resolution} = \frac{100\text{ns}}{\sqrt{\text{no. of intervals averaged}}} \pm 100\text{ps}$$

Ratio mode :

Rear panel switch selects ratio mode. Selection of Freq. B then measures ratio between channel B input and rear panel input :

$$\text{Displayed ratio} = \frac{nB}{R}, \text{ where } n = \begin{matrix} 10^4 & \text{for range (1)} \\ 10^5 & \text{for range (2)} \\ 10^6 & \text{for range (3)} \\ 10^7 & \text{for range (4)} \\ 10^8 & \text{for range (5)} \end{matrix}$$



*Characteristic*

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Delay control : A rear panel control provides a variable delay for use in Time Interval, Count B, and Period A modes to eliminate false triggering due to contact bounce. Both channels are disabled for a pre-determined period following receipt of a start signal. The decimal point flashes when delay is switched on.

Range : 150  $\mu$ s to 8 ms continuous adjustment.

Dead time : Typically 100 ns (time between delay trigger pulse and delay becoming operative).

9. Display

8 digit with memory. (7 segment l.e.d. of 8 mm height).

Features : Decimal point automatically selected. Lamp indicates overflow. Leading zeros suppressed. Digit check facility - releasing all range buttons displays all segments and decimal points.

Display time : Front panel control varies display time typically from 100 ms to 10 s in addition to gate time.

Gate indication : Lamp indicates gating period.

10. Accuracy

Frequency measurement :  $\pm 1$  count  $\pm$  frequency standard error.

*Characteristic*

*Performance*

Period measurement :  $\pm 1$  count  $\pm$  frequency standard error  
 $\pm \frac{\text{trigger error}}{\text{no. of periods averaged}}$

Time interval measurement:

Single interval :  $\pm 1$  count  $\pm$  frequency standard error  $\pm$  trigger error.

Interval averaging :  $\pm$  systematic error  $\pm$  frequency standard error  
 $\pm \frac{100 \text{ ns} \pm \text{trigger error}}{\sqrt{\text{no. of periods averaged}}}$

- 1) Minimum pulse width for period or time measurement is 50 ns.
- 2) Minimum dead time from each stop event to next start event is 100 ns.
- 3) Trigger error is  $<0.3\%$  of one period for sine wave of 40 dB S/N or better and amplitude equal to sensitivity of instrument. For any waveshape, trigger error is less than  $\frac{\pm 2 \times \text{peak noise voltage}}{\text{signal slope}}$  or  $\frac{\pm 0.85 \text{ ns}}{\text{signal slope}}$  for 40 dB S/N
- 4) Systematic error is the difference in delays between the start and stop channels which can be minimized by external matching. Without matching the error is 10 ns max. per input.



*Characteristic*

*Performance*

Frequency standard : Internal oscillator or external input automatically selected. Application of external signal overrides internal oscillator. Front panel lamp indicates when external standard is accepted.

External standard input

Frequency : 10 MHz (sine or square wave). Usable from 10 kHz to 10 MHz for ratio measurements.

Input level : 500 mV to 5 V p-p.

Impedance : Approximately 10 k $\Omega$  a.c. coupled.

11. Internal standard

Adjustment range : Control accessible through rear panel allows adjustment of internal standard to compensate for ageing.

Stability

*Oven controlled crystal oscillator type,  
code nos. 52438-303J and 52438-304F*

Temperature :  $\leq \pm 0.1$  p.p.m. over operating temperature range, 0°C to 40°C.

Age rate :  $< 1$  p.p.m. per year after 30 days continuous use.

*Temperature-compensated crystal oscillator type,  
code no. 52438-302L*

Temperature :  $< \pm 1.5$  p.p.m. over operating temperature range 0°C to 40°C.

Age rate :  $< 2$  p.p.m. per year after 30 days continuous use.

*Characteristic*

*Performance*

Auxiliary output : Internal standard at 10 MHz available from rear panel socket.

Level : Greater than 100 mV p-p into 50  $\Omega$  (approximately 4 V e.m.f.).

Impedance : Approximately 2 k $\Omega$ .

12. Data interface

BCD data output and remote range selection are available using the data output lead (see accessories). This lead, installed by the user provides the following connections.

*Mnemonic*

*Function*

ABCD	}	BCD output, bit parallel byte serial.
BBCD		
CBCD		
DBCD		
DEN	Display enable input.	
OFL	Overflow indication output.	
NCLR	Counter and display clear input.	
NINH	Counter gate control : may be used as an output to monitor gate or as an input to control gate.	
SCX	External display scan input, also controls data output multiplexing.	
SCR	Internal/external multiplexing switch and multiplexer reset input.	
DPT	Decimal point output.	
LZS	Leading zeros suppression output.	



*Characteristic*

*Performance*

<i>Mnemonic</i>	<i>Function</i>	
ATB	} 1 of five range selection input	
BTB		
CTB		
DTB		
ETB		
FUNC	Select UHF mode input	
NREM	} Select 1 of five modes	
TIME		Not remote (i.e. local)
PER		Time interval
CNTB		Period
FREQ		Total count
	Frequency	

*Characteristic*

*Performance*

15. <u>Safety</u>	Meets the requirements of IEC 348.
16. <u>Power requirements</u>	
Voltage :	AC mains voltage ranges (switchable) 95 to 120 V, 105 to 132 V, 190 to 240 V, 210 to 264 V.
Frequency :	45 to 440 Hz.
Consumption :	Approximately 20 VA.
17. <u>Dimensions and weight</u>	
Height :	108 mm (4.25 in) overall.
Width :	215 mm (8.5 in) without handle. 256 mm (10.1 in) with handle.
Depth :	338 mm (13.3 in) overall.
Weight :	2.2 kg (4.85 lb).
18. <u>Accessories</u>	
Supplied :	Mains lead 43123-076Y. Operating Manual H 52438-900P, Vol. 1, code no. 46881-361P.
Optional :	*Cover (lid) 54124-022L. *BNC lead, 1 m, 50 Ω, 43126-012S. Rack mounting kit 46883-401T. Data output lead kit 46883-405C. *Monitor output lead kit 43129-399L. Telescopic aerial, BNC 54421-001N. Service Manual H 52438-900P, Vol. 2, code no. 46881-362X. Attenuator 20 dB, 1 W, 54431-011D.

\* These items are supplied accessories with the UCT Set 52438-304F.

13. Environmental

Rated range of use

Temperature : 0°C to 40°C.

Conditions of storage and transport

Temperature : -40°C to +70°C.

Humidity : Up to 90% relative humidity.

Altitude : Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3.9 lbf/in<sup>2</sup>).

Limit range of operation

Temperature : 0°C to 55°C.

14. Radio frequency interference

This equipment conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.



Chapter 2

INSTALLATION

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UNPACKING AND REPACKING

1. Retain the packing materials and the packing instruction note (if included) in case it is necessary to reship the instrument.
2. If the instrument is to be returned for servicing attach a label indicating the service required, type or model number (on rear label), serial number and your return address. Pack the instrument in accordance with the general instructions below or with the more detailed information in the packing instruction note.
  - (1) Place a pad in the bottom of the container.
  - (2) Place pads in the front and rear ends of the container with load spreaders facing inwards.
  - (3) Put the polythene cover over the instrument and place it in the container with the front and rear projections against the load spreaders.



- (4) Place pads in the two sides of the container with cushioning facing inwards.
- (5) Place the top pad in position.
- (6) Wrap the container in waterproof paper and secure with adhesive tape.
- (7) Mark the package FRAGILE to encourage careful handling.

If the original container or materials are not available, use a strong double-wall carton packed with a 7 to 10 cm layer of shock absorbing material around all sides of the instrument to hold it firmly. Protect the front panel with a plywood or cardboard load spreader; if the rear panel has guard plates or other projections a rear load spreader is also advisable.

#### MOUNTING ARRANGEMENTS

3. If a plastic cover is fitted over the instrument, it should be removed before the instrument is used.
4. The instrument is supplied ready for bench mounting, but a rack mounting tray is available as an accessory. It consists of a housing with two compartments either of which will accommodate 2438 without its case. The other compartment is covered with a blank front panel and can be used to house a second instrument of similar size. Full fitting instructions are supplied with the tray.

#### MAINS SUPPLY

5. The mains lead supplied is a free cable, fitted at one end with a socket which connects to the 3-pin plug on the instrument's rear panel. When fitting a mains plug to the lead, make sure that the following colour coding is observed :

Live - Brown  
Neutral - Blue  
Earth - Green/Yellow

- ⚠ 6. Before connecting the instrument to the mains supply, check that rear panel AC SUPPLY switches are correctly set and that the fuses fitted are the correct rating. The instrument is normally despatched with the AC SUPPLY switches set to 230/240 V. To change to another supply voltage, remove the rear panel switch locking plate, and change the switch positions so that the locking plate can be refitted to reveal the required supply voltage marked on the rear panel.

#### Fuses

7. The correct fuse rating for any supply voltage is also marked on the rear panel. The supply voltage ranges available and their corresponding fuse ratings are as follows. (Fuses are time-delay type.)

230-240 V - 250 mA (T)  
210-220 V - 250 mA (T)  
115-120 V - 500 mA (T)  
105-110 V - 500 mA (T)

#### SAFETY TESTING

8. Where safety tests on the mains input circuit are required, the following procedures can be applied. These comply with BS4743 and IEC Publication 348. Tests are to be carried out as follows and in the order given, under ambient conditions, to ensure that mains input circuit components and wiring (including earthing) are safe.

(1) Earth lead continuity test from any part of the metal frame to the bared end of the flexible lead for the earth pin of the user's mains plug. Preferably a heavy current (about 25 A) should be applied for not more than 5 seconds.

Test limit : not greater than 0.5  $\Omega$ .

(2) 500 V d.c. insulation test from the mains circuit to earth and other circuits.

Test limit : not less than 2 M $\Omega$ .



## DATA INTERFACE

9. A data interface kit is available as an optional accessory - see Chap. 1, para. 12. The kit consists of a connector assembly and installation instructions. The connector assembly consists of the data interface connector which you mount on the rear panel of the instrument after you have removed the blanking plate. Also it consists of a ribbon cable from the data interface connector which divides into five branches, each of which is wired to a miniature socket. When the connector assembly is installed, the miniature sockets plug into miniature printed circuit plugs, according to the instructions supplied. The data interface socket can thereby provide a link between the control and readout circuitry of 2438 and outside control and data handling circuits.

10. Control signals set the counter-timer to remote, set the counter range, clear and trigger the count sequence and enable or disable the display. The resulting frequency reading is available as serial b.c.d. data corresponding to the display digits which are multiplexed into the interface by external synchronizing signals. Decimal point position and suppressed leading zeros data are multiplexed simultaneously.

11. The functions of the data interface lines are as follows. Refer to Fig. 1. All lines are positive true t.t.l. unless otherwise stated.

<u>DBCD</u>	BCD coded data output (most significant bit)	} negative true
<u>CBCD</u>	BCD coded data output	
<u>BBCD</u>	BCD coded data output	
<u>ABCD</u>	BCD coded data output (least significant bit)	
DEN	Display enable input.	
OFL	Overflow output.	
NCLR	This input requires two logical '0' pulses of at least 1 $\mu$ s duration, at least 50 $\mu$ s apart to clear the counter system and display.	
NINH	A logic '0' at this input closes the counter gate. When this input goes to logical '1' a new cycle is started.	
SCX	A rising edge at this input advances the multiplexer.	

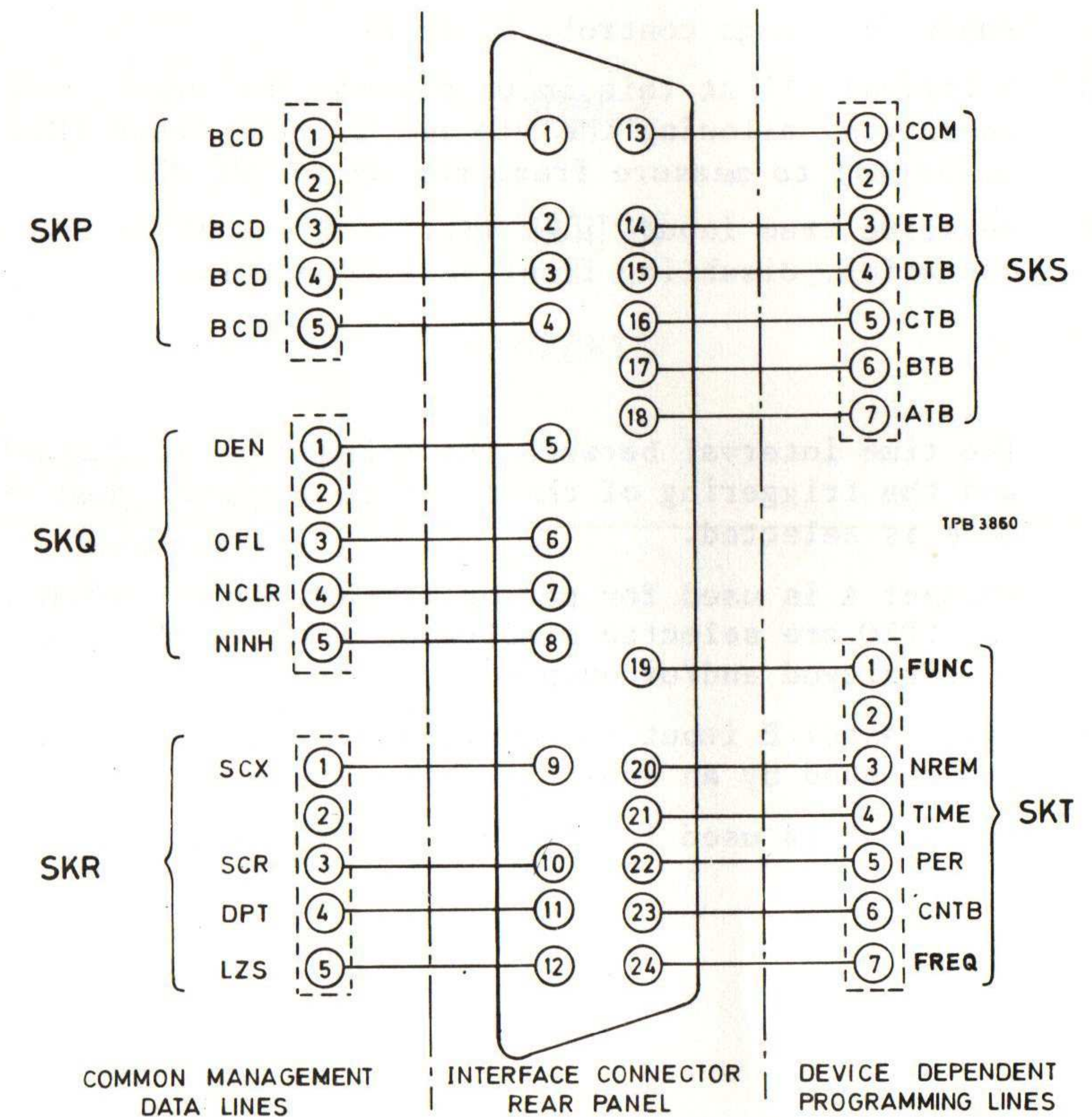


Fig. 1 Data interface pin assignment

SCR	When this input signal is logical '1', the multiplexer operates from control signals generated in the instrument. When this input falls to logical '0', the multiplexing of the data output lines is set to the most significant digit, and external scanning from the SCX input is enabled.
DPT	Output for left-hand decimal points, multiplexed.
LZS	Output for leading suppressed zeros, multiplexed.
ETB	Input for range control, MHz or s.
DTB	Input for range control, MHz or ms.
CTB	Input for range control, kHz or $\mu$ s.
BTB	Input for range control, kHz or $\mu$ s.



ATB Input for range control, Hz or ns.  
 FUNC A logical '1' at this input selects the u.h.f. mode of operation, allowing the channel B input (when FREQ is selected) to measure frequency up to 520 MHz.  
 NREM Negative true input, i.e. t.t.l. '0', enables remote operation, disabling front panel controls.

TIME The time interval between the triggering of channel A and the triggering of channel B is measured when this mode is selected.  
 PER Channel A is used for period measurements. When PER and FREQ are selected simultaneously, the delay time is displayed and/or output.  
 CNTB The channel B input is counted. The count is started and stopped by an input to channel A.  
 FREQ Channel B is used for frequency measurements.

Chapter 3

OPERATION

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## EXTERNAL FEATURES

### Front panel

1. Refer to Fig. 1 for front panel details.

(1) MONITOR socket, channel A, (SMS connector). This output allows triggering points to be monitored on an oscilloscope. A rectangular wave of approximately 250 mV is produced, whose rising and falling edges occur as channel A is triggered on and off, i.e., the rising edge corresponds to the trigger point.

(2) SUPPLY OFF/DISPLAY TIME control. Turn this control clockwise to switch the instrument on. Illuminated display indicates that the instrument is switched on. Rotate the control further clockwise to increase the display time between measurements. Display time is variable from 100 ms to 10 s.

(3) OVERFLOW indicator. Indicates that the most significant digit or digits have overflowed the display. Select a higher frequency or longer period range.

(4) to (9) Mode selector push buttons. (6), (7), (8) and (9) are interlocked.

(4) RESET. Operate this momentary action push button to clear the contents of the memory and display.

(5) START. Operate this momentary action push button to start or stop channel B count. Alternatively, channel B count may be started or stopped by an input to channel A. If the RESET button is not operated, this and subsequent counts will be cumulative, i.e. total count.

(6) COUNT B. Select this push button to set the instrument to the channel B count mode. When channel B is enabled by an input to channel A or by operation of the START/stop button, the counter will be advanced each time

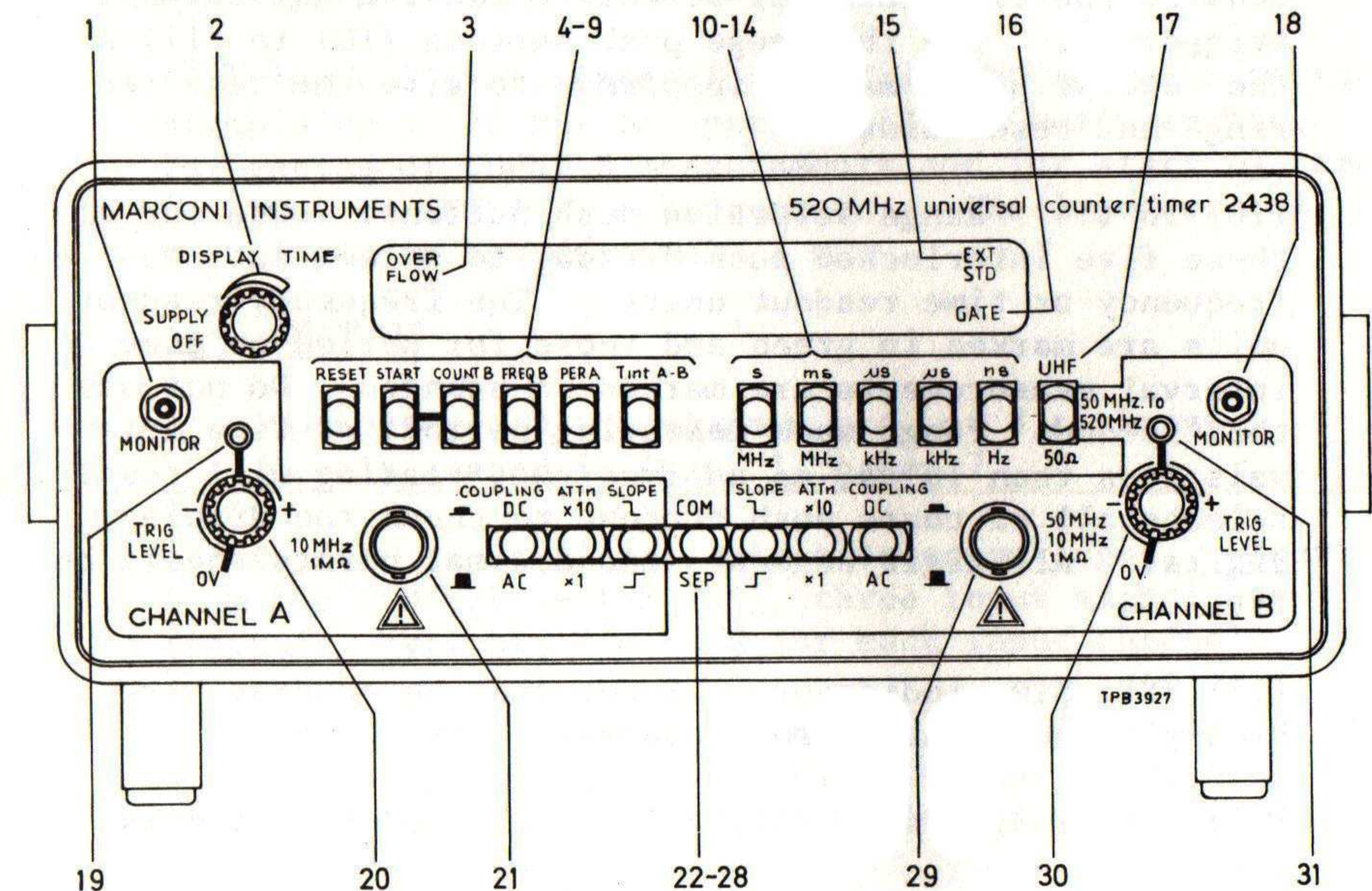


Fig. 1 Front panel

channel B is triggered, up to a maximum rate of  $10^7$  events per second until the count is disabled by another input to channel A or another operation of the START/stop button. In this mode, the display reads total count up to  $10^8$  events.

(7) FREQ. B. Select this green push button to use channel B as a frequency meter input. Use the range push buttons (10) to (14) and their associated readout units marked in green to give the required range and resolution.

(8) PER A. Select this orange push button to measure the period of the channel A input signal. Use the range push buttons (10) to (14) and their associated readout units marked in orange to give the required range and resolution.



(9) T INT A-B. Select this orange push button to measure the time interval between channel A and channel B triggering. Use the range push buttons (10) to (14) and the readout units marked in orange to give the required range and resolution.

(10) to (14) Range selection push buttons. Use one of these five interlocked push buttons to select the required frequency or time readout units. The frequency readout units are marked in green and those for period or time interval measurements are marked in orange. Do not use the 'seconds' range when measuring periods or time intervals less than 10  $\mu$ s, as an incorrect reading will result. Release all of these push buttons to check the display digits. All digit segments and decimal points should be lit.

(15) EXT. STD. indicator. Shows that an external frequency standard has been accepted.

(16) GATE indicator. Lights when the counter gate is open.

(17) UHF selector. Push this green button in to select the UHF input to channel B for frequency measurement only, up to 520 MHz.


(18) Monitor socket, channel B. See (1).

(19) TRIG. LEVEL indicator, channel A. Flashes to show that the channel A input signal is within triggering range. Steadily illuminated lamp indicates that the trigger level is too low for the input signal amplitude. Lamp off indicates that the trigger level is too high for the input signal amplitude. Adjust the TRIG. LEVEL control (20) accordingly.

(20) TRIG. LEVEL control, channel A. Adjust this control to bring the trigger level to a value that will give reliable triggering. The trigger level is continuously adjustable from -2.5 V to +2.5 V, which is effectively increased to between -25 V and +25 V when the attenuator x10 for this channel is selected. In addition, turning this control to the switched position at its anti-

clockwise extreme presets the trigger level to 0 V. Use the TRIG. LEVEL indicator for guidance.

(21) Input socket, channel A. This BNC socket accepts signals up to 10 MHz for period (PER A) measurements, for gating of COUNT B measurements and for starting time interval (T INT A-B) measurements. The impedance of this input is approximately 1 M $\Omega$ .

 CAUTION

Do not exceed the maximum a.c. or d.c. input levels stated in Chap. 1, para. 7.

(22 to 28) Input signal conditioning switches. Apart from the COM/SEP switch (25), three input signal conditioning switches are used for each input channel.

(22) Input COUPLING switch, channel A. Press in for d.c. coupling, release for a.c. coupling. Use d.c. coupling below 10 Hz, i.e. period longer than 100 ms.

(23) Input ATTENUATION switch, channel A. Press in for x10 attenuation, release for no (x1) attenuation. Use this switch to give the required trigger level range. See TRIG LEVEL control and TRIG LEVEL indicator.

(24) Trigger SLOPE switch, channel A. Press in for falling edge, i.e. negative slope triggering, and release for rising edge, i.e. positive slope triggering.

(25) COM/SEP switch. Press in to connect both channels to both input sockets. Release to allow inputs to be fed independently to each channel. In the time interval (T INT A-B) mode, the same signal may be used for both starting and stopping the timing sequence.

(26) Trigger SLOPE switch, channel B. See (24).

(27) Input ATTENUATION switch, channel B. See (23).

(28) Input COUPLING switch, channel B. See (22).



(29) Input socket, channel B. This BNC socket accepts signals up to 10 MHz for time interval and total count measurements. For frequency and ratio measurements, it accepts signals to 50 MHz, and with the UHF button selected, to 520 MHz. Its impedance is approximately  $1\text{ M}\Omega$  except when UHF is selected when it is  $50\ \Omega$ .

(30) TRIG LEVEL control, channel B. See (20). Inoperative in FREQ B mode.

(31) TRIG LEVEL indicator, channel B. See (19).

#### Rear panel

2. Refer to Fig. 2 for rear panel details.

(1) 10 MHz STD/RATIO switch. Use this switch to select frequency ratio mode or external frequency standard input. The display decimal point is suppressed when RATIO is selected and there is a suitable ratio input to the rear EXT/IN socket.

(2) DELAY TIME A-B control. Rotate this control clockwise from its OFF position to give a delay time between  $150\ \mu\text{s}$  and 8 ms. The display decimal point flashes to show that the delay circuit is operating. The delay time can be read from the instrument's display by selecting the UHF and PER A push buttons together. The purpose of this delay is to prevent false triggering due to contact bounce. See para. 17.

(3) AC SUPPLY switches. Position of locking plate allows switch selection of supply voltage and reveals correct fuse rating.

(4) AC SUPPLY plug. Suitable for supply voltages from 105 V to 240 V a.c., 45 to 500 Hz.

#### CAUTION

Ensure that AC SUPPLY switches are correctly set before connecting mains supply.

(5) EXT IN socket. According to selection made using the 10 MHz STD/RATIO switch, this  $10\text{ k}\Omega$  BNC input accepts signals for frequency ratio mode measurements or for external frequency standard operation.

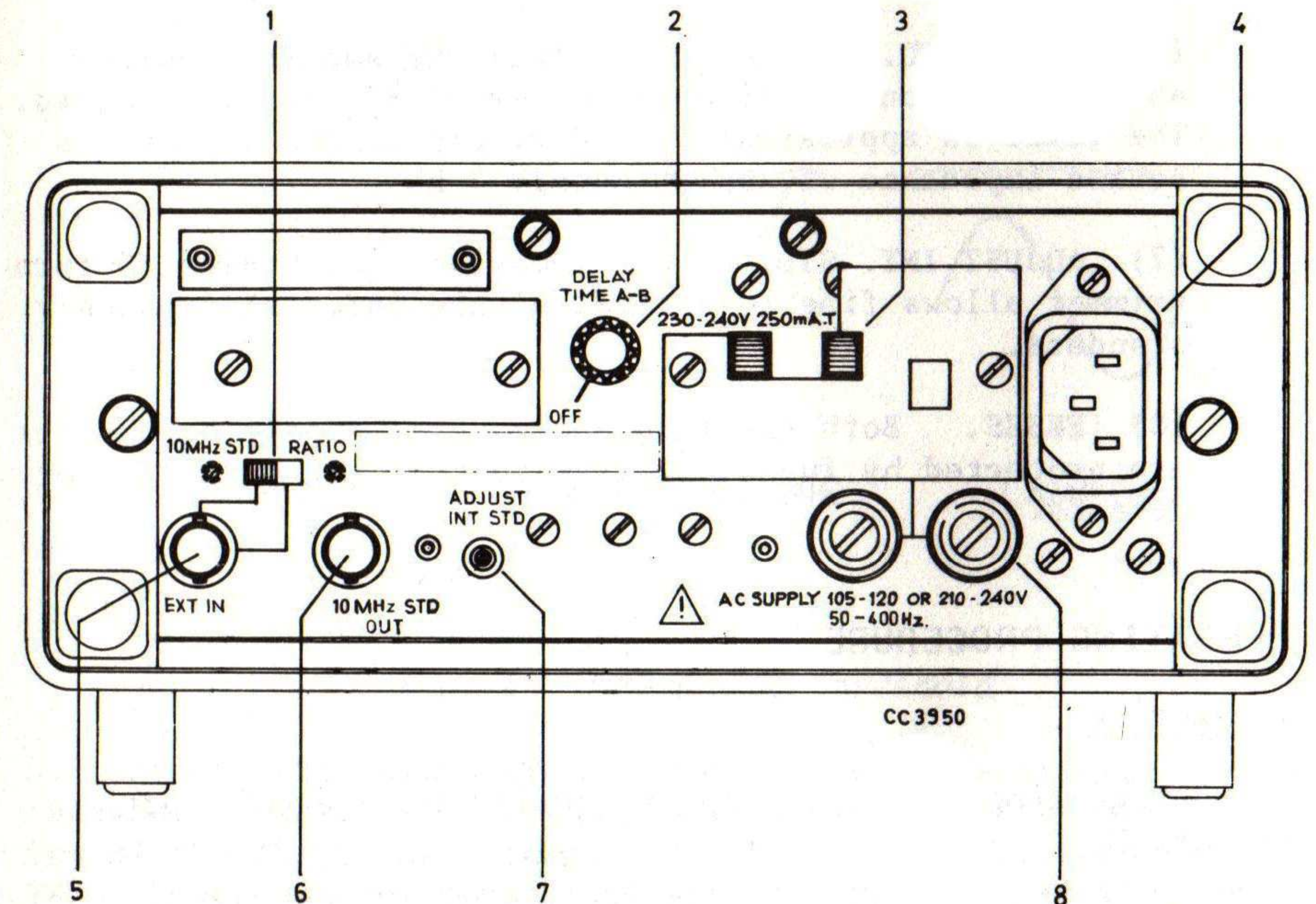


Fig. 2 Rear panel

#### CAUTION

Do not exceed the maximum levels for this input as stated in Chap. 1, paras. 7 and 10.

External frequency standard signals should be sine or square waves of 10 MHz and between 500 mV p-p and 5 V p-p amplitude. The EXT. STD. lamp on the display indicates that the external standard signal has been accepted. The instrument will switch back to its internal frequency standard should the external standard fre-



quency signal fail. The frequency of signals for frequency ratio measurements should be between 10 kHz and 10 MHz, and less than the channel B input frequency. Their amplitude should be between 180 mV and 1.8 V r.m.s.

(6) 10 MHz STD. OUT socket. This BNC socket provides an auxiliary output from the internal frequency standard. The level is approximately 100 mV p-p across 50  $\Omega$  via a source impedance of approximately 2 k $\Omega$ .

(7) ADJUST INT. STD. A screwdriver adjustable 10-turn trimmer allows fine adjustment of the internal frequency standard.

(8) FUSES. Both the live and neutral supply conductors are protected by fuses. Refer to Chap. 2, para. 7, for details.

## OPERATING PROCEDURE

### Triggering

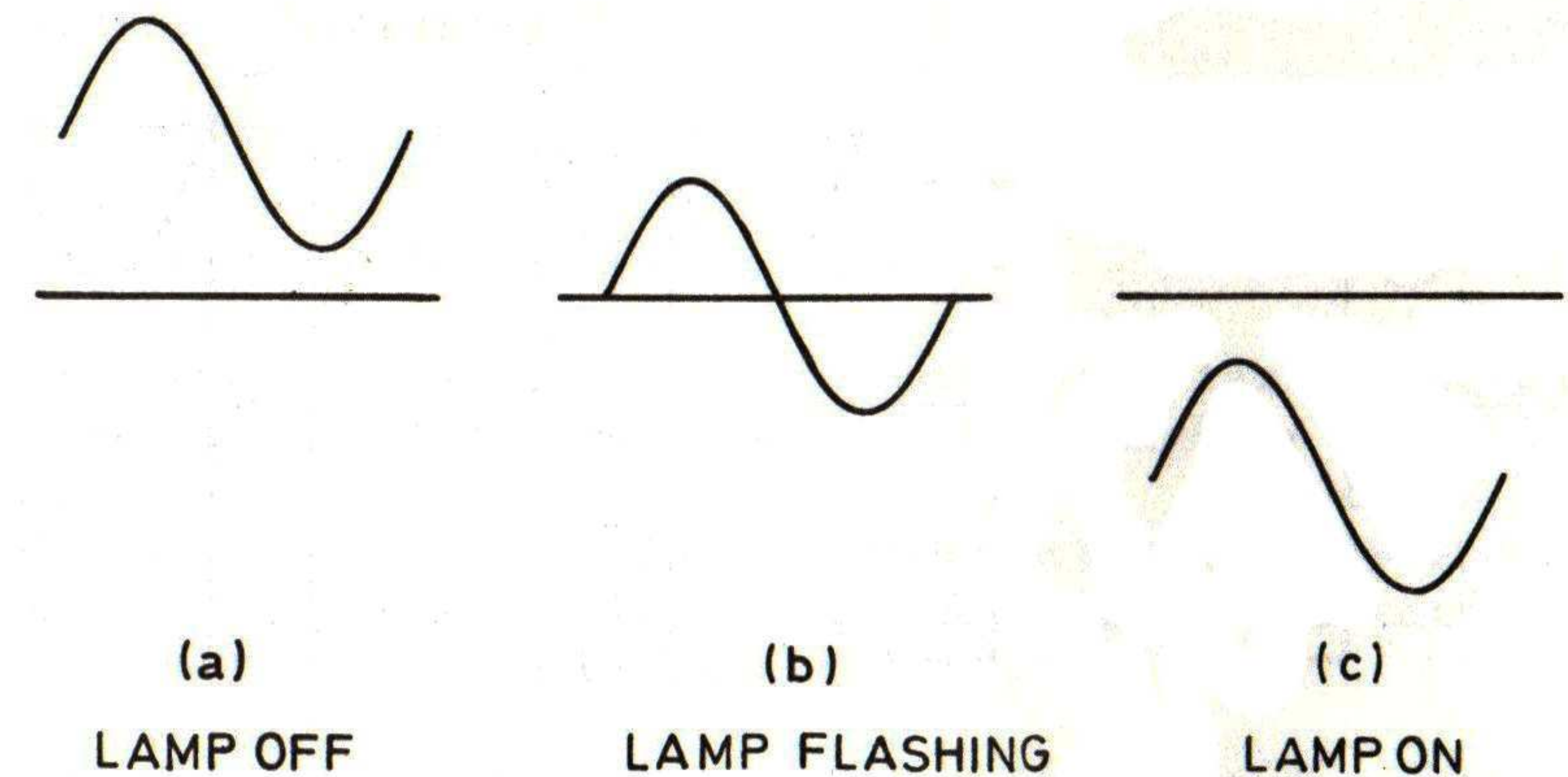
3. Triggering principles apply equally to channel A or channel B.

4. Triggering occurs when the input signal passes over the trigger threshold set by the TRIG. LEVEL control. The TRIG. LEVEL lamp indicates whether the input signal is triggering.

(a) The lamp is continuously off when the entire input signal is more positive than the trigger threshold.

(b) The lamp flashes when the input signal lies across the trigger threshold, causing the input circuit to trigger.

(c) The lamp is continuously on when the entire input signal is more negative than the trigger threshold.



TPB3979

Fig. 3 Triggering threshold

5. Adjust the TRIG. LEVEL control so that the trigger threshold intersects the input signal, indicated by the flashing of the TRIG. LEVEL lamp. If the lamp is on, turn the TRIG. LEVEL control down, i.e. anti-clockwise. If the lamp is off, turn the TRIG. LEVEL control up, i.e. clockwise. If the signal does not trigger inside the range of the TRIG. LEVEL control, select the x10 setting of the attenuator push button switch for that channel. The range of the TRIG. LEVEL control is expanded from  $\pm 2.5$  V to  $\pm 25$  V when the x10 attenuator is used. To obtain a 0 V trigger level, turn the TRIG. LEVEL control fully anti-clockwise to its switched position which is preset to give a trigger level of 0 V. If a large d.c. component in the input signal prevents satisfactory triggering, select a.c. coupling. When dealing with large amplitude input signals, check to see that the input amplitude ratings of the counter are never exceeded.

### Monitor outputs

6. Fig. 4 illustrates the action of the trigger circuit for



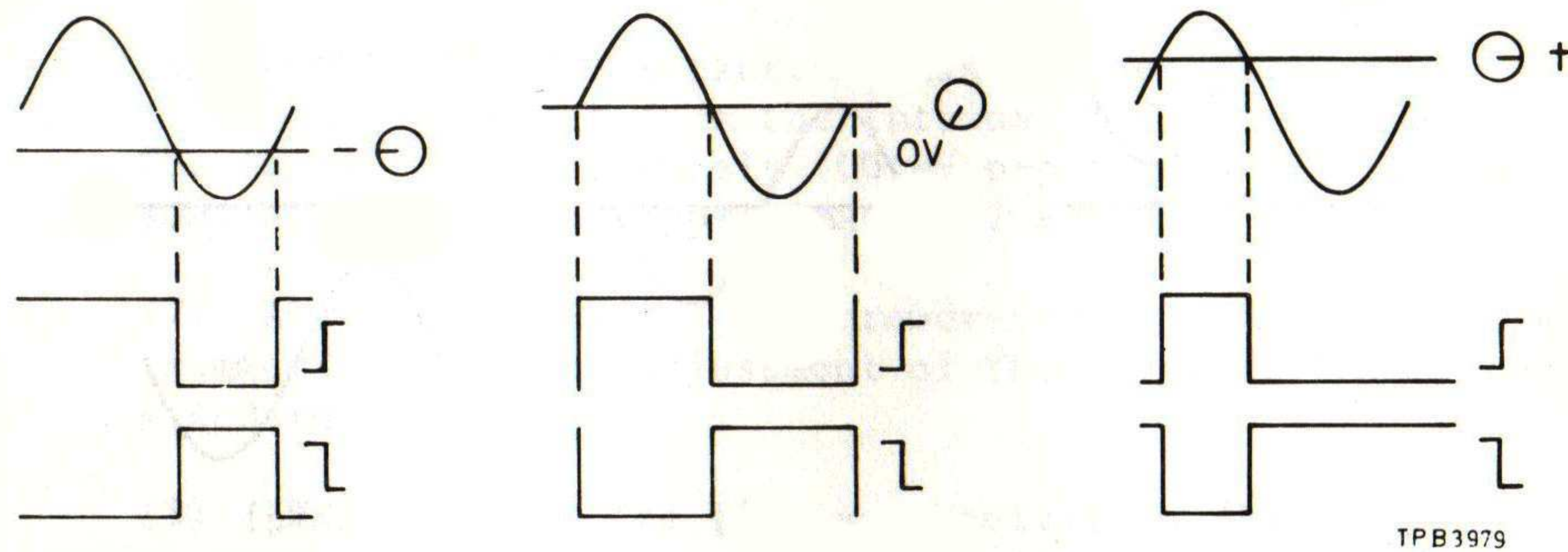


Fig. 4 Monitor output

different trigger level settings and trigger slopes. The output of the trigger circuit may be sampled at its monitor output. The trigger level relative to the input waveform may be visualized using an oscilloscope triggered from the monitor output, and with the input signal to the counter also fed to the Y input of the oscilloscope. The monitor output amplitude is approximately 250 mV.

#### Total count - COUNT B

7. In this mode, pulses fed into channel B are counted while the gate is open. The gate is opened by operation of the START/stop button, or by an input triggering channel A. The gate is closed by the next operation of the START/stop button, or by an input triggering channel A. The gate may be subsequently opened and closed to count further pulses fed into Channel B, and this count is added to the existing reading on the display to give a total count. The display may be reset to zero by operating the RESET push button. The maximum rate at which the 2438 can count channel B pulses is  $10^7$  per second, and the maximum total count it can display without overflow is  $10^8-1$ .

8. Proceed as follows to use the total count mode.
  - (1) Connect input signal to channel B and obtain satisfactory triggering.
  - (2) Select COUNT B push button.
  - (3) Operate RESET push button.
  - (4) Operate START/stop push button to start count and check to see that the GATE OPEN lamp lights.
  - (5) Operate the START/stop push button to stop and again to continue the count, if required, until the total count sequence is no longer required.
  - (6) Alternatively, the count may be started or stopped by an input to channel A. This facility allows remote control of the total count sequence.

Note...

Large amplitude channel B signals can cause spurious triggering of channel A, resulting in unwanted start and stop signals. If the count sequence is being started and stopped manually, turn the channel A TRIG LEVEL control to the extreme of its range and select x10 attenuation. If required, the channel A input socket may be terminated in a low impedance to further reduce the interference. If the channel A input is being used to start or stop the count sequence, try to use as large a signal as possible and of the opposite polarity to the channel B signal. Alternatively, the channel B signal may be attenuated externally before connection to the counter timer.

#### Time interval - T INT A-B

9. The time interval between an input triggering channel A and an input triggering channel B is measured by counting the number of pulses produced by the frequency standard in that interval. In this mode the channel A and channel B inputs open and close the counter gate respectively.



10. Proceed as follows to measure time interval.

- (1) Select T INT A-B push button.
- (2) Select range to give required accuracy and resolution, within a suitable measurement time.
- (3) Set trigger controls for both channels to give the required type of time interval measurement. See paras. 19 to 25.
- (4) Perform measurement; check that GATE lamp lights.
- (5) Read display.

Period - PER A

11. Period measurements are achieved in a similar manner to time interval measurements, except that the gate is opened to allow the counter to count pulses from the frequency standard for a period that is both started and stopped by the triggering of channel A.

12. Proceed as follows to measure period.

- (1) Select PER A push button.
- (2) Select range to give required accuracy and resolution within a suitable measurement time.
- (3) Adjust the TRIG. LEVEL control and trigger slope so that triggering occurs at a point of maximum slope on the input waveform. Triggering in this manner reduces the error due to noise on the signal.
- (4) Perform measurement; check that GATE lamp lights.
- (5) Read display.

Frequency - FREQ B

13. Frequency is measured by counting the number of pulses or cycles that occur in the interval during which the gate is open. The gate is opened and then closed for an interval which is determined by an exact sub-multiple of the frequency produced by the counter's crystal oscillator.

14. To measure frequency, proceed as follows.

- (1) Connect input signal to channel B and check that the TRIG. LEVEL lamp is flashing.
- (2) Select FREQ B push button and check that the display decimal point lights. If it does not, check that the 10 MHz STD/RATIO switch is in the 10 MHz STD position.
- (3) Select UHF push button if the frequency to be measured is greater than 50 MHz.
- (4) Select range to give required resolution within a suitable measurement time.

<i>Readout units</i>	<i>Gate time</i>	<i>Gate time (UHF)</i>	<i>Resolution</i>
MHz	1 ms	10 ms	1 kHz
MHz	10 ms	100 ms	100 Hz
kHz	100 ms	1 s	10 Hz
kHz	1 s	10 s	1 Hz
Hz	10 s	100 s	0.1 Hz

- (5) Perform measurement; check that GATE lamp lights.
- (6) Read display.

Frequency ratio

15. This mode is similar in operation to the frequency mode except that the gate interval is determined by a sub-multiple of a second frequency which is connected to the rear panel EXT. IN socket. The EXT. IN frequency should be not greater than 10 MHz and not less than 10 kHz; also, it must be the lower of the two frequencies.



16. Proceed as follows to measure frequency ratio.

- (1) Connect the higher frequency signal to the channel B input, and check that the TRIG LEVEL lamp is flashing.
- (2) Select FREQ B push button.
- (3) If the higher frequency is greater than 10 MHz, select UHF.
- (4) Connect the lower frequency signal to the rear panel EXT. IN socket and slide the switch near the socket to the RATIO position. Check that there is no decimal point displayed.

CAUTION

Do not exceed 1.8 V r.m.s. at the EXT. IN socket.

- (5) Select range to give required resolution within a suitable measurement time. Remember that the gate time will be increased because the time base is taken from a sub-multiple of the EXT. IN frequency. For example, gate time is multiplied by ten when the EXT. IN frequency is 1 MHz, by one hundred for an EXT. IN frequency of 100 kHz and by one thousand for an EXT. IN frequency of 10 kHz.
- (6) Perform measurement; check that GATE lamp lights.
- (7) Read display.

Delay

17. Delay is used to prevent erroneous triggering generated by signals that suffer from noise due to contact bounce or ringing. As soon as the input has been triggered in the delay mode, further triggering is locked out for a period that is determined by the setting of the rear panel DELAY control. When the PER A and UHF push buttons are selected, delay time is displayed. The decimal point flashes to show that the delay mode is in use. The delay time must be less than the period or time interval to be measured.

18. Proceed as follows to use the delay mode.

- (1) Connect inputs and set up triggering as required.
- (2) Select PER A and UHF. Check that the display decimal point is flashing.
- (3) Adjust the rear panel DELAY control to give the desired delay time reading on the display.
- (4) Release UHF and if a time interval measurement is to be made, release PER A and select T INT A-B.
- (5) Perform measurement; check that GATE lamp lights.
- (6) Read display.

Pulse duration measurement

19. Pulse duration is ascertained by measuring the time interval between the mesial (mid-way) points of the pulse's first and last transition. To measure pulse duration, proceed as follows :

- (1) Connect the signal to channel A input.
- (2) Select COM so that the signal is also connected to the channel B input.
- (3) If the pulse to be measured is positive select positive slope triggering for channel A and negative slope triggering on channel B.
- (4) If the pulse to be measured is negative select negative slope triggering for channel A and positive slope triggering for channel B.
- (5) Use the TRIG. LEVEL controls and lamps to set the threshold amplitude for both input channels to half-way between the base and top amplitude of the input waveform. For greater accuracy the trigger levels can be set using an oscilloscope display triggered by the MONITOR outputs.



(6) Check to see the GATE lamp lights, then read display.

Transition duration measurement

20. First and last transition durations of pulses, i.e. 'rise' and 'fall' times, can also be measured using the same technique as for pulse duration measurement, except for the following.

21. For first transition duration.

(1) Select positive trigger slope for both input channels or negative trigger slope for both channels for positive or negative pulses respectively.

(2) Adjust the channel A TRIG. LEVEL control so that triggering occurs at 10% of the pulse amplitude. For positive pulses, adjust the control so that the TRIG. LEVEL lamp is on the off/flashing boundary, and for negative pulses adjust the control so that the TRIG. LEVEL lamp is on the on/flashing boundary.

(3) Adjust the channel B TRIG. LEVEL control so that triggering occurs at 90% of the pulse amplitude. For positive pulses, adjust the control so that the TRIG. LEVEL lamp is on the on/flashing boundary and for negative pulses adjust the control so that the TRIG. LEVEL lamp is on the off/flashing boundary.

(4) Check to see the GATE lamp lights, then read display.

22. For last transition duration.

(1) Select negative trigger slope for both input channels or positive trigger slope for both channels for positive or negative pulses respectively.

(2) Adjust the channel A TRIG. LEVEL control so that triggering occurs at 90% of the pulse amplitude. For positive pulses, adjust the control so that the TRIG. LEVEL lamp is on the off/flashing boundary, and for negative pulses adjust the control so that the TRIG. LEVEL lamp is on the on/flashing boundary.

(3) Adjust the channel B TRIG. LEVEL control so that triggering occurs at 10% of the pulse amplitude. For positive pulses, adjust the control so that the TRIG. LEVEL lamp is on the on/flashing boundary and for negative pulses adjust the control so that the TRIG. LEVEL lamp is on the off/flashing boundary.

(4) Trigger levels for any of these measurements may be accurately verified by using the MONITOR outputs to trigger an oscilloscope display of the input waveform.

(5) Check to see the GATE lamp lights, then read display.

TABLE 1 CONTROL SETTINGS FOR TRANSITION DURATION MEASUREMENT

	Channel A	Channel B
<u>First transition</u>		
positive pulse:	lamp: off/flashing slope: ⌈	lamp: on/flashing slope: ⌈
negative pulse:	lamp: on/flashing slope: ⌋	lamp: off/flashing slope: ⌋
<u>Last transition</u>		
positive pulse:	lamp: on/flashing slope: ⌋	lamp: off/flashing slope: ⌋
negative pulse:	lamp: off/flashing slope: ⌈	lamp: on/flashing slope: ⌈

On/off ratio

23. Use 2438 as follows for on/off ratio measurement.

(1) Measure the pulse duration of the 'on' portion of the signal, and record the reading. See para. 19 for procedure.



(2) Measure the pulse duration of the 'off' portion of the signal, and record the reading. This part of the measurement is most easily done by reversing the positions of the SLOPE push buttons.

(3) Calculate on/off ratio by dividing the first reading by the second.

#### Duty factor

24. Use 2438 as follows to measure duty factor.

(1) Measure the pulse duration of the 'on' portion of the signal, and record the reading. See para. 19 for procedure.

(2) Measure the period of the signal and record the reading. This part of the measurement is most easily done by releasing the T INT A-B button and selecting PER A.

(3) Calculate duty factor by dividing the first reading by the second.

#### Phase measurement

25. The relative phase angle between two signals of the same frequency can be found by proceeding as follows :

(1) Connect one of the signals to channel A input and the other to channel B input.

(2) Set the TRIG. LEVEL controls to 0 V, and both trigger slope switches to the same polarity, as this assures triggering at the same amplitude point on each of the input signals.

(3) Select T INT A-B mode and check that the COM/SEP switch is in the SEP position.

(4) Select a suitable range and read the counter display. The reading,  $t_1$ , is the time interval by which channel A signal leads channel B. Record the reading.

(5) Select PER A and read the counter display. This reading,  $t_2$ , is the period of the input signal, which allows the phase angle to be calculated.

(6) Calculate phase angle as follows.

$$\frac{\text{Time interval}}{\text{Period}} \times 360 = \text{phase angle A-B (degrees)}$$

or

$$\frac{\text{Time interval}}{\text{Period}} \times 2\pi = \text{phase angle A-B (radians)}$$

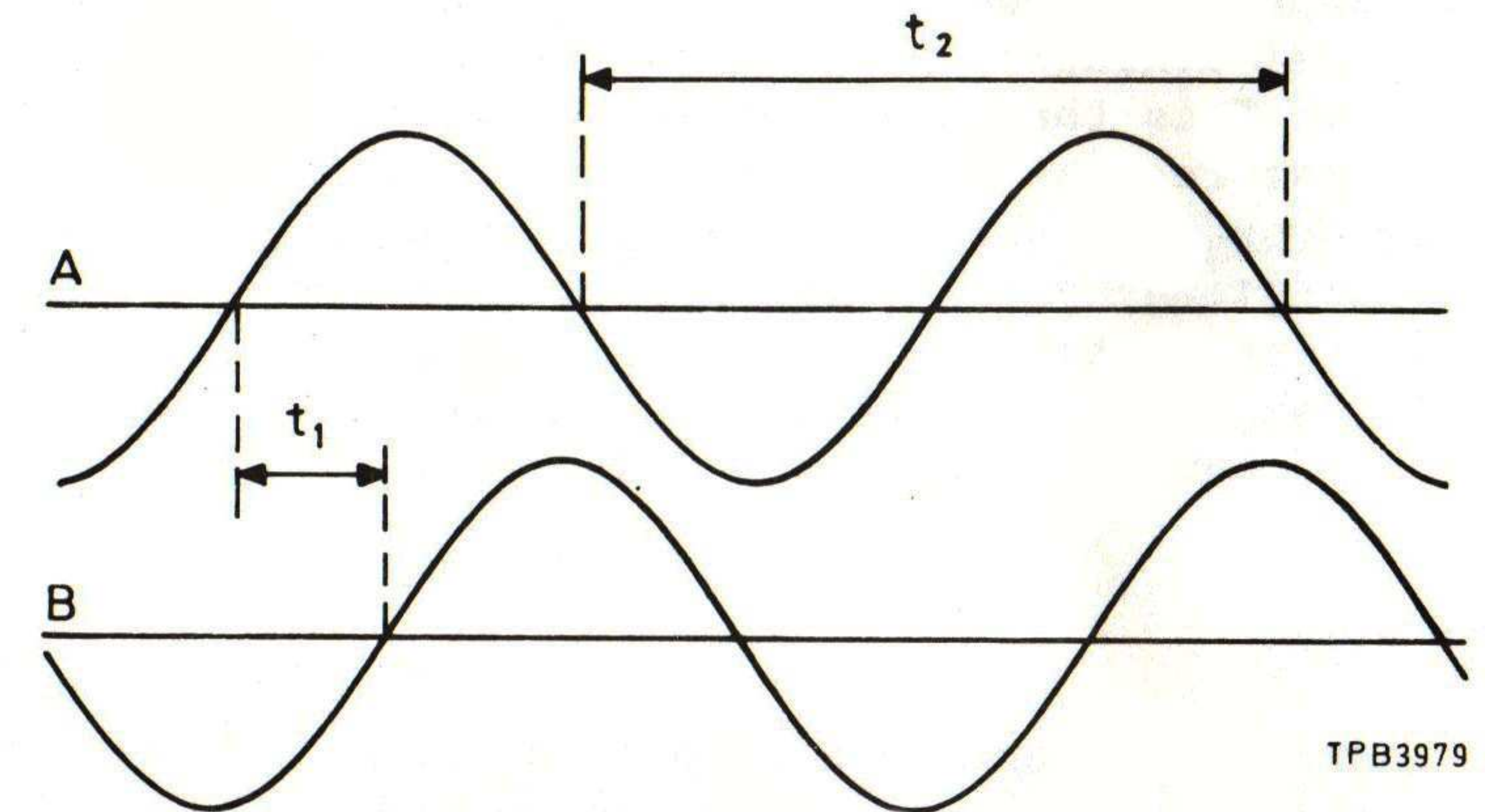


Fig. 5 Phase measurement

#### Display digit check

26. Release all range selection push buttons and check that all segments and decimal points of the display are illuminated.



## SOURCES OF ERROR

### ±1 count uncertainty

27. This uncertainty, inherent in all electronic digital counters, is a result of the time relation between the gate open time and the occurrence of the pulses to be counted. To reduce the effect of this uncertainty in the *FREQ B* mode, use as long a gate time as practicable so that a large number of pulses are counted. The ±1 count uncertainty will then represent a proportionally small error. In the *PER A* mode period averaging similarly reduces the effect of ±1 count uncertainty.

28. Use time interval averaging on repetitive time interval signals, especially when the signal has noise or jitter. Time interval averaging reduces the ±1 count uncertainty by  $1/\sqrt{N}$ , where  $N$  is the number of intervals averaged. For the three highest resolution ranges,  $N$  is 1000, 100 and 10. Averaging does not take place on the two single interval ranges. If the repetition of the time intervals is harmonically related to the frequency standard signal, then the advantage of using time interval averaging may be lost. In this case, offset the repetition frequency of the input signals.

### Trigger error

29. Trigger errors are chiefly due to noise. Fig. 6 shows how the instant of triggering can be shifted by noise on the input signal. Note that the noise can advance or delay triggering and hence lengthen or shorten the measurement. Trigger error due to noise can be reduced by improving the signal to noise ratio, and this can often be achieved by increasing the amplitude of the input signal. If possible, arrange triggering to occur at a point of maximum slope on the input waveform, since noise signals result in smaller time errors where signal slope is greater. On pulse waveforms where the transition time approaches zero, careful setting of trigger level will allow accurate measurements to be made even in the presence of high noise levels.

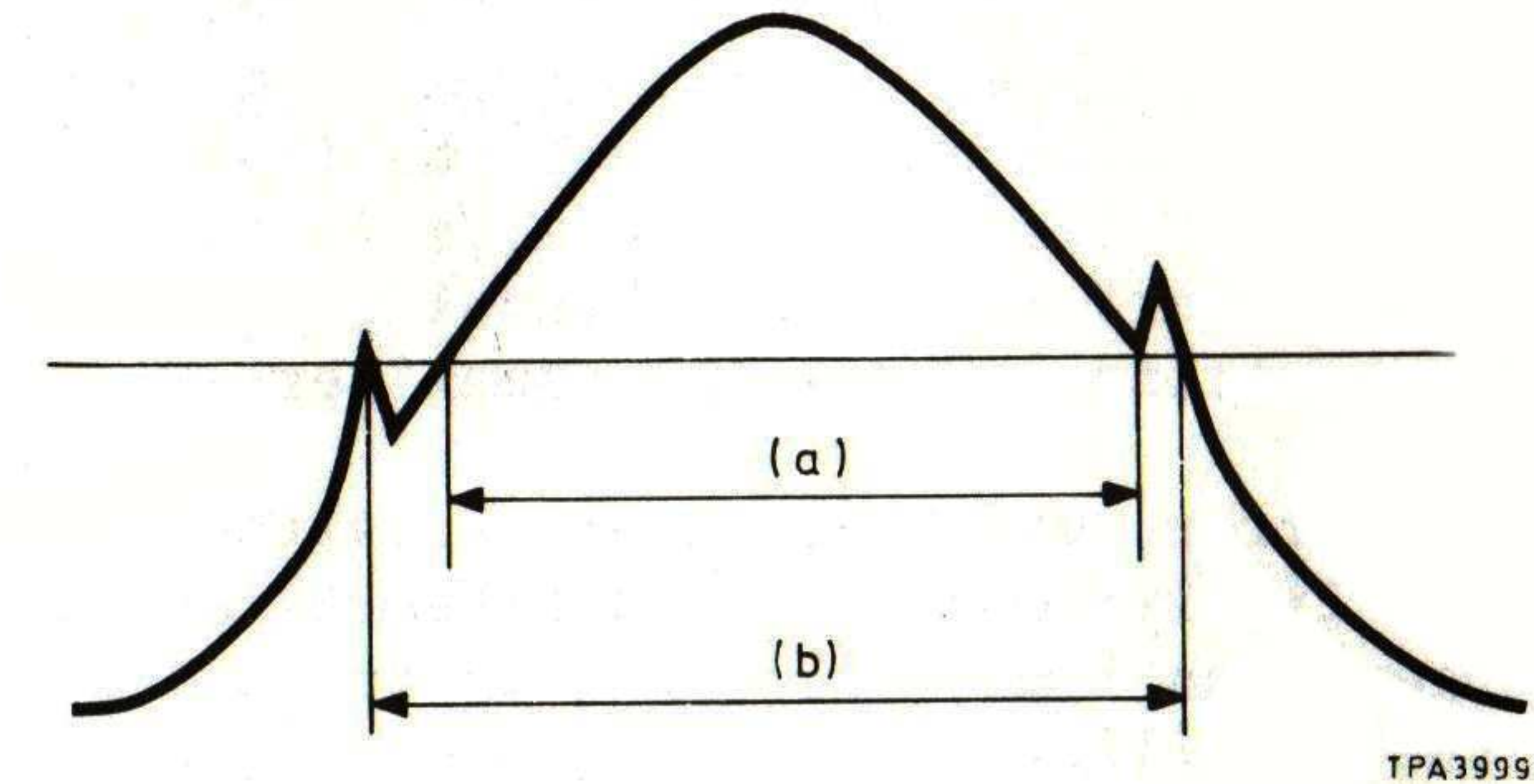


Fig. 6 Trigger error

30. To obtain accurate readings at very low signal levels, use the *TRIG. LEVEL* control and *TRIG. LEVEL* lamp to manually select the 0 V trigger point, rather than the preset 0 V trigger level at the anti-clockwise end of the *TRIG. LEVEL* control's travel.

### Frequency standard error

31. The stability of the frequency standard determines the limit of accuracy obtainable. When all other errors have been eliminated, or are insignificant, the residual error is due to the slight instability of the frequency standard. The stability figures for the versions of frequency standard are given in Chap. 1. This error may be reduced by using an external frequency standard of better stability. Otherwise, best stability from the internal standard may be realized by avoiding extremes of temperature.

### Systematic error

32. When electrical signals are used to start and stop time interval measurements there is a time inequality between the signal paths from the sources of the signals to the outputs



of the trigger circuits. This time inequality is termed systematic error. Different input lead lengths account for some time inequality: for example, if the input to channel B is via a 50  $\Omega$  coaxial cable that is 1 m longer than the input lead for channel A, then channel B could suffer a delay of 5 ns relative to channel A. Also, trigger circuits take a finite time to produce an output after the input signal has crossed the trigger threshold. There is inevitably a disparity between the performance of channel A and channel B in this respect, resulting in a further small error.

33. Systematic error, which is rarely more than a few nanoseconds, is not likely to degrade measurement accuracy for intervals longer than 1 ms, where the error is insignificant compared to the stability of the frequency standard. For single interval measurements the systematic error is always insignificant compared with the  $\pm 1$  count error. Because time interval averaging reduces the  $\pm 1$  count error, systematic error may then be significant for measurements of short intervals where the input signals are free from noise. To minimize systematic error, always keep the input leads the same length and ensure that the inputs are properly matched.

Chapter 4-1

BRIEF TECHNICAL DESCRIPTION

CONTENTS

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1	Circuit configurations
8	Input circuits, channel A and channel B
9	Gate control circuits
10	Reset timing
11	Counting stages
12	Integrated logic circuit
13	Frequency standard
14	Display

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CIRCUIT CONFIGURATIONS

1. The various measurement modes possible with 2438 are enabled by the different ways in which the instrument's circuits can be interconnected. Invariably, the display reading is the number of pulses admitted to the counting stages of the instrument via the main gate. The source of the pulses admitted via the main gate and the source of the gate control signal are determined by the measurement mode that is selected. The following block diagrams and their descriptions show in a simplified way how some of 2438's circuits are con-



nected to realize the different measurement modes.

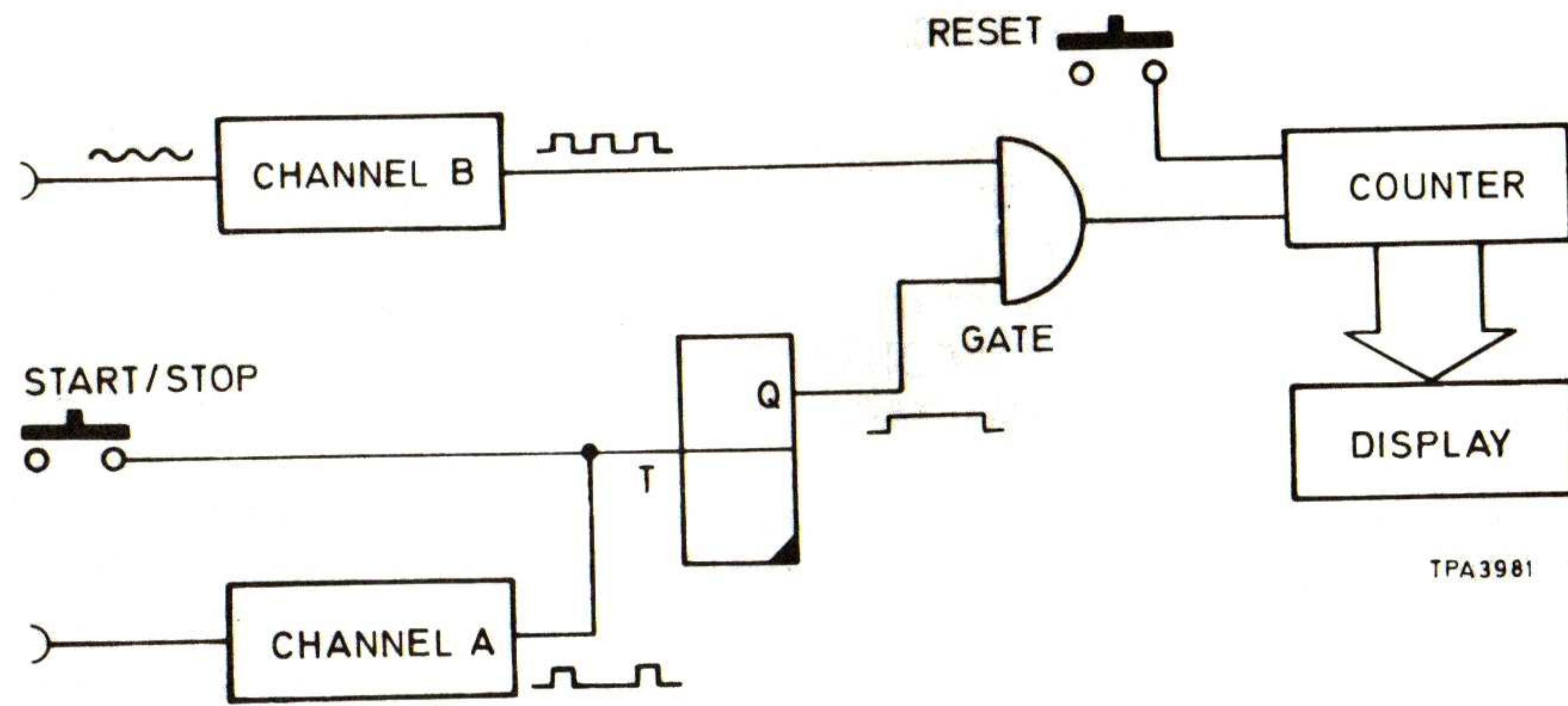


Fig. 1 COUNT B mode

2. In the COUNT B mode, see Fig. 1, input A or the START/stop button toggles a bistable circuit which opens and closes the gate to allow a train of pulses from the channel B input to enter the counting stages. Subsequent pulse trains may be admitted to the counting stages by further opening and closing of the gate. The total count of channel B pulses is displayed until the counter is manually reset.

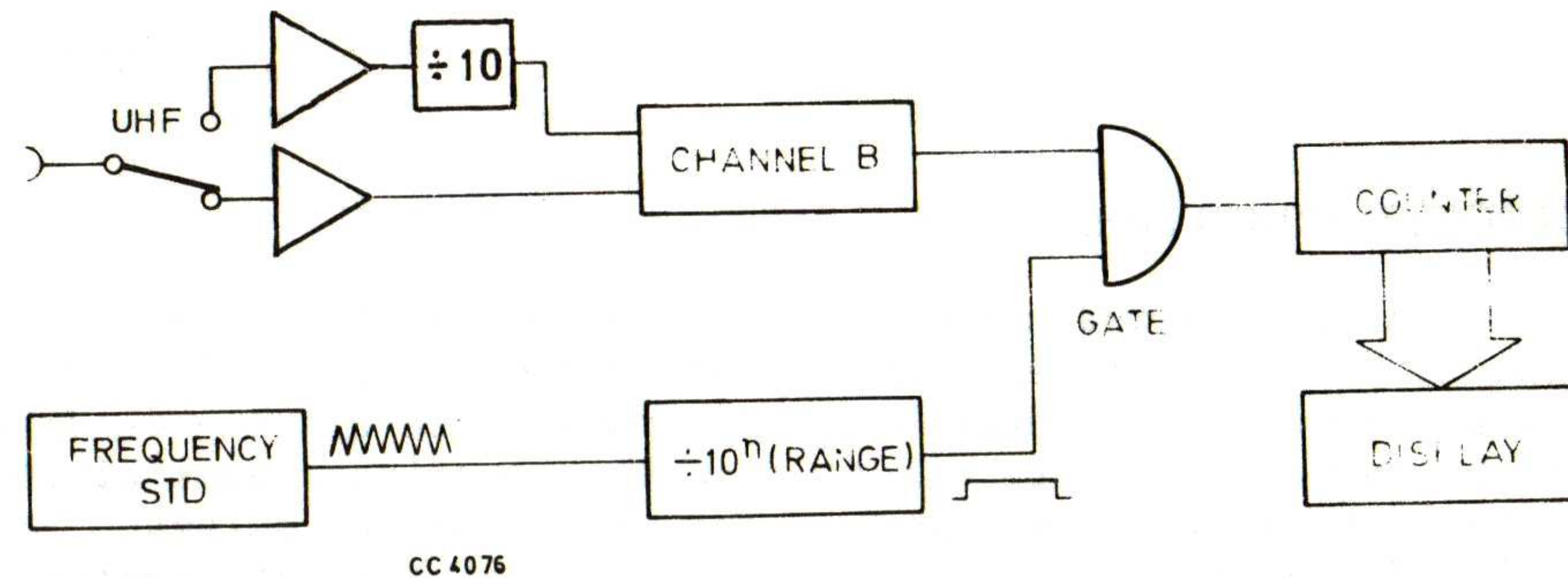


Fig. 2 FREQ B mode

3. 2438 acts as a frequency meter in the FREQ B mode, see Fig. 2. The gate is opened for an exact time taken from a sub-multiple of the frequency standard. During this time, pulses that are derived from channel B input signal are admitted to the counting stages, resulting in a reading of pulses per unit time; i.e., frequency. Range switches allow selection of other sub-multiples of the frequency standard, to give flexibility of gate time, accuracy and resolution. The input signal is routed via the u.h.f. amplifier and prescaled by ten when the frequency to be measured is between 50 MHz and 520 MHz.

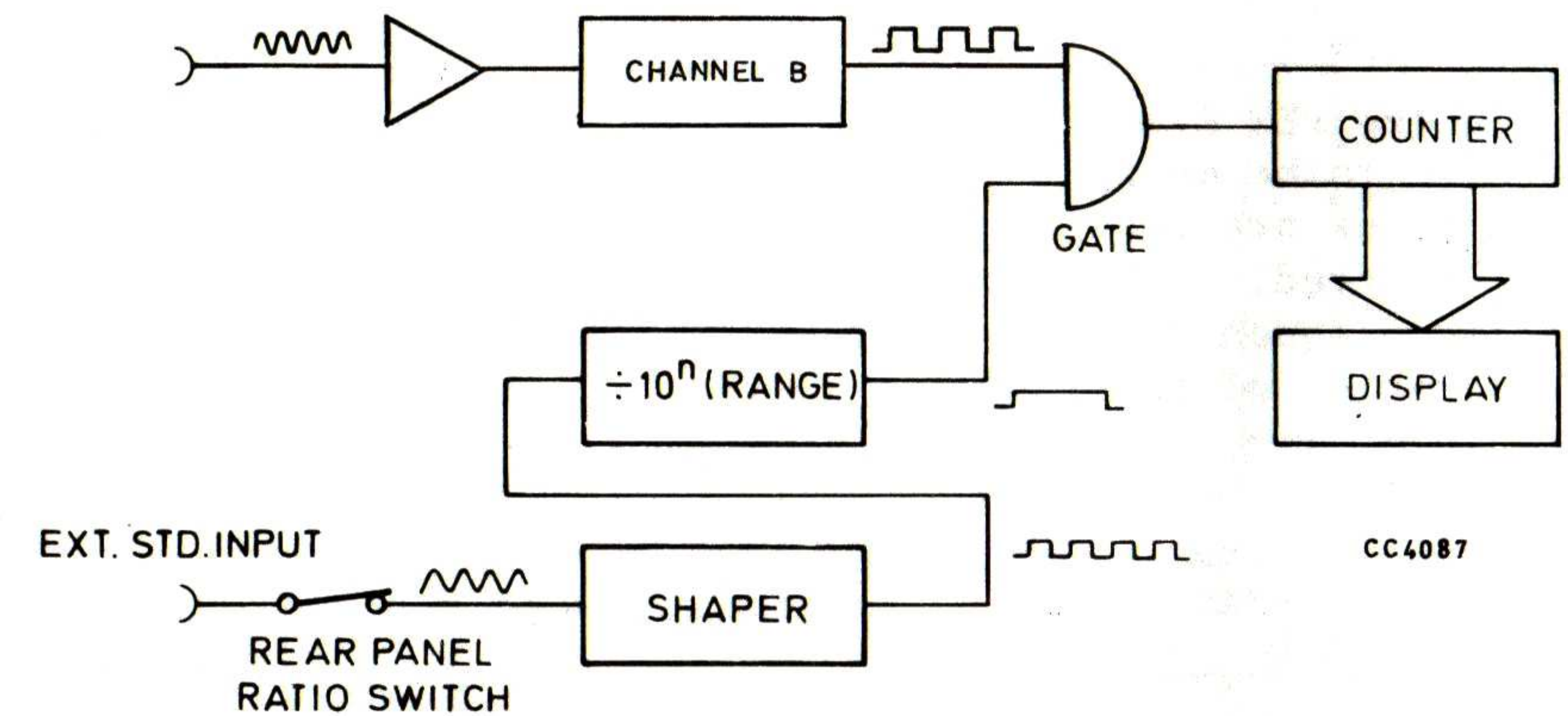


Fig. 3 Frequency ratio mode

4. When frequency ratio measurements are made, see Fig. 3, the rear panel input signal replaces the frequency standard so that the counter display reads the ratio between the two input signals.



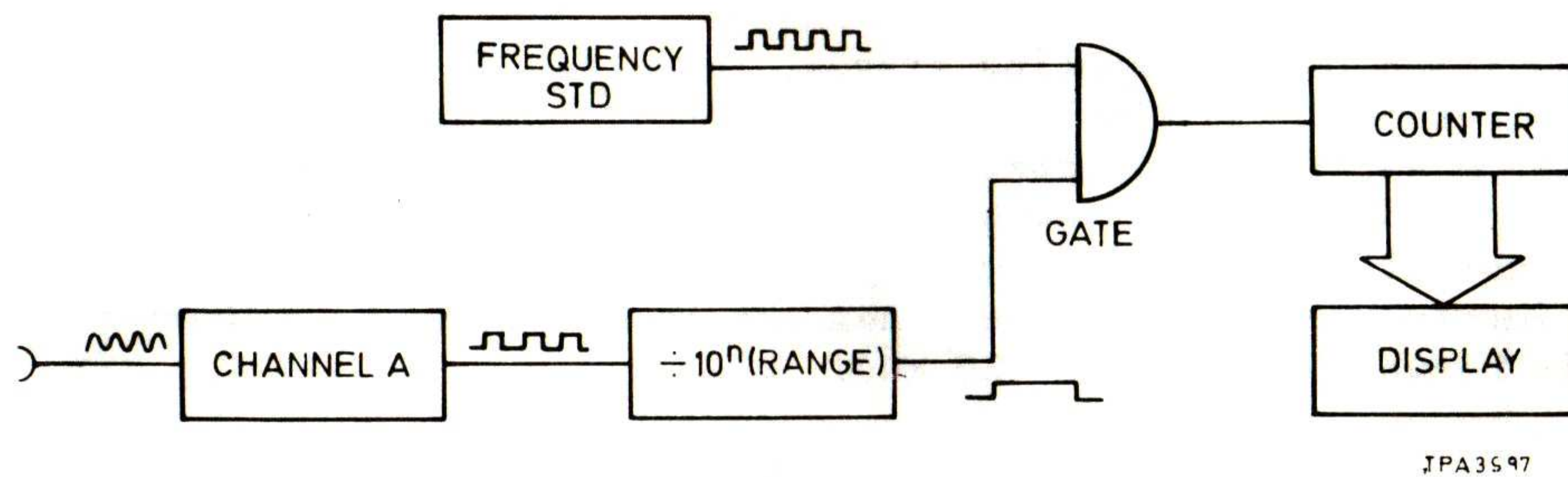


Fig. 4 PER A mode

5. In the PER A mode, see Fig. 4, the input signal whose period is to be measured, is converted to a pulse train. These pulses are then divided; the ratio depends on the range selected. The resulting gate control signal admits standard frequency pulses so that the reading is proportional to the period of the input signal.

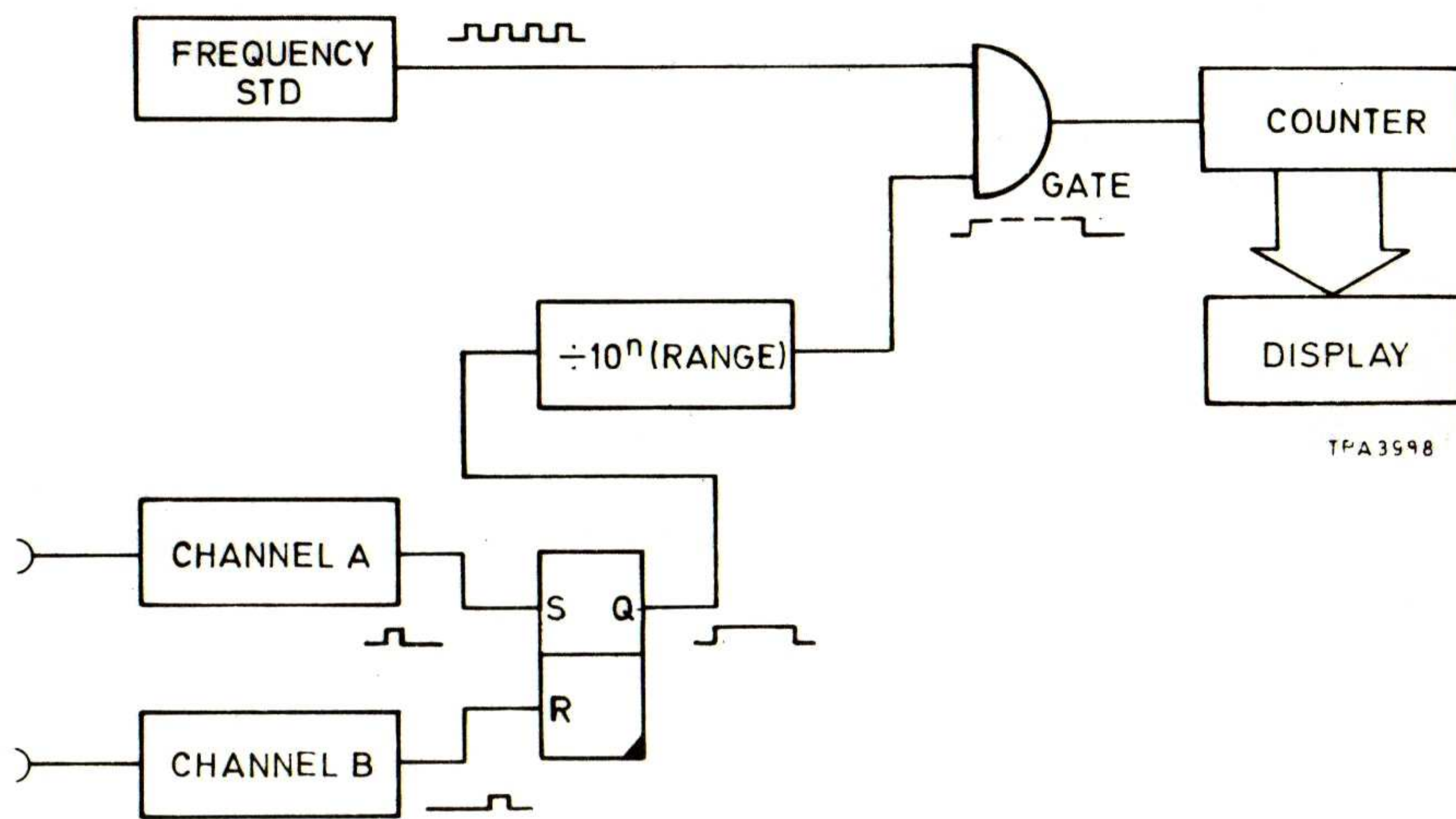


Fig. 5 T-INT A-B mode

6. The T-INT A-B mode, see Fig. 5, is similar to the period mode except that the gate control signal is obtained in a different way. An input to channel A produces a pulse which sets the bistable Q output high. An input to channel B produces a pulse which resets the bistable Q output low. In the single time interval mode, the output of the bistable is used directly to open and close the counter gate. In the time interval averaging mode, successive outputs from the bistable are divided to produce a control signal that allows a succession of time interval gating cycles to admit pulses to the counter.

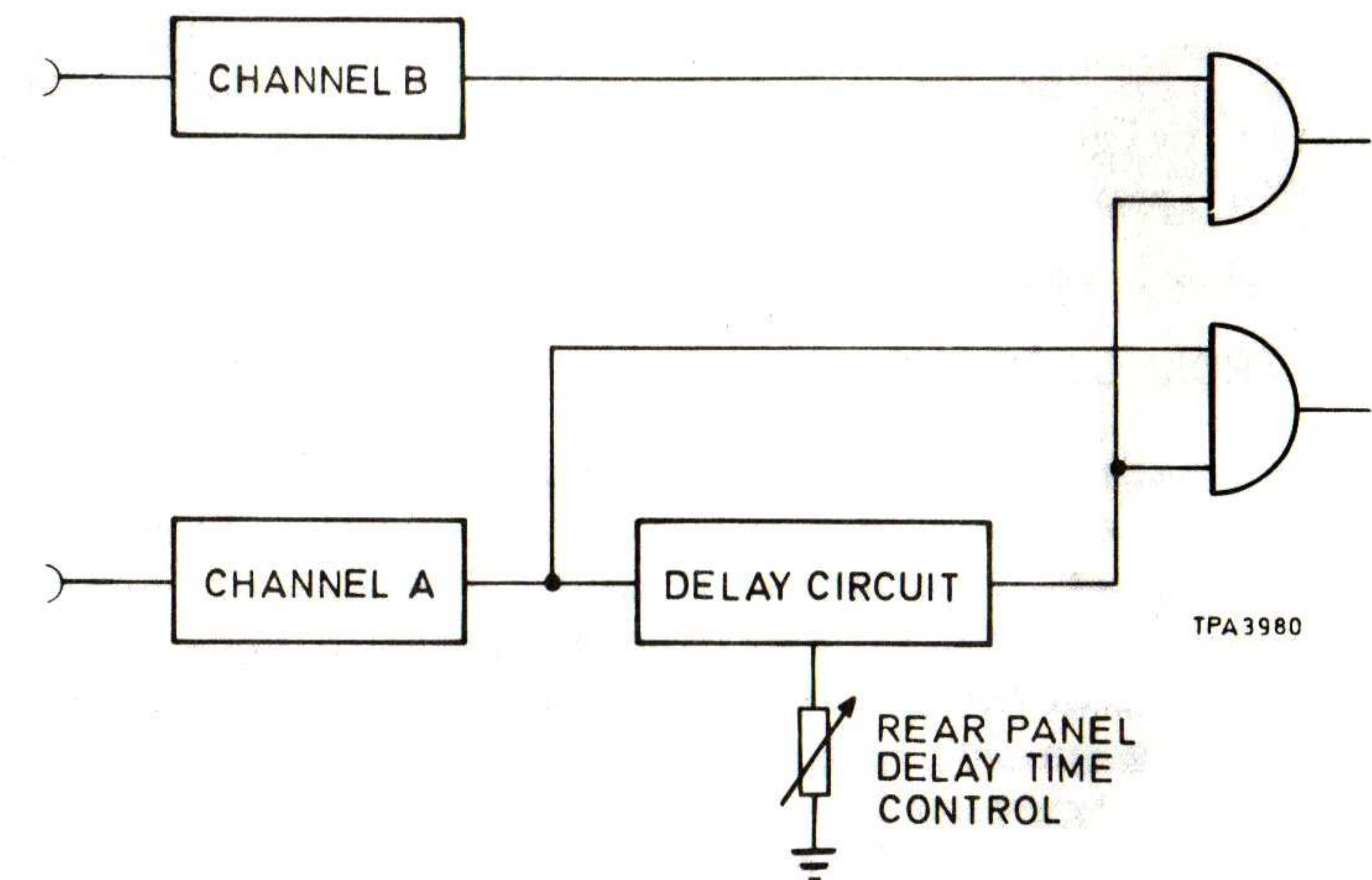


Fig. 6 Delay circuit

7. If the delay control is switched on, the first input signal to reach channel A triggers a monostable delay circuit, which, for a time determined by the delay control setting, prevents further input signals to either channel A or channel B from reaching the gate control circuits. The delay time reading, which is obtained by selecting PER A and UHF while in the delay mode is achieved by feeding 1 MHz pulses into channel A which the counter measures over the delay period.



## INPUT CIRCUITS, CHANNEL A AND CHANNEL B

8. The input circuits are identical except that channel B enables signals to be used for frequency measurements up to 50 MHz. Also, channel B has a u.h.f. amplifier which can be switched to provide operation to 520 MHz. Otherwise, the frequency limit of the input circuits is 10 MHz. The input signal can be simultaneously connected to both channels by means of the SEP/COM switch. A capacitor can be switched into the signal path for a.c. coupling, and a x10 attenuation section can be switched into the signal path so that larger input amplitude signals can be used. After these switches, the signal passes through a buffer amplifier and then to a Schmitt trigger. The d.c. level of the input signal can be shifted according to the setting of the TRIG. LEVEL control. The selection of trigger slope is achieved by using either the true or the complementary output of the Schmitt trigger. The Schmitt trigger also feeds the MONITOR output and the TRIG. LEVEL lamp circuit.

## GATE CONTROL CIRCUITS

9. The outputs from channels A and B are processed to produce the required gate control signals, which depend on the mode selected, as described in paras. 1 to 7. A bistable and its associated circuit allow alternate A and B inputs to produce time interval gating signals. The same circuit is used to produce gating signals from successive inputs to channel A for period and count measurements, and to produce a gating signal from the frequency time base signals which are derived from the frequency standard. The gating signals produced by this bistable are, in the case of multi-period and multiple time interval measurements, counted by one, two or three decade counter stages to give the correspondingly longer gate time required. In the case of time interval, single period, frequency or count mode, the bistable output signal is retimed so that it is coherent with the 10 MHz clock signal derived from the frequency standard. At the main gate, these gating signals are used to allow the pulse train to enter the counting stages. The pulses gated into the counting stages are taken from the channel B input (frequency or count mode) or from the 10 MHz clock signal (time interval or period mode).

## RESET TIMING

10. At the end of a measurement, the counter main gate closes and the display timing circuit, whose 'on' time is adjustable from the front panel DISPLAY TIME control, is triggered and prevents further counting for the required display time. After the display time has elapsed, further signals are generated that reset the gate control circuits ready for another measurement. The contents of the counter stages are transferred to latches for storage and display while the counter is in the next count sequence.

## COUNTING STAGES

11. Two high speed decade counting stages follow the main gate. The next decade stage consists of a divide by two circuit followed by a divide by five circuit which is incorporated in the integrated counter circuit. Five more decade counters follow. These are also part of the integrated counter circuit.

## INTEGRATED LOGIC CIRCUIT

12. As well as counting, the integrated logic circuit has other important functions in the operation of the instrument. After each measurement (except in the COUNT B mode), the b.c.d. outputs of all eight counting stages are latched into a memory for display while the next measurement is taking place. The memory output for each digit is multiplexed in turn to the display. Leading zeros are detected and an inhibit signal produced. Also, the integrated logic circuit uses the control signals from the range switches to program a divide by n counter which divides the frequency standard signal to produce the frequency measurement timebase.

## FREQUENCY STANDARD

13. Two types of frequency standard are available. Both are temperature compensated 10 MHz crystal oscillators in which a change in ambient temperature causes a thermistor and varactor diode network to compensate the crystal oscillator tuning by an amount equal and opposite to the tuning drift that



would otherwise occur with such a temperature change. In the oven controlled version, the crystal is thermally coupled to a power transistor and a thermistor. The thermistor controls the output of an operational amplifier, which drives the power transistor. The dissipation of the power transistor is thus maintained at a level that gives a steady temperature at the thermistor and at the crystal. Both types have a control that allows adjustment to compensate for crystal ageing. Associated with the frequency standard are the circuits that allow the use of an external frequency standard or a frequency input for ratio measurements.

## DISPLAY

14. The eight digit display uses 8 mm high seven-segment l.e.d. numerical displays. OVERFLOW, EXT. STD. and GATE indicators are single l.e.d. lamps in the display assembly. The decimal point is automatically positioned according to the range selected. The decimal point is suppressed in the COUNT B and frequency ratio modes and flashes in the delay mode when the delay time is displayed. The display digits can be checked by releasing all range push buttons which illuminates all numerical display segments including decimal points.



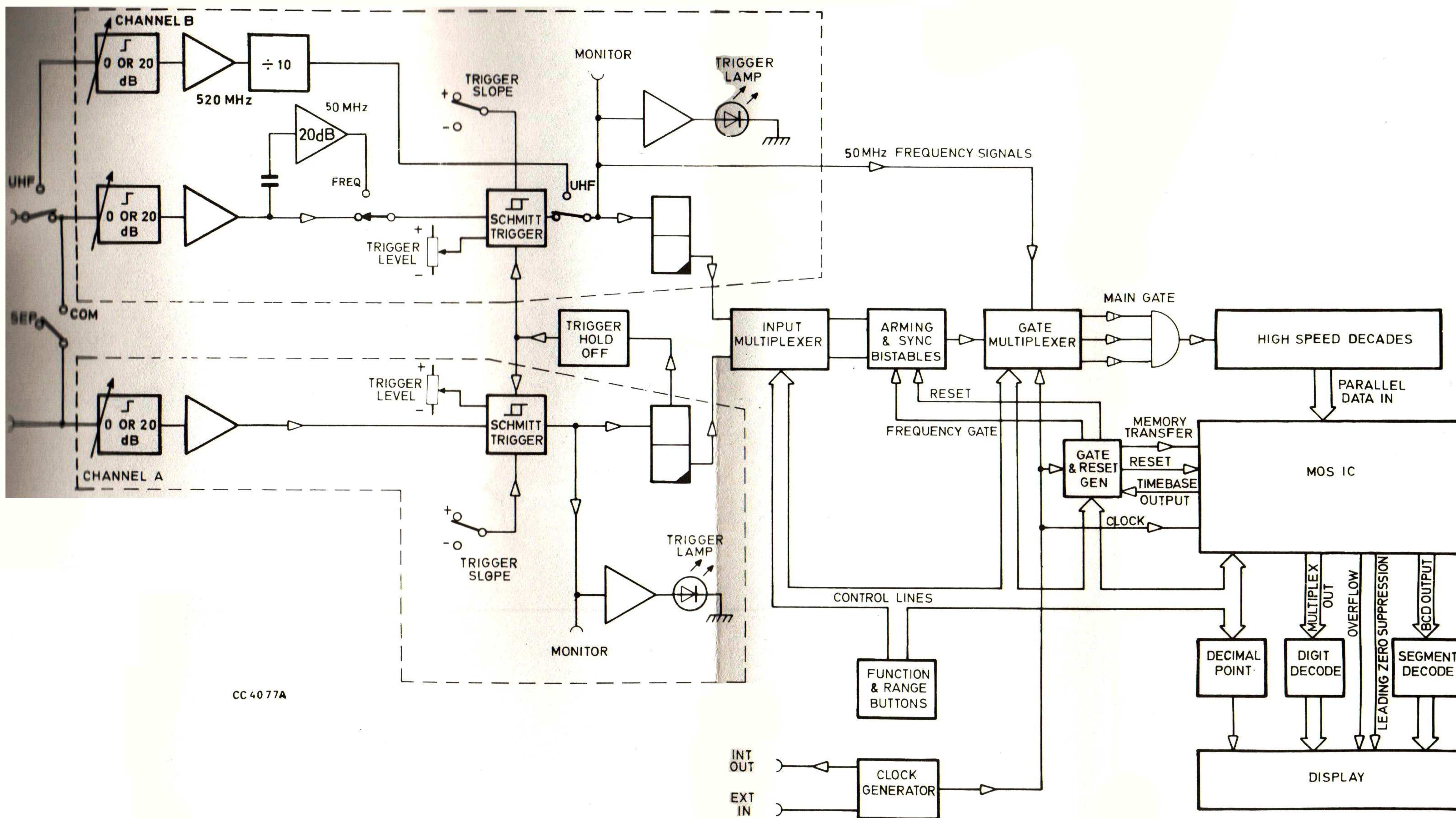


Fig. 7  
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Simplified block diagram

Fig. 7  
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