Timer Counter
TC11/12
Instruction Manual

ADVANCE
INSTRUMENTS

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Contents

Introduction

Section 1

Timer Counters TC11 and TC12 are instruments designed for the measurement of frequencies up to at least 15MHz. TC11 offers a four digit display with a maximum gate time of 1 second (1Hz resolution) whilst the TC12 with similar facilities to the TC11 offers a five digit display with a maximum gate time of 10 seconds (0.1Hz resolution).

Both instruments may also be used for counting and timing measurements using the START/STOP gate facilities. Multiple period operation enables low frequencies to be measured to a high degree of accuracy.

An input impedance of 1MΩ shunted by 18pF enables standard oscilloscope probes to be used. This facility together with a three position input attenuator giving sensitivites of 10mV, 100mV and 1V RMS ensures accurate measurements over a wide range of signal levels.

The internal standard of 100kHz is accurate to one part in 10^5. Facilities are provided for the substitution of an external standard or signal within the frequency range 10Hz to 2MHz; thereby also allowing the instruments to be used for ratio measurements.

Integrated circuits are used for maximum reliability and the internal construction allows immediate access to all components. Indicator tubes of a new type provide an extremely bright clear display, and enable the instruments to be used in adverse lighting conditions.

Data output is available from pins on the printed circuit board (8421 code).

DISPLAY
TC11 Four in line numerical indicators.
TC12 Five in line numerical indicators.

FREQUENCY MEASUREMENT
2Hz to at least 15MHz via input A.
GATE TIMES TC11 0.1mS to 1S.
TC12 0.1mS to 10S.
Selected in decade steps.

TIME MEASUREMENTS

TIME UNITS TC11 10μS to 1S.
TC12 10μS to 10S.
Selected in decade steps.

Start and Stop inputs can be A to A, B to B and B to C or by push button. Time A to A (equivalent to single period) is the time interval between successive negative going signals at input A.

MULTIPLE PERIOD
From 10 to 10^5 periods selected in decade steps over the frequency range of 2Hz to at least 100kHz via input A. Operates from positive going signals.

COUNT MODE
2Hz to at least 15MHz via input A with start and stop controls via inputs B to B, B to C or manually by push button control.

ACCURACY

FREQUENCY TIME AND PERIOD ±1 count ±accuracy of standard ± trigger point error.
COUNT Absolute, but ±1 count when the gate is operated.

FREQUENCY STANDARD

INTERNAL 100kHz crystal oscillator set to 1 part in 10^5 at room temperature. Stability ± 6 parts in 10^5 over the temperature range 0 to +50°C; typically ±3 parts in 10^5 from +10 to +40°C.
EXTERNAL Sinusoidal signal 10kHz to 2MHz, 0.5V to 10V RMS or a suitable pulse source from 10Hz to 2MHz, 1V to 20V peak to peak.
NB Use of other than 100kHz standard will change the scale of measurement, e.g. frequency ratio may be measured.

INPUT A

SENSITIVITY 10mV, 100mV and 1V RMS selected by a three position switched attenuator (2Hz to 15MHz)
MAXIMUM INPUT 250V RMS (DC to 20kHz) on all attenuator positions. 3V RMS on 10mV position. 30V RMS on 100mV and 1V positions at frequencies above 20kHz.
INPUT IMPEDANCE 1MΩ in parallel with 18pF (suitable for use with an oscilloscope probe). In 10mV position protective limiting causes the impedance to drop to 200kΩ, 120pF with signal levels over 1V RMS.

INPUTS B AND C

SENSITIVITY 1V peak negative going, fall time between 1 and 100nS Maximum input ±3V peak, capacitive coupled.
(Operative on time and count functions only).

RESET INPUT
Operates from a contact to ground; open circuit voltage +18V maximum, short circuit current 15mA maximum. Alternatively a negative going pulse of between 6V and 20V and at least 1mS duration; the positive levels should lie between 0 and +20V.

CHECK FACILITY
The 100kHz standard is counted for the gate time selected.

DISPLAY TIME
Continuously variable from less than 0.1S to at least 4S with switched hold position and manual or external reset.

DATA OUTPUT
The display data is available from pins on the printed circuit board. (Format is 8421 BCD positive going, negative true. Outputs are high impedance unbuffered).

POWER SUPPLY REQUIREMENTS
100 to 125V or 200 to 250V, 45 to 65Hz.
Consumption 25VA.

TEMPERATURE RANGE
0 to +50°C

ACCESSORIES SUPPLIED
One 50Ω BNC connector, Part No. 1166.
One miniature Jack plug (for external standard) Part No. 2127
Four (4) mm plugs, Part No. 1244
Instruction Manual, Part No. 25884

DIMENSIONS AND WEIGHT
$11\frac{1}{2}$" (29.3cm) wide, $5\frac{3}{4}$" (14.6cm) high, $9\frac{7}{8}$" (25cm) deep overall.
10.5 lb (4.8kg)

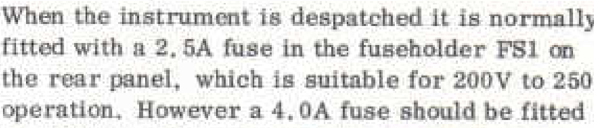
3.1 PRELIMINARY

The instrument is normally despatched from the factory for use with AC supply voltages within the range 200V to 250V. To operate from AC supply voltages between 100V and 125V proceed as follows:-

Four taps are provided on the side of the supply transformer T1 nearest the top of the instrument; these are marked 0; 112V; 0; 112V and enable the primary windings to be connected either in series (for 200V to 250V operation) or in parallel (for 100V to 125V operation).

The instrument is normally supplied for 200V to 250V operation with the windings connected in series, i.e. thus:-

To connect for 100V to 125V operation, remove the link and parallel the windings thus:-



Note that no connections to the other tags on the transformer must be made or disturbed.

When the instrument is despatched it is normally fitted with a 2.5A fuse in the fuseholder FS1 on the rear panel, which is suitable for 200V to 250V operation. However a 4.0A fuse should be fitted for 100V to 125V operation to prevent the fuse from being blown with the switch-on surge. The supply on-off switch is operated by the function switch, and when the instrument is connected to the supply and switched to the required function the neon indicator tubes will be illuminated.

3.2 DISPLAY AND RESET

When the SAMPLE RATE control is switched to the HOLD position, reset may be actuated manually by the push button or by a closed contact to ground at the external reset socket. Repetitive readings are obtained by turning the control clockwise, the length of time for which a reading is displayed depends on the setting of this control and may be varied from at least four seconds to less than 0.1 seconds when the control is fully clockwise, at the maximum sample rate.

The use of longer display times is advisable with measurements having a gate time longer than about 0.01 sec. since a very rapid sampling rate (short display time) makes it difficult to observe the steady display during the period when the gate is closed.

3.3 FREQUENCY MEASUREMENT

The frequency of signals of at least 10mV RMS and not greater than 250V RMS up to 20kHz, and not greater than 3V RMS above 20kHz, from 2Hz to 15MHz can be measured, using the BNC input socket A. The input attenuator should be used with larger signals as appropriate, in the 100mV or 1V position. This will also enable inputs up to 30 volts, above 20kHz, to be measured. The input impedance of 1MΩ and 18pF approximately, enables a normal oscilloscope probe to be used.

The TIME UNITS switch shows five gate times: 10^{-4}, 10^{-3}, 10^{-2}, 10^{-1}, and 1 second, there is additionally a 10 sec. gate time on the TC12. The display is in Hz or kHz, as shown on the TIME UNITS switch when the display reading is multiplied by the factor shown; for example, on Hz x 100, (with a gate time of 10^{-2} secs) a reading of 0633 would be 63300Hz or 63.3kHz. The longer gate times can be used to obtain a greater number of digits and thus greater accuracy. For greater accuracy below about 100kHz it is advisable to select MULTIPLE PERIODS.

The number of digits can be extended beyond the readout capability by taking two measurements, one measurement to obtain the most significant digits, and another to obtain further digits, whilst overspilling the most significant ones by using longer gate times.

Note that an external standard is necessary to achieve accuracies of more than 1 in 10^5.

3.4 PERIOD MEASUREMENT

(a) TIME A-A for Single Period Measurements. To obtain an accurate determination of lower frequencies it is better to measure the period of the signal, that is, the time elapsing between two consecutive negative going signals exceeding the triggering threshold, this is performed when the selector switch is set to TIME A-A.

The setting of the TIME UNITS switch determines the units of the display and it is necessary to take the reciprocal to obtain the frequency. For example, using ten micro seconds units (TIME UNITS: 10^{5} secs) a reading of 2000 x 10μS ±10μS gives a frequency of 50Hz±0.05%.

However any period measurement suffers from a trigger point error due to hum and noise on the signal, causing the trigger point at which measurements are made to jitter in time. If random fluctuations occur in the reading, different attenuator positions should be tried to obtain the most consistent display. When using the 100mV or 10mV positions particularly, care should be taken not to pick up spurious signals, with unscreened leads for example. The effects of the trigger point error may be further minimised by increasing the number of periods over which the measurement is made.

(b) MULTIPLE PERIOD
The time indicated on the counter is always in 10 microsecond units, and is the time elapsing between the first positive going signal to trigger the counter and a selected subsequent positive signal.

The selection of the latter signal is made according to the NUMBER OF PERIODS selected, which may be any power of ten from 10 to 10^{5} in decade steps.

On MULTIPLE PERIODS x 10^{3} a reading of 2000 x 10μS gives accuracy 50kHz ±0.05% neglecting any trigger point error, and accuracy increases progressively with greater numbers of periods and with lower frequencies.

3.5 TIME MEASUREMENTS
In addition to the TIME A-A function, time measurements can be made in three modes.

(a) TIME B-B
The TIME UNITS selected are counted between the first and second negative going pulses at the B input socket, after a reset has been applied. Subsequent pulses have no effect, until reset is again applied. The pulses, which are specified in SECTION 2, must not exceed 3V or the instrument may be damaged.

(b) TIME B-C
In this position of the FUNCTION SWITCH, the selected TIME UNITS are counted between the application of a negative going pulse at the B input and a subsequent negative going pulse at the C input. The counter does not respond to any pulse at the C input before the pulse at B or any subsequent pulses before the next reset is applied.

Both the B and C inputs may be activated by a closed contact to ground if a 150KΩ resistor is connected between the input and ground (i.e.across the contact) and a 470K resistor from the input to the RESET socket, which provides a suitable voltage, approximately 16V via 220K. Contact bounce may be suppressed by a capacitor of the order of 0.01μF connected across the contacts.

(c) MANUAL
In the TIME and COUNT positions the manual START and STOP push buttons may be used to control the gate. Reset must be applied before the buttons are operated again.

3.6 COUNTING
This function is similar to the TIME B-B and B-C functions except that the number of cycles of any signal at the A input socket is counted between start and stop signals. These start and stop signals may be applied in any of the ways detailed for the time measurement.

3.7 CHECK
This facility enables the counting and time base decades to be checked. When the function switch is in this position the standard frequency is counted for a time selected by the time units switch. In the 1 second gate position the counter should display all digits zero ±1 count. The SAMPLE RATE control should be set anticlockwise to enable the display to be seen. When the instrument is first switched on it may not count correctly until a reset pulse is applied, since the decades may not start at a zero count state.

Note: Check that the EXT. STANDARD jack plug has been removed, since this cuts off the internal standard.

3.8 EXTERNAL STANDARD (Rear panel socket)
This input can be used to increase the accuracy, or change the scale of measurements. Inserting a jack in this socket automatically disconnects the internal 100kHz standard. Inputs should be as specified in SECTION 2; with positive pulse inputs, the mark-space ratio should not be less than 10 to 1.

3.9 FREQUENCY RATIO
Frequency ratios may be measured by using the frequency function and applying f1 to the normal input and f2 to the EXT. STANDARD input.

The ratio $10\frac{f1}{f2}$ is displayed with the TIME UNITS switch in the 10^{-4} position; other positions will give $100\frac{f1}{f2}$, $1000\frac{f1}{f2}$ for the 10^{-3} and 10^{-2} positions respectively and so on. The 10^{-5} position cannot be used for frequency ratio measurement.

4.1 GENERAL
The circuits of the instrument fall into three main sections, the counting decades and display, the timebase, and the input amplifier. A large part of the circuitry consists of integrated circuits and only the function of these will be described and not their internal circuitry.

Block diagrams of the interconnection of the various circuits for different functions are to be found at the end of Section 5, Fig. 1.

4.2 INPUT CIRCUITS (Fig. 2)
The input signal at socket A is amplified by the input amplifier and converted to square waves by the trigger circuit.

The input signal is fed through the switched attenuator to the high impedance field effect transistor stage VT1 which is biased by a constant current stage VT2. Protection against excessive negative signals is given by MR1 and large positive signals are limited by VT1 itself together with R4 and R5. The signal is coupled by the emitter follower stage VT3 to the three stage transistor amplifier VT4, VT5 and VT6. DC feedback over these three transistors stabilises their operating bias. Capacitors C17, 20 and C21 maintain a level response at high frequencies.

The trigger circuit VT7 and VT8 is a bistable type and VT9 is used to drive into subsequent circuitry without loading the bistable excessively.

4.3 COUNTING AND DISPLAY CIRCUITS (Fig. 4)

(a) START-STOP GATE
The pulses which are to be counted are fed via amplifier VT1 and differentiated by C3, R3.

The transistors VT2, VT3 and VT4, form a gate which is controlled by the two bistable circuits IC1, and IC14 which operate as follows:

Initially, after reset, the two '0' outputs are at the logic '0' level which is 'high' and this output from the 'start' bistable IC14 therefore switches VT4 on , this closes the gate.

A negative going pulse at the clock input 'T' of the start bistable causes it to toggle since there is a low (1) level on the clear C input, but the high '0' level on the set S input prevents any further action by this bistable, until it is from VT4 and opens the gate.

Since initially the 'stop' bistable IC1 has high '0' levels on both inputs S and C, it cannot toggle until after the start bistable has toggled and changed the C input to a low '1' level. Then a negative going pulse on the stop bistable clock input T will cause it to toggle, the '0' high level on the set S input prevents any further action until reset is applied. When the stop bistable has toggled, it applies bias to VT3 and closes the gate.

While the gate is open pulses can pass to the driver stage VT5.

Integrated Circuits IC2 to IC6 form a decade capable of operation at frequencies up to 15MHz. IC2 is a J-K bistable, (see Table 4.2) which divides the input frequency by two, since the two steering inputs S and C are open, i.e. connected to the '1' state, ground. The '1' output from IC2 is fed to the clock input of bistable IC3 which has the C steering input open since IC6 has been reset to the '1' state ('1' output at 0V). The '1' output from IC3 drives the clock input of bistable IC4, the steering inputs of which are permanently open. As can be seen from Table 4.1 after the sixth input pulse, the '0' outputs from IC3 and IC4 are at the '1' low level. This causes the output of the first gate, pin 7, IC5, to change to the high level and thus apply a low '1' level to the steering input C of IC6, via the second gate of IC5 which acts as an inverter. At the eighth pulse, the negative going output from IC2 causes IC6 to toggle, and its '1' output now at the high '0' level, inhibits IC3 until after the tenth pulse. The tenth pulse causes IC6 to toggle back to the set state and all the bistables are then again in the '0' state.

Table 4.1 shows the counting, where '1' indicates the bottomed state and '0' the cut off state, at the '0' output of each IC.

Input Pulse No.	IC2 BCD '1'	IC3 BCD '2'	IC4 BCD '4'	IC6 BCD '8'
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	0	0	0
11	1	0	0	0
12	0	1	0	0
		etc		

(c) INTEGRATED DECADES AND DISPLAY
The BCD outputs from the high frequency decade are fed to the integrated decoding and indicator driving package IC10 and additionally the positive going edge of the BCD's output drives an integrated circuit decade IC7.

The BCD output of IC7 drives IC8 and so on. Each integrated decade has an associated decoding and read out package to drive the numerical indicator tube. The decoding IC's convert the BCD input to decimal form and 'turn on' the appropriate output connection which causes the neon indicator tube to display the appropriate digit.

(d) RESET PULSE GENERATOR
The reset circuit which resets all decades to zero at the end of the display period functions as follows:-

When the sample rate control is switched from the 'HOLD' position a charging current can flow through it into C13, after a stop pulse has triggered the stop bistable IC1 and cut off VT8. The charging rate is determined by the setting of the sample rate potentiometer. As C13 charges it switches on VT7 and causes VT9 to cease conducting. VT9 is directly coupled to VT10 and the switching action regenerates through R21 so that a positive reset pulse occurs on the reset line from the collector of VT10. VT11 acts as a buffer to supply the reset pulse to the integrated circuits.

The reset pulse resets the '0' output of the stop bistable, IC1, to the 'high' state and bottoms VT8 which therefore discharges C13 through R17, and C12 charges through R19 and R21 giving a reset pulse length of approximately 5mS.

The circuit of VT6 enables manual reset to be applied.

4.4 TIMEBASE AND POWER CIRCUITS (Fig. 3)
(a) 100kHz OSCILLATOR
Crystal XL and transistor VT8 form a conventional Pierce Oscillator circuit.

The basic resonant frequency of the crystal is slightly below 100kHz and the series capacitor can be adjusted to raise the frequency to exactly 100kHz.

VT10 is an emitter follower stage which only lightly loads the oscillator stage. The output from VT10 is fed via the EXTERNAL STANDARD Jack socket to the trigger circuit VT11, VT12 which shapes the 100kHz, or the external standard frequency, into pulses suitable for driving the timebase.

(b) TIMEBASE (see Fig. 3)
The timebase consists of integrated circuit decades which divide the frequency down in stages of ten from 100kHz to 1Hz, or 0.1Hz in the TC12. The connection to the first decade is made via the function switch so that the decades may be used to divide the input frequency in the multiple period function.

The circuitry comprised of IC8 and IC9 is used to re-clock the timebase to eliminate propogation errors when deriving start and stop pulses for the counter gate. The start and stop pulses are timed from the BCD '1' output from the first decade IC2 as follows:-

Reset is applied to VT7 which clamps the output of one side of the bistable formed by the inter-connection of two gate circuits in IC9.

The first positive going edge from the BCD '1' output of IC2 is amplified and differentiated by part of IC8 and appears as a positive going pulse at the upper gate circuit of IC9, pin 3, and causes it to toggle. The negative going output from the bistable is used as the start pulse.

The selected time units, switched by the TIME UNITS switch from a decade output are amplified and differentiated by the remaining circuitry of IC8 and positive going pulses are fed to the lower gate of the bistable IC9. The first positive going edge occurs after a complete count of 10 by the appropriate decade and this resets the bistable so that the next positive going '1' output from IC2 can cause the bistable to toggle and give a negative stop pulse.

These positive going '1' pulses are therefore gated by the required decade output to give an exact gate time.

Transistors VT4 and VT5 form a gate which is closed during reset to prevent pulses passing into the decades during the reset period and VT6 inverts the signal so that the trailing edge of the reset pulse does not trigger the decade.

(c) POWER SUPPLIES
VT1 is a series regulator transistor for the main power supply, and is controlled by VT2 and VT3 from the reference zener MR5 to give a constant 5.2 volt supply. The integrated circuits are operated from a 3.8 volts supply obtained from the 5.2 volt supply by series silicon diodes MR3 and MR4.

The 200 volt DC rectified output from MR1 supplies the indicator tubes, and is decoupled by R2, R3 and C2 together with zener diodes MR6 to give a 20 volt supply with a minimum of ripple, suitable for the input amplifier. A further 16 volt supply is obtained from MR8 and C25 and is used to feed the display timer circuit.

Table 4.2 J K Bistable Logic

Output state after application of negative going pulse at the clock input (pin 3).

Set (Pin 2)	Clear (Pin 4)	'1' Output (Pin 9)
0	0	X^n
0	1	0
1	0	1
1	1	X^{-n}

0 = High 1 = Low X^n = output state prior to clock pulse i.e. does not toggle

5.1 GENERAL

(a) REMOVAL OF CASE
The top and bottom covers may be taken off by removing the two screws at the rear of the instrument and sliding the covers back. If necessary the side covers can also be slid back when the two rear side trims, each retained by two screws, have been removed. The case should only be removed with the instrument power supply disconnected, to prevent accidental short circuits.

(b) ACCESS TO COMPONENTS
The top (timebase) board of the instrument is hinged for ease of servicing, and is retained by two screws at the rear.

The input amplifier screen is secured by four screws and the side cover should be removed to gain access to the upper fixings which are to the side plate.

(c) FUSE REPLACEMENT
In addition to the line supply fuse FS1 on the rear panel (see SECTION 3.1) there is a fuse in the stabilised supply, rated at 1.0 amp, which is fitted on the right hand side of the upper board.

5.2 OSCILLATOR FREQUENCY ADJUSTMENT
When the instrument is despatched from the factory, the oscillator will have been set for the greatest accuracy in the temperature range, 20 to 25°C. Ageing is a characteristic of crystal oscillators and this results in a slow drift of frequency.

This slow drift is unpredictable and if the best performance is desired it is advisable to check against a standard frequency at periods of a few months and correct as necessary.

A standard frequency having an accuracy of at least 1 part in a million is required such as Advance Off Air Frequency Standard OFS1A or Advance FS3 or a straight receiver tuned to the B B C 200kHz Programme from Droitwich can be used but only in the absence of modulation.

If the standard frequency is a multiple or sub multiple of 100kHz it can be displayed together with the 100kHz counter frequency from the rear socket, on an oscilloscope to form a Lissajous figure, or with one frequency viewed on a normal timebase triggered from the other frequency. Use the trimmer C17 to obtain a stationary display. Alternatively adjust the trimmer to obtain the correct reading of frequency on a second gate time, with a standard frequency equal to, or greater than 100kHz.

5.3 GUIDE TO SERVICING

(a) POWER SUPPLIES AND BIAS VOLTAGES
Typical voltages measured at various points in the instrument, with function switch on CHECK and SAMPLE RATE set to HOLD are as follows:-

TABLE 5.1 Operating Voltages

Fig. 3 VT1 emitter	+5.4V at 0.62 amps
Fig. 3 C3	+3.5 to 3.95 V at 0.42 amps
Fig. 2 VT2 emitter	+2.9V ±20%
Fig. 2 VT4 collector	+2.6V ±20%
Fig. 2 VT5 collector	+3.3V ±20%
Fig. 2 VT6 collector	+3.0V ±20%

Other DC voltages should be within 10% of the values in the circuit diagrams except +200V, +16V supplies and AC voltages which should be ±15%. It is important to ensure that at no time more than +4V is applied to the integrated circuits, and if a fault is repaired in the power supply circuits the link on this board (see Fig. 6) can be removed and a dummy load of a 15Ω 2 watt resistor connected to ground. The voltages across the resistors should not exceed 4V; the link may then be replaced.

(b) FAULT LOCATION
When repairing the instrument the fault should be localised to a specific section of circuitry, where the faulty component can more readily be located. Table 5.2 gives a suitable procedure. Reference should be made to SECTION 4, Fig. 1 and circuit diagrams.

Further fault finding may be carried out using a suitable oscilloscope (Advance OS2000 or OS2100).

The 100kHz standard should be traced through the timebase decades, ensuring that they divide by ten, with the SAMPLE RATE control in the HOLD position.

Checking the remaining circuitry is often most easily done using the COUNT function with a normal input signal; after the generation of RESET and application of manual START the counting gate should open and the counting decades may be checked.

Table 5.3 shows typical waveforms observed with a high performance oscilloscope and probe.

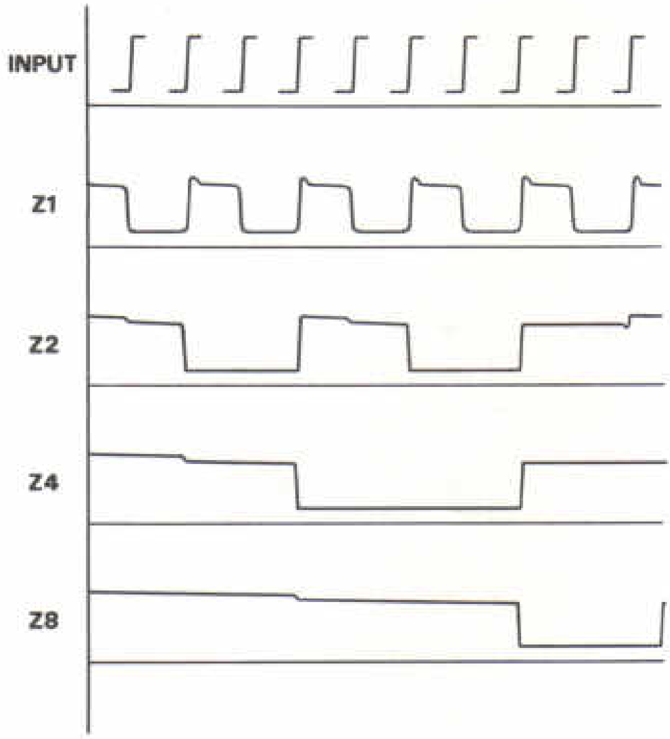
Note that when ordering spares the circuit reference and board assembly number should always be quoted in addition to the part number and value.

TABLE 5.2 Fault Location

Test	Fault	Possible Cause
Check supply tapping and supply fuse, switch to CHECK.	No display	Failure of 200V supply.
	All tubes blurred	Failure of 5.4V supply (check FS2) or 3.8V supply.
Press reset button	Display not zero	Faulty reset circuit
Display resets to zero but does not count, switch to 10μS TIME UNITS and TIME B-B, press RESET and START buttons.	Does not count	Fault in start-stop gate or logic. Fault in 100kHz oscillator, trigger or EXT. STD socket. Fault on display board.
Switch to each TIME UNITS position in turn and check that counting occurs when RESET and START applied.	Does not count with longer TIME UNITS	Faulty decade. Faulty Part IC8. Fig. 3 Fault on display board.
Apply suitable input to socket A	Counts on CHECK and TIME B-B, B-C but not other functions	Fault in input amplifier or trigger.
	Counts incorrectly	See next test.
Set Time Units to 1 sec. and TIME B-B. press RESET and START.	Right hand digit does not count 0-9	Fault in transistor decade or read out package.
As above but 0.1 sec. TIME UNITS.	Second digit does not count 0-9	Fault in decade IC2 or read out IC8 Fig. 4.
Etc. up to 10μS		Faulty decade or read out.
Apply known input frequency to socket A measure frequency.	Incorrect frequency steady readings	Incorrect triggering in input amplifier. Incorrect gate time - try other positions of TIME UNITS SWITCH to find faulty decade in timebase. Fault in reclocking circuit of timebase. Incorrect standard frequency.
Frequency or Period measurements.	Erratic readings	Hum or noise on input signal, or input amplifier. Check for steady output from amplifier trigger circuit. Power supply ripple. Poor grounding or screening of input amp.
	Two digits on display tube	Incorrect (not BCD) output from decade. Faulty readout package.
	Correct operation on manual RESET but not SAMPLE RATE	Display timer circuit fault.

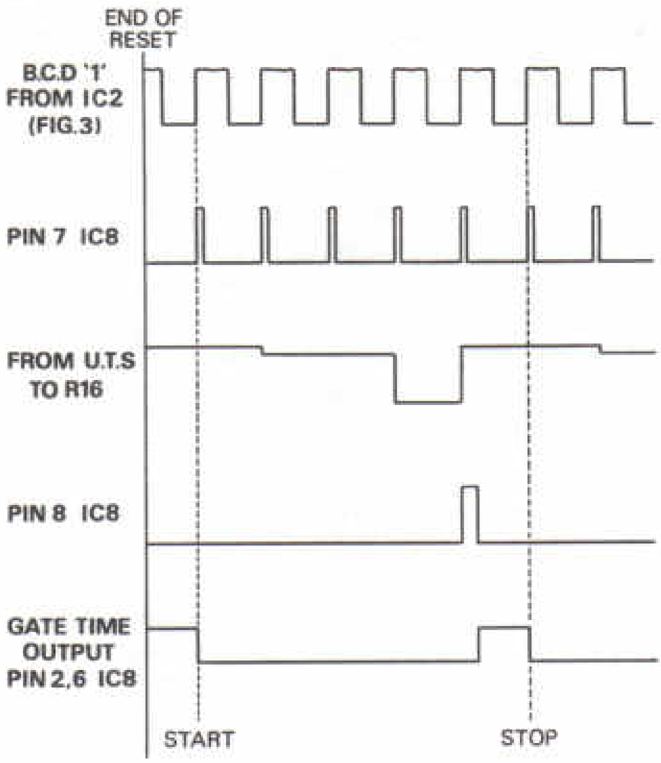
Table 5. 3 Waveforms

(a) B.C.D Decade Outputs



Note: The small steps in the waveforms are not significant

(b) Reclocking Circuit



Shown with Time Units Switch set to 10^{-4} sec.

Component List and Illustrations

Section 6

6.1 AMPLIFIER FOR TC11 TC12

Circuit Ref	Value	Description			Part No.
RESISTORS					
R1	1MΩ		10%	½W 350V	1171
R2	100K		5%	1/8W	319
R3	5.6K		5%	1/8W	787
R4	120K		5%	1/8W	5332
R5	120K		5%	1/8W	5332
R6	22K		5%	1/8W	1544
R7	8.2K		5%	1/8W	314
R8	33K		5%	1/8W	317
R9	4.7K		5%	1/8W	386
R10	1K		5%	1/8W	384
R11	1K		5%	1/8W	384
R12	6.8K		5%	1/8W	313
R13	6.8K		5%	1/8W	313
R14	1K		5%	1/8W	384
R15	2.2K		5%	1/8W	425
R16	33Ω		5%	1/8W	2931
R17	330Ω		5%	1/8W	1894
R18	27Ω		5%	1/8W	724
R19	390Ω		5%	1/8W	2410
R20	1.5K		5%	1/8W	385
R21	820Ω		5%	1/8W	1637
R22	330Ω		5%	1/8W	1894
R23	33Ω		5%	1/8W	2931
R24	15Ω		5%	1/8W	2085
R25	1.5K		5%	1/8W	385
R26	820Ω		5%	1/8W	1637
R27	220Ω		5%	1/8W	304
R28	1K		5%	1/8W	384
R29	33Ω		5%	1/8W	2931
R30	15Ω		5%	1/8W	2085
R31	330Ω		5%	1/8W	1894
R32	12K		5%	1/8W	1685
R33	1K		5%	1/8W	384
R34	12K		5%	1/8W	1685
R35	12K		5%	1/8W	1685
R36	1K		5%	1/8W	384
R37	2.7K		5%	1/8W	311
R38	12K		5%	125W	1685
R39	1.8K				310
R40	470Ω				1373
R41	2.7K				311
R42	1.2K				2087
R43	1.2K				2087
CAPACITORS					
C1	0.1μF	Polyester	10%	400V	2385
C2	4.7pF	Silver Mica	+½pF	350V	4502
C3	4.7pF	Silver Mica	+½pF	350V	4502
C4	33pF	Silver Mica	5%	350V	4779
C5	68p	Silver Mica	5%	350V	4513
C6	100p	Ceramic	10%	500V	22376

Circuit Ref	Value	Description			Part No.
CAPACITORS (Cont)					
C7	.047μF	Ceramic	+80% -20%	30V	2793
C8	.05μF	Ceramic	±20%	12V	19657
C9	.05μF	Ceramic	±20%	12V	19657
C10	200μF	Electrolytic	-10% +50%	10V	20782
C11	.047μF	Ceramic	+80% -20%	30V	2793
C12	.05μF	Ceramic	±20%	12V	19657
C13	.05μF	Ceramic	±20%	12V	19657
C14	200μF	Electrolytic	-10% +50%	10V	20782
C15	.05μF	Ceramic	±20%	12V	19657
C16	1000μF	Electrolytic	-10% +50%	6.4V	24797
C17	12pF	Ceramic	10%	500V	22365
C18	200μF	Electrolytic	-10% +50%	10V	20782
C19	.05μF	Ceramic	±20%		19657
C20	220pF	Ceramic	±10%	500V	22379
C21	220pF	Ceramic	±10%	500V	22379
C22	68p	Ceramic	10%	500V	22374
C23	500μF	Electrolytic	-20% +50%	6V	1742
C24	.05μF	Ceramic	20%	12V	19657
C25	200μF	Electrolytic	-10% +50%	10V	20782
C26	.05μF	Ceramic	20%	12V	19657
C27	18pF	Ceramic	10%	500V	22367
C28	15pF	Ceramic	10%	500V	22366
C29	.05μF	Ceramic	20%	12V	19657
C30	1000μF	Electrolytic	-10% +50%	6.4V	24797
MR1		Diode 1N916			1949
MR2		Diode 1S44			18970
VT1		F E Transistor MPF102			
VT2		Transistor BSX19			22171
VT3		Transistor 2N3662			24123
VT4		Transistor 2N3662			24123
VT5		Transistor 2N3662			24123
VT6		Transistor 2N3662			24123
VT7		Transistor BSX20			23307
VT8		Transistor BSX20			23307
VT9		Transistor BSX19			22171
S1		Switch 2 Pole, 3 way Slider			
MR3		Diode ZF-15 Zener			4669

6.2 TC11 TC12 DISPLAY

Circuit Ref	Value	Description			Part No.
RESISTORS					
R1	1.2K		5%	1/8W	2987
R2	330Ω		5%	1/8W	1894
R3	4.7K		5%	1/8W	386
R4	330Ω		5%	1/8W	1894
R5	680Ω		5%	1/8W	309
R6	680Ω		5%	1/8W	309
R7	680Ω		5%	1/8W	309
R8	330Ω		5%	1/8W	1894
R9	33K		5%	1/8W	317
R10	33K		5%	1/8W	317
R11	33K		5%	1/8W	317
R12	33K		5%	1/8W	317
R13	220K		5%	1/8W	4023
R14	1K		5%	1/8W	384
R15	1K		5%	1/8W	384
R16	1K		5%	1/8W	384
R17	100Ω		5%	1/8W	11504
R18	680Ω		5%	1/8W	309
R19	15K		5%	1/8W	305
R20	2.2K		5%	1/8W	425
R21	15K		5%	1/8W	315
R22	220Ω		5%	1/8W	304
R23	330Ω		5%	1/8W	894
R24	3.3K		5%	1/8W	317
CAPACITORS					
C1	15pF	Ceramic	10%	500V	22366
C2	.05pF		20%	12V	19657
C3	22pF		10%	500V	22368
C4	15pF		10%	500V	22366
C5	15pF		10%	500V	22366
C6	47p		10%	500V	22372
C7	.05µF		10%	12V	19657
C8	1000p		25%	250V	22395
C9	.05µF		20%	12V	19657
C10	.05µF		20%	12V	19657
C11	.1µF		+80% -20%	30V	19647
C12	.22µ		10%	160V	2601
C13	4.7µF		10%	100V	
MR1		Diode 1S44			18970
MR2		Diode 1S44			18970
TRANSISTORS					
VT1		BSX20			23307
VT2		BSX19			22171
VT3		BSX19			22171
VT4		BSX19			22171
VT5		BSX19			22171
VT6		2N3905			20818
VT7		F E Transistor MPF102			
VT8		BSX19			22171

Circuit Ref	Value	Description		Part No.
TRANSISTORS (Cont)				
VT9		2N3905		20818
VT10		BSX19		22171
VT11		BSX20		23307
INTEGRATED CIRCUITS				
IC1		5992629		24090
IC2		5992629		24090
IC3		5992629		24090
IC4		5992629		24090
IC5		5991429		24091
IC6		5992629		24090
IC7		6995879		25873
IC8		6995879		25873
IC9		6995879		25873
IC10		U19284		27347
IC11		U19284		27347
IC12		U19284		27347
IC13		U19284		27347
IC14		5992629		24090
ILP1		Numicator ZM1172		25874
ILP2		Numicator ZM1172		25874
ILP3		Numicator ZM1172		
ILP4		Numicator ZM1172		25874
ILP5		Numicator ZM1172		25874
IC15		Integrated Circuit U19284	TC12 only	27347
IC16		Integrated Circuit 6995879		25873

ILP5. IC15, IC16 are for TC12 only

6.3 TC11 TC12 100kHz TIMEBASE AND POWER SUPPLY CIRCUIT

Circuit Ref	Value	Description			Part No.
RESISTORS					
R1	330Ω		5%	1/8W	1894
R2	15K		5%	1W	2051
R3	15K		5%	1W	2051
R4	820Ω		5%	1/8W	1637
R5	330Ω		5%	1/8W	1894
R6	1K		5%	1/8W	384
R7	4.7K		5%	1/8W	386
R8	4.7K		5%	1/8W	386
R9	4.7K		5%	1/8W	386
R10	1.8K		5%	1/8W	310
R11	390Ω		5%	1/8W	2410
R12	560Ω		5%	1/8W	308
R13	33K		5%	1/8W	1638
R14	2.7K		5%	1/8W	311
R15	3.3K		5%	1/8W	1638
R16	270Ω		5%	1/8W	2716
R17	2.2K		5%	1/8W	425
R18	27K		5%	1/8W	316
R19	10K		5%	1/8W	11503
R20	Not fitted				
R21	10K		5%	1/8W	11503
R22	Not fitted				
R23	1K		5%	1/8W	384
R24	8.2K		5%	1/8W	314
R25	5.6K		5%	1/8W	787
R26	10K		5%	1/8W	11503
R27	330Ω		5%	1/8W	1894
R28	4.7K		5%	1/8W	386
R29	470Ω		5%	1/8W	1373
R30	4.7K		5%	1/8W	386
R31	10K		5%	1/8W	11503
R32	470Ω		5%	1/8W	1373
R33	1.2K		5%	1/8W	2087
R34	10Ω		5%	1/8W	2259
R35	33Ω		5%	1/8W	2931
R36	6.8K		5%	1/8W	313
R37	Not used				
R38	22K	Variable Resistor			
CAPACITORS					
C1	16μF	Electrolytic	-20% +50%	350V	
C2	30μF	Electrolytic	-20% +50%	250V	12189
C3	1000μF	Electrolytic	-10% +50%	6.4V	24797
C4	100μF		-10% +50%	6.4V	24797
C5	.047	Ceramic	+80% -20%	30V	2793
C6	200μF	Electrolytic	-10% +50%	10V	20782
C7	3200μF	Electrolytic	-10% +50%	16V	

Circuit Ref	Value	Description			Part No.
CAPACITORS (Cont)					
C8	18pF	Ceramic	10%	500V	22367
C9	18pF		10%	500V	22367
C10	05μF	Ceramic	20%	12V	19657
C11	05μF	Ceramic	20%	12V	19657
C12	470p	Ceramic	10%	500V	22383
C13	18p	Ceramic	10%	500V	22367
C14	1500pF				22388
C15	.05μF		20%	12V	19657
C16	2200p		20%	500V	22389
C17	4-60p	Trimmer			1866
C18	Not fitted				
C19	Not fitted				
C20	4700p		25%	500V	22393
C21	10μF		-20% +100%	6V	18249
C22	330pF	Ceramic	10%	500V	22381
C23	.047μ	Polyester	20%	400V	3398
C24	18pF	Ceramic	10%	500V	22367
C25	400μF	Electrolytic	-10% +50%	25V	20784
C26	.05μF	Ceramic	20%	12V	19657
TRANSISTORS					
VT1		Part of Main Assy. 2N3055			
VT2		2N5053			4039
VT3		2N930			21548
VT4		BSX19			22171
VT5		BSX19			22171
VT6		BSX19			22171
VT7		BSX20			23307
VT8		BSX19			22171
VT9		Not fitted			
VT10		BSX19			22171
VT11		BSX19			22171
VT12		BSX19			22171
DIODES					
MR1		BYX10			21251
MR2		Bridge Rectifier		1.5A	19725
MR3		1N4003			23462
MR4		1N4003			23462
MR5	4.3V	Zener	5%	400mW	27320
MR6	20V	Zener	5%	400mW	19955
MR7		1S44			18970
MR8		MS1			18806
FS1		Fuse		1A	1254
IC1		Not fitted			
IC2		Integrated Circuit Decade 6995879			25873
IC3		Integrated Circuit			25873
IC4		Integrated Circuit			25873
IC5		Integrated Circuit			25873
IC6		Integrated Circuit			25873
IC8		Integrated Circuit 5992729			24094

6.4 TC11 TC12 INTERCONNECTION DIAGRAM

Circuit Ref	Value	Description				Part No.
RESISTORS						
R71	10K	Cr. Carbon	5%	1/8W		11503
R72	2.7K	Cr. Carbon	5%	1/8W		311
R73	2.7K	Cr. Carbon	5%	1/8W		311
R74	2.7K	Cr. Carbon	5%	1/8W		311
R75	2.7K	Cr. Carbon	5%	1/8W		311
CAPACITORS						
C71	4700pF	General Purpose Ceramic				22393
C72	4700pF	General Purpose Ceramic				22393
VT1		Transistor 2N3055				3813
T1		Transformer				MT598
SWITCHES						
S1		Time Units				25664
S2		Function				25665
S3		Stop PBS1M Rendar				4881
S4		Start SP60 PBS/CO/1 Rendar				4208
S5		Reset PBS1M Rendar				4881
RV2/S6		Control Pot 5MΩ REV Log. with switch ABM AY45				25877
SOCKETS						
SK1		Belling Lee L1413 4mm Black			Reset	25878
SK2		Belling Lee L1413 4mm Black			Ground	25878
SK3		Belling Lee L1413 4mm Black			Input C	25878
SK4		Belling Lee L1413 4mm Black			Input B	25878
SK8		Socket Jack Rendar MJ600/A			Ext. Std.	2726
SK9		Connector 50Ω BNC UG1094/A			Input A	1222
FS1	2.5A					21189

6.3 TC11 TC12 100kHz TIMEBASE AND POWER SUPPLY CIRCUIT

Circuit Ref	Value	Description		Part No.
IC9		Integrated Circuit 5991429		24091
XL1		Crystal 100kHz		
IC7		Integrated Circuit 6995879	TC12 only	25873

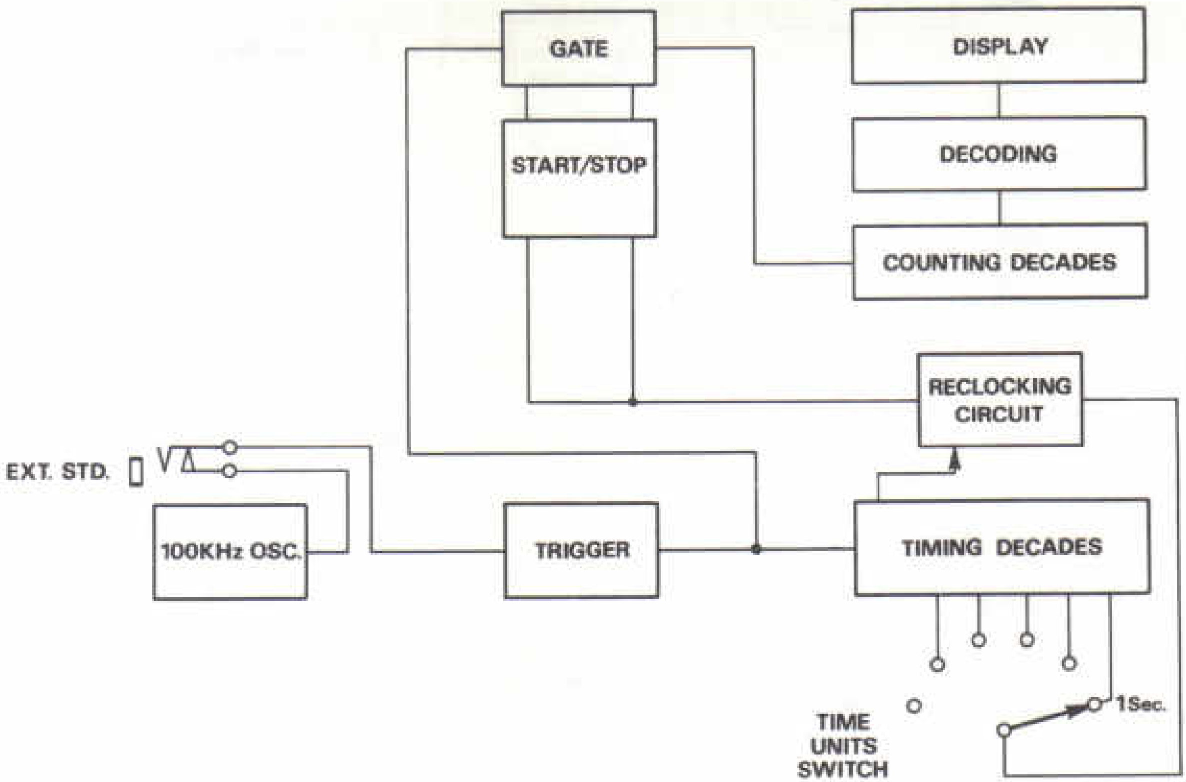


Fig. 1 (a) Check Facility

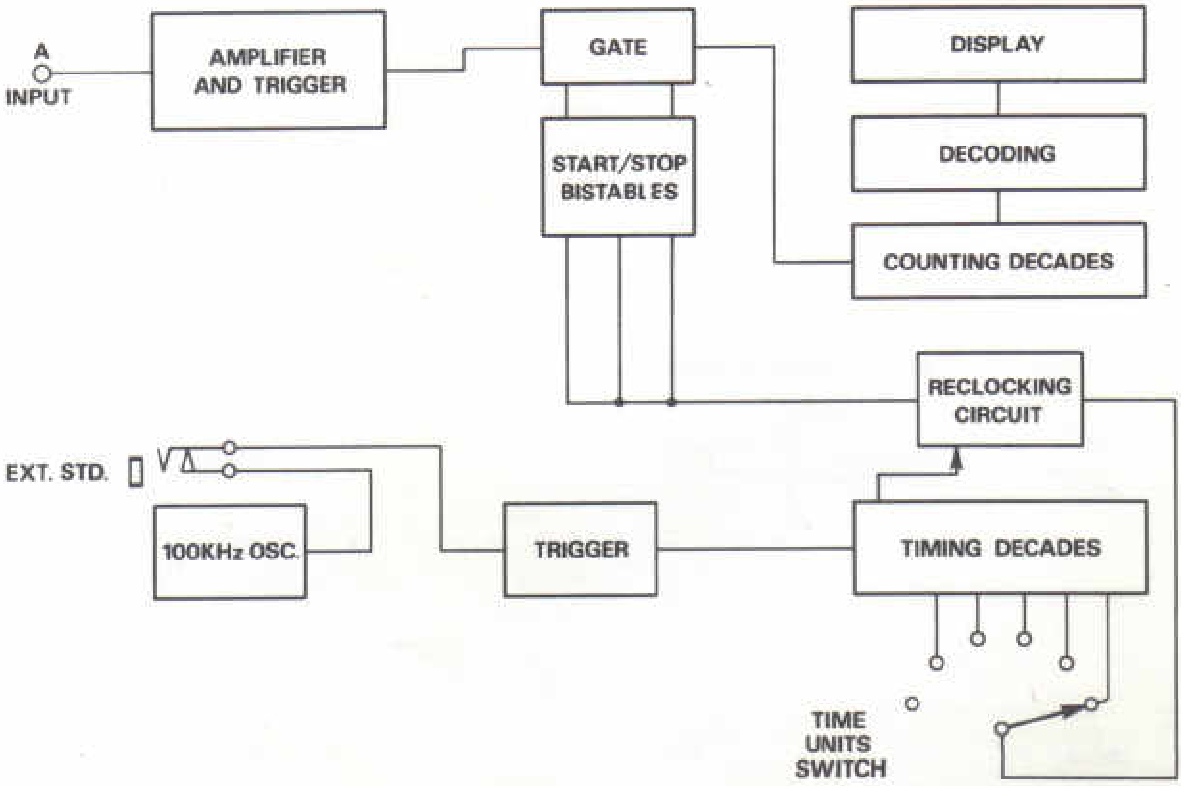


Fig. 1 (b) Frequency Measurement

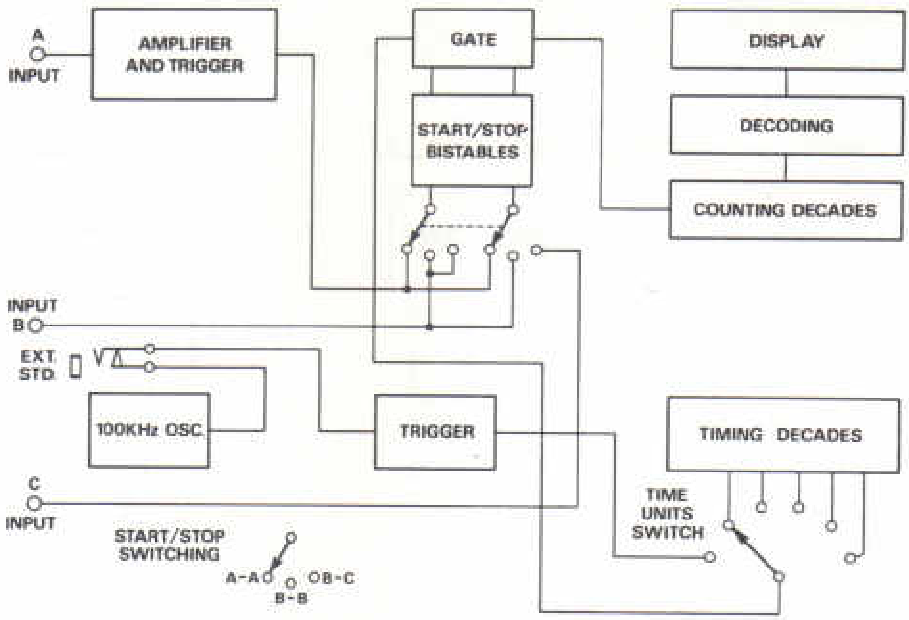


Fig. 1 (c) Time Measurements

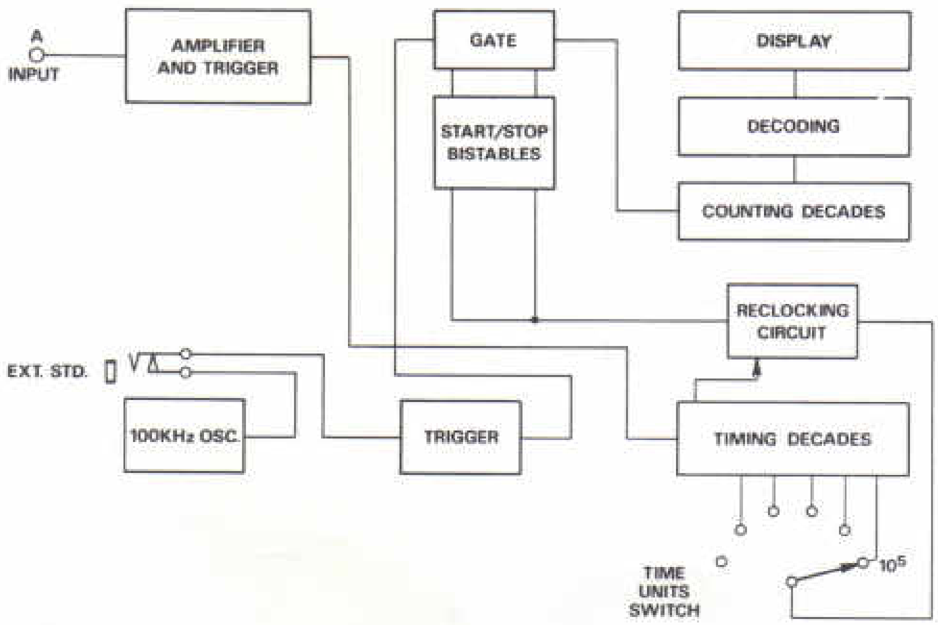


Fig. 1 (d) Multiple Period Measurements

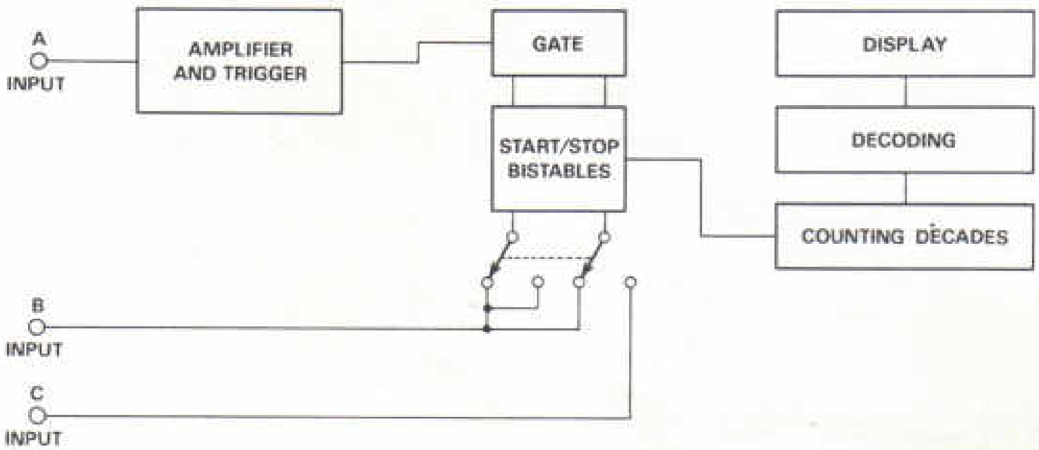
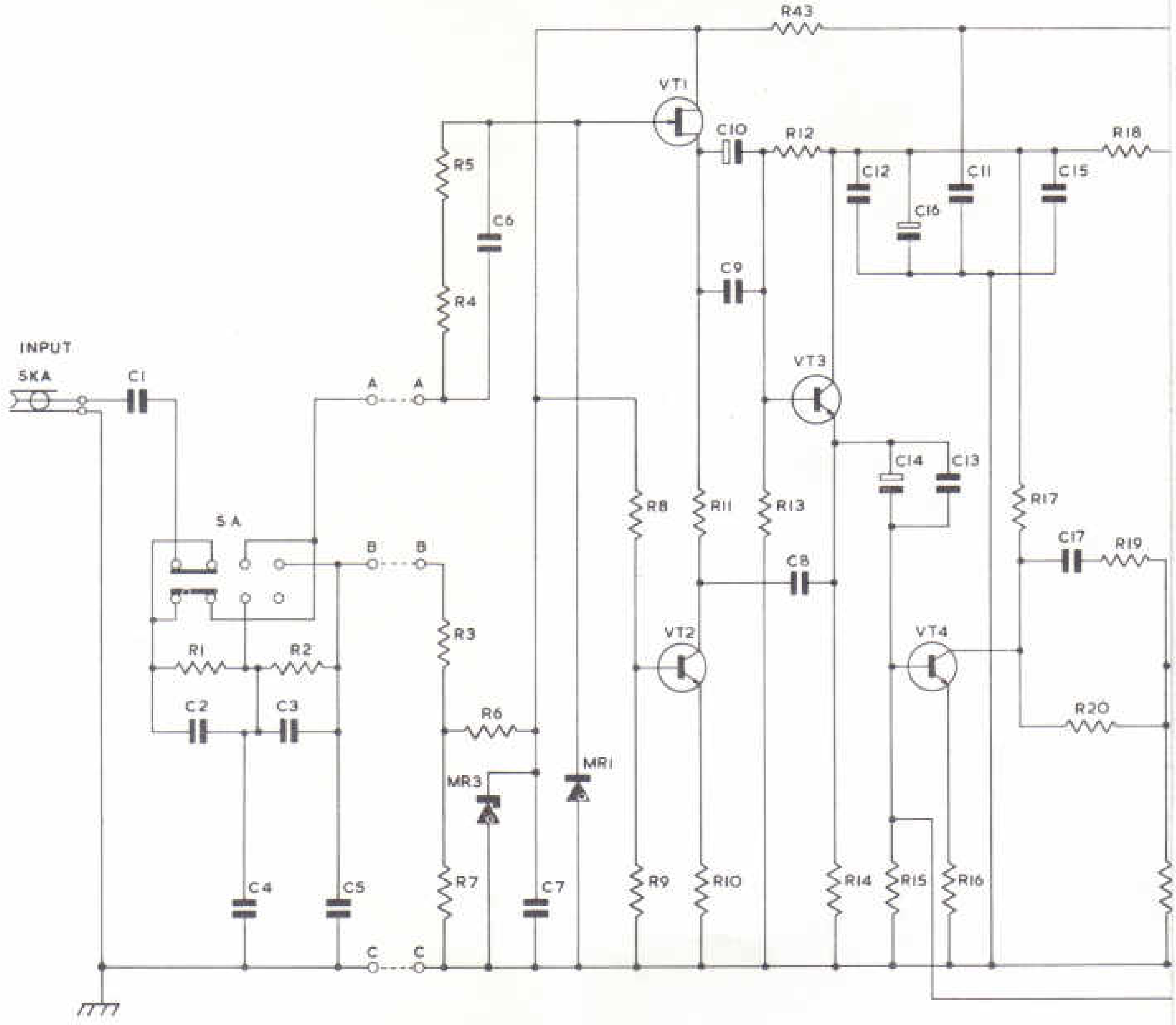


Fig. 1 (e) Count

Fig. 2 Input Amplifier Circuit Diagram



INPUT
SKA
C1
SA
A
A
B
B
C
C
R1
R2
C2
C3
C4
C5
R3
R4
R5
C6
R6
R7
MR3
MR1
C7
R8
R9
VT1
R43
C10
R12
R18
C12
C11
C15
C16
C9
VT3
R11
R13
C14
C13
R17
C17
R19
C8
VT2
VT4
R20
R10
R14
R15
R16

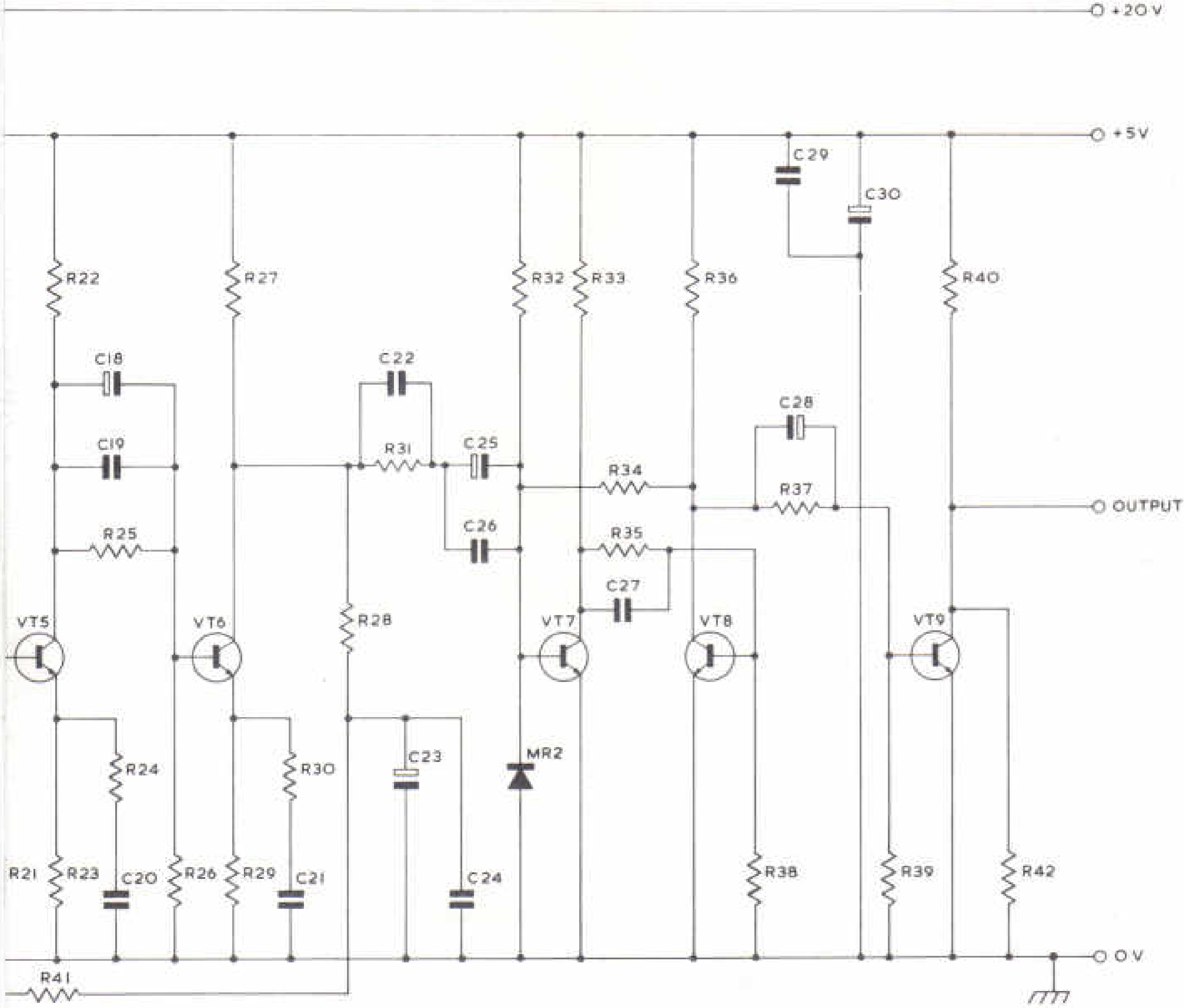
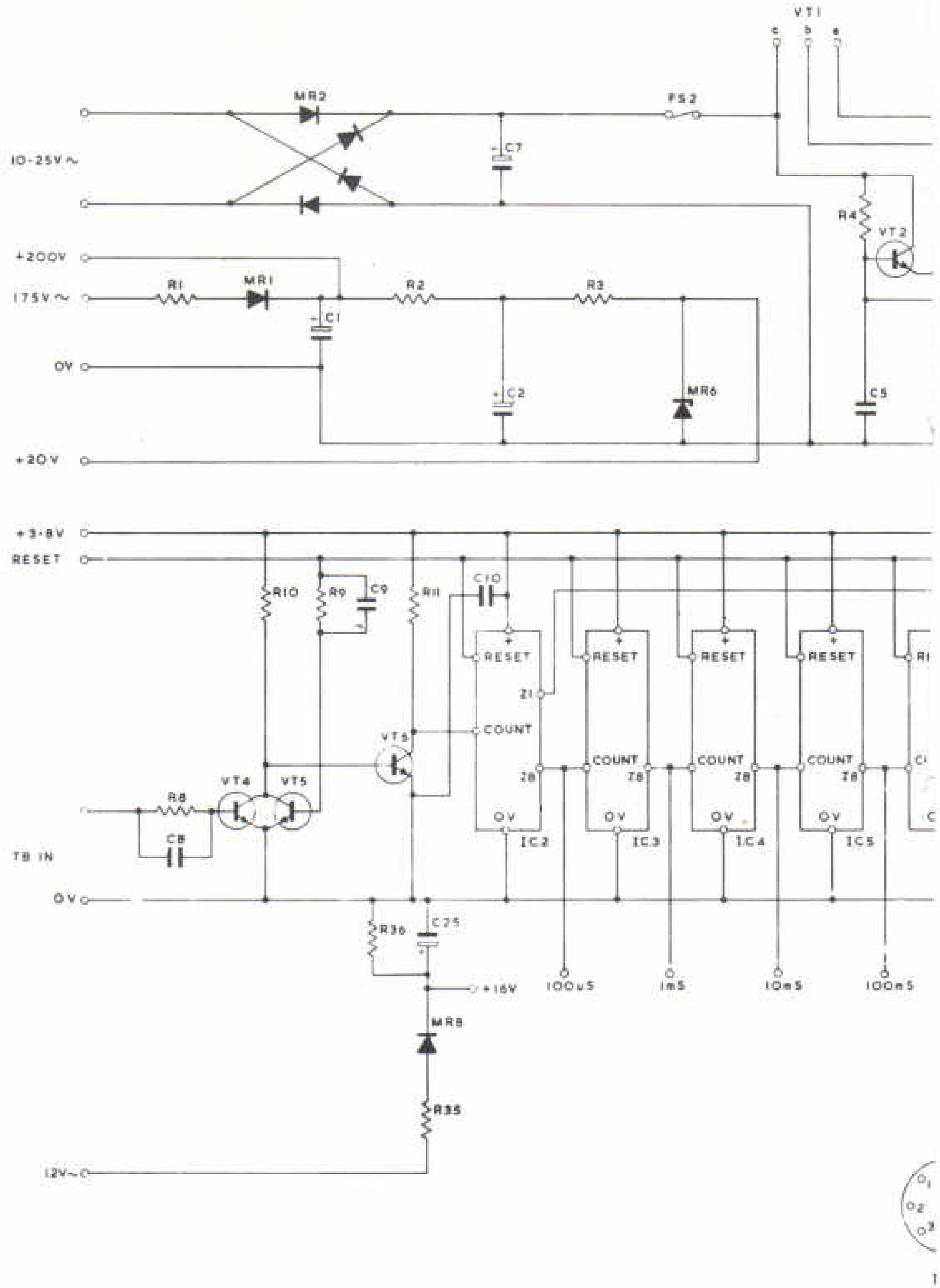
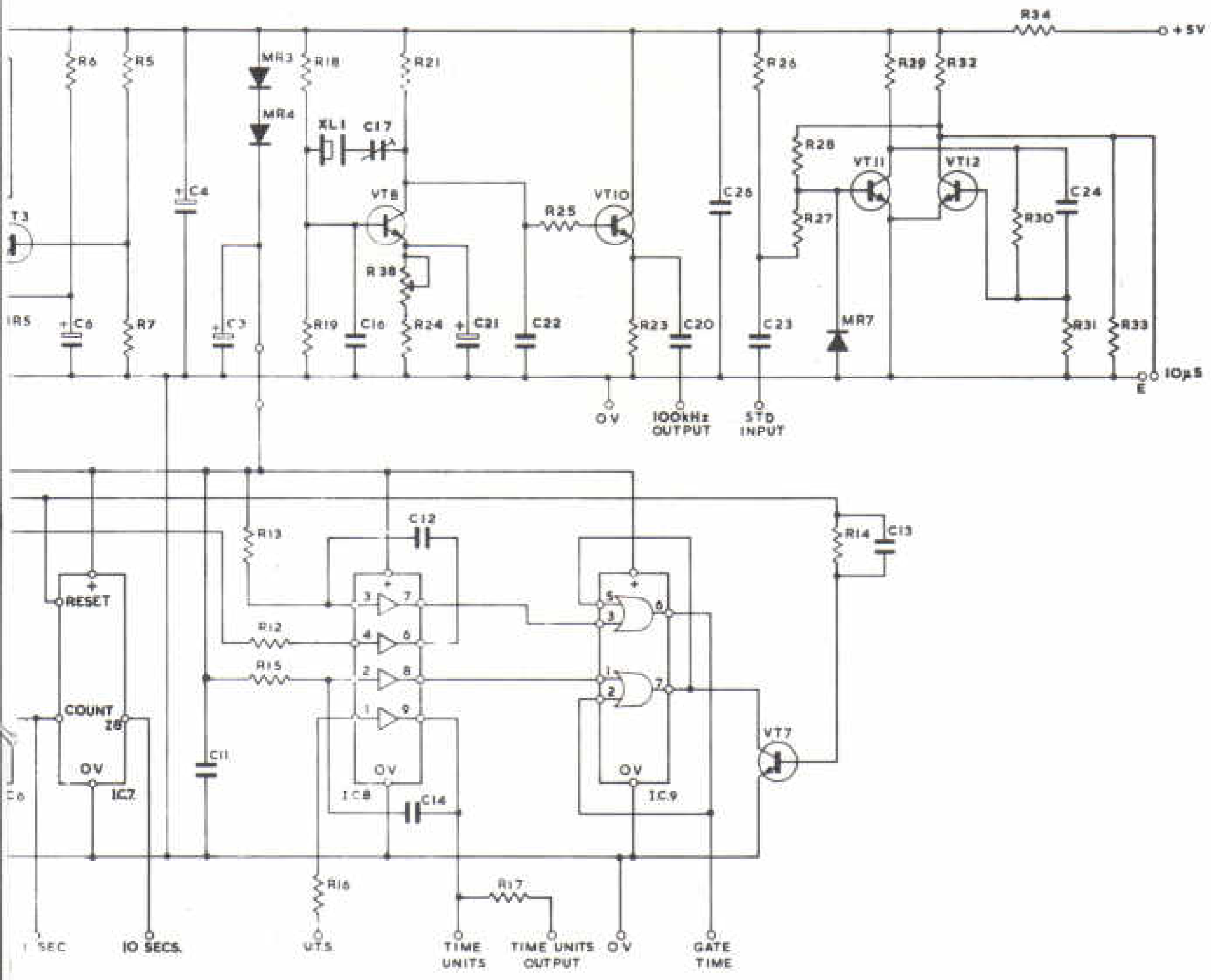


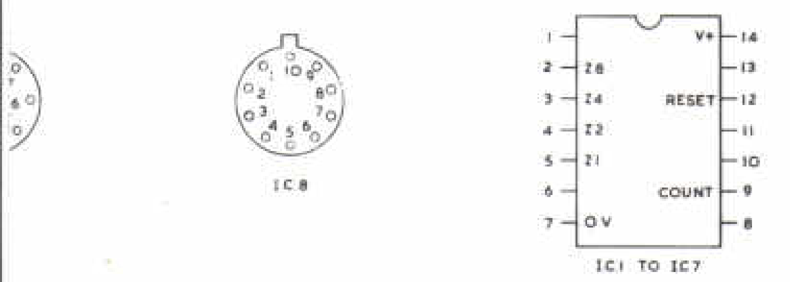
Fig. 2 Input Amplifier Circuit Diagram

Fig. 3 Timebase and Power Circuit Diagram



VT1
c
b
e
MR2
FS2
C7
10-25V ~
R4
VT2
+200V
R1
MR1
R2
R3
175V ~
C1
0V
C2
MR6
C5
+20V
+3·8V
RESET
R10
R9
C9
R11
C10
RESET
COUNT
Z1
Z8
0V
VT6
VT4
VT5
R8
C8
TB IN
0V
IC2
IC3
IC4
IC5
R36
C25
+16V
100uS
1mS
10mS
100mS
MR8
R35
12V~

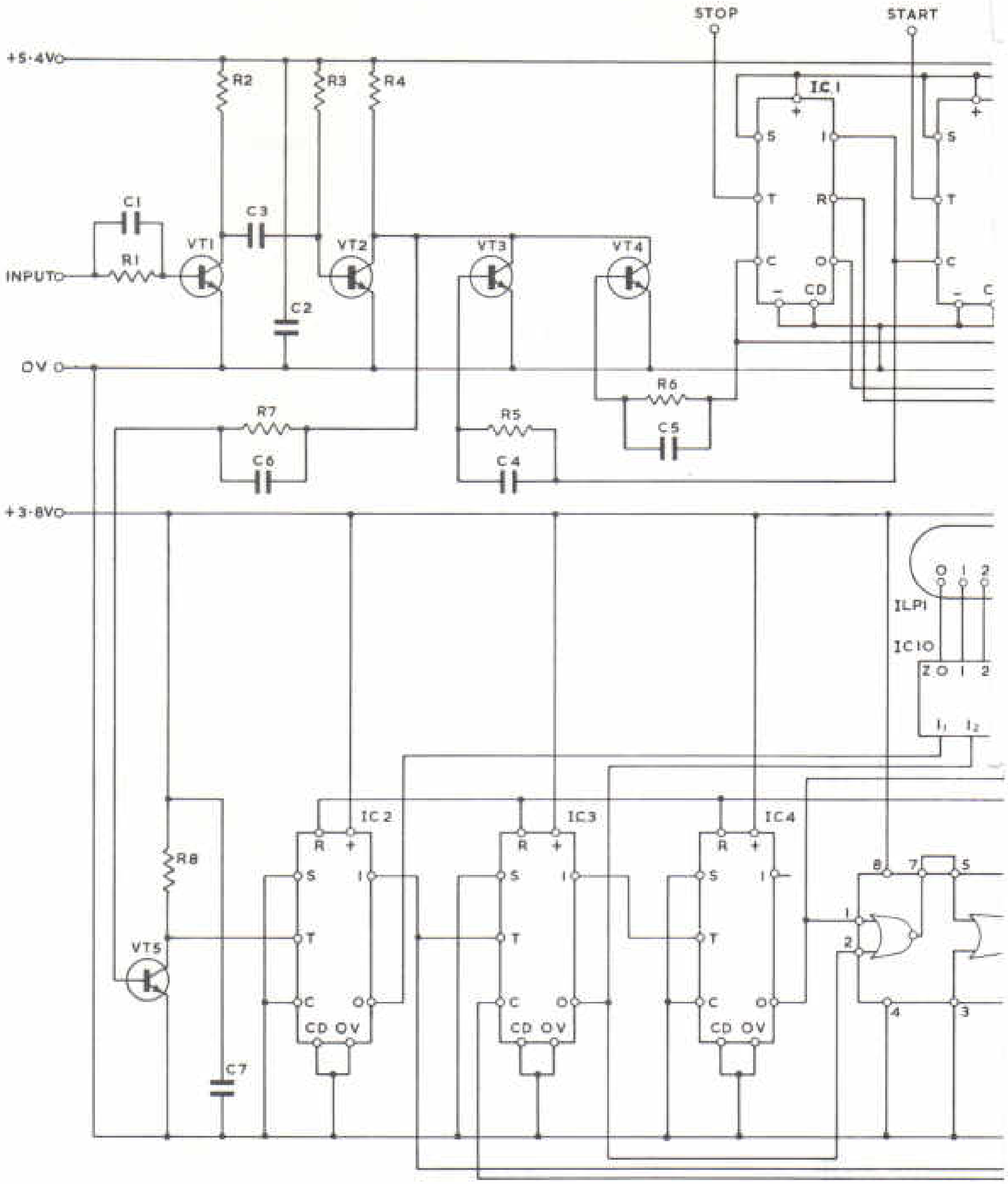


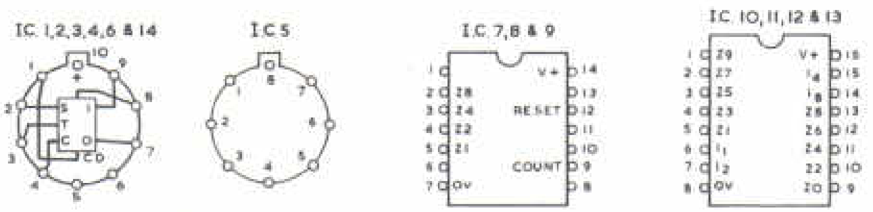


TOP VIEW OF INTEGRATED CIRCUITS

Fig. 3 Timebase and Power Circuit Diagram

Fig. 4 (a) Decade and Display Circuit Diagram TC11





TOP VIEW OF INTEGRATED CIRCUITS

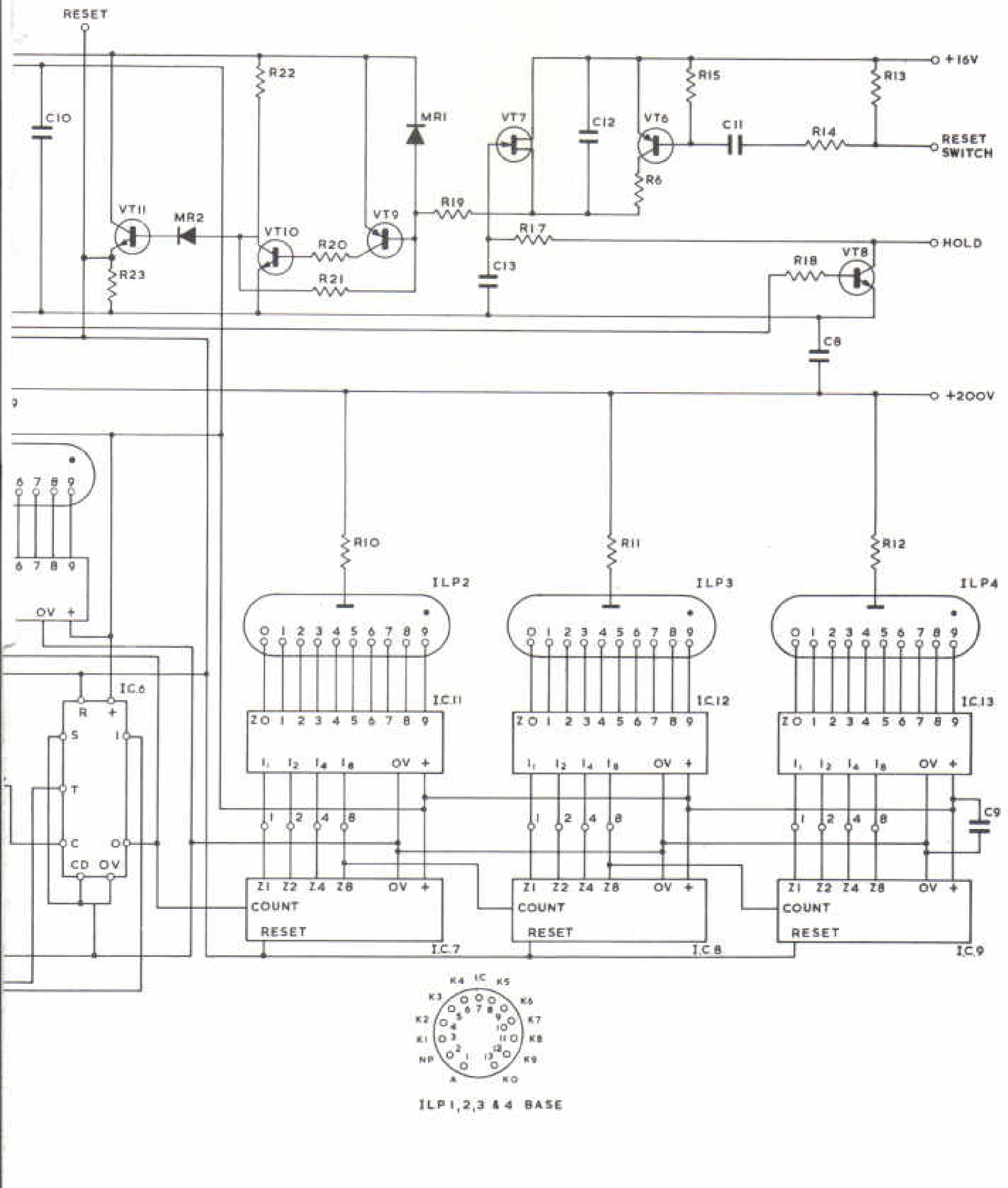
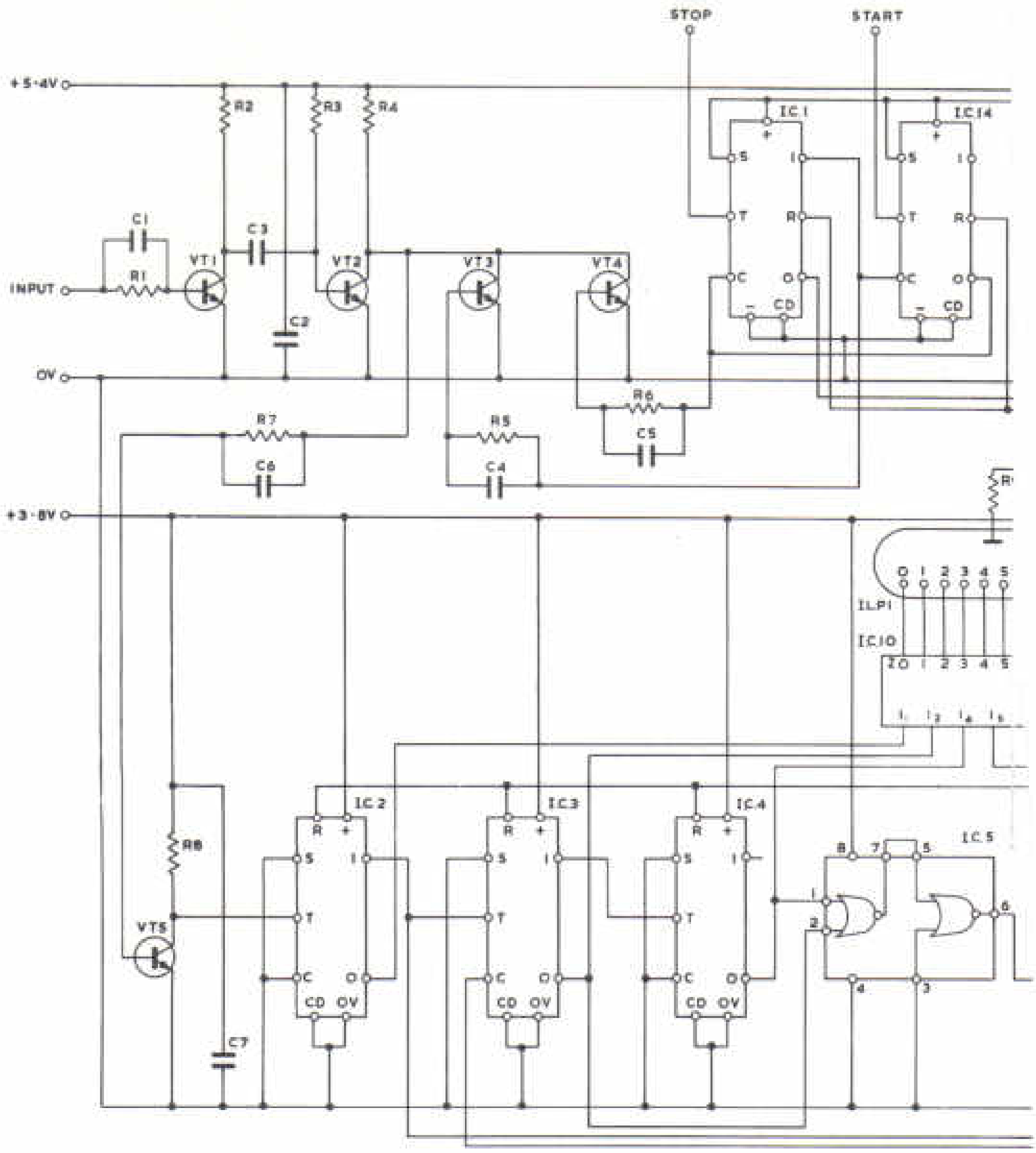
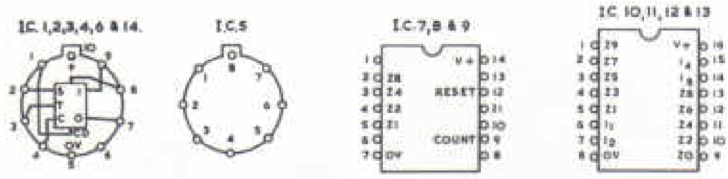


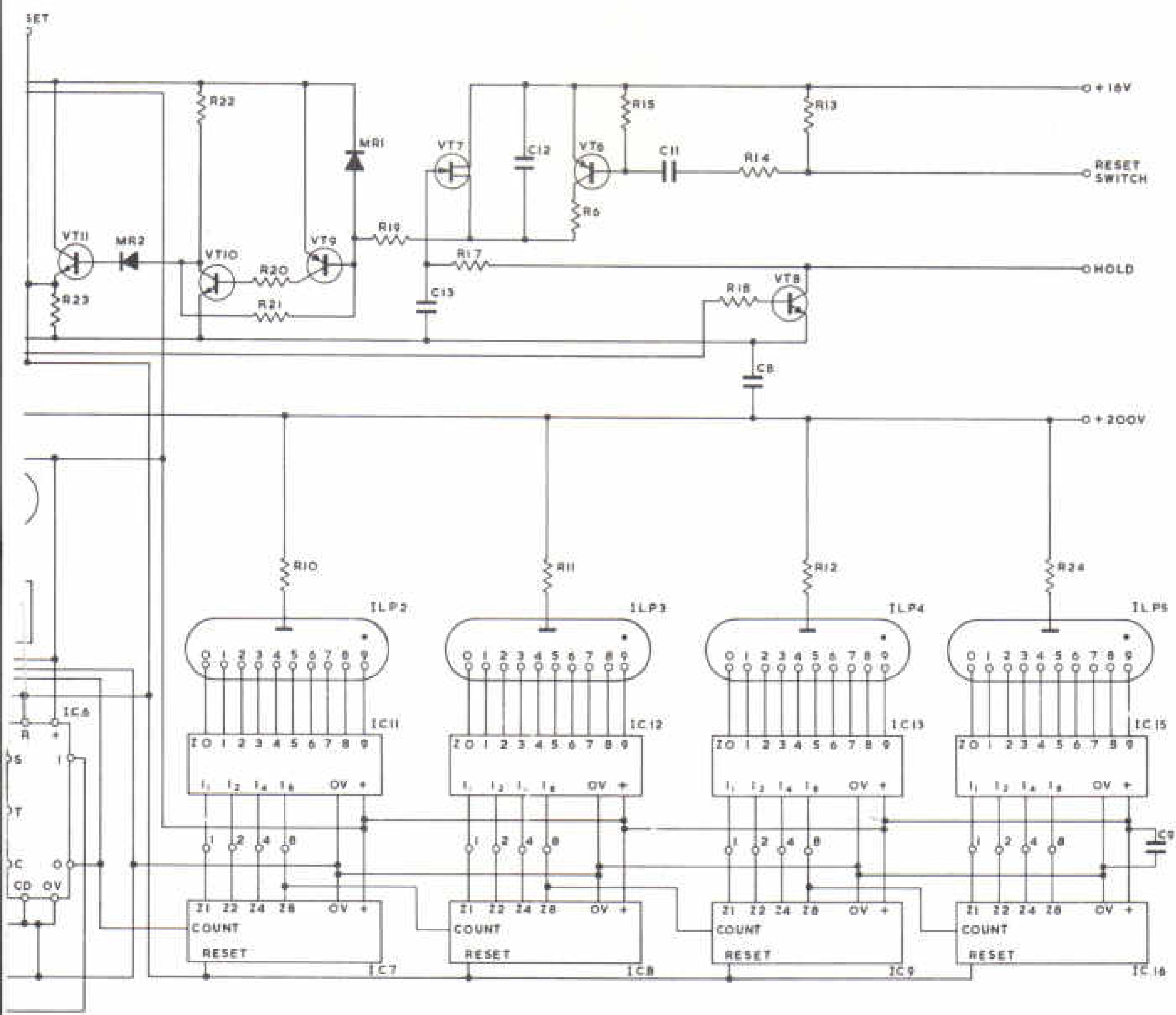
Fig. 4 (a) Decade and Display Circuit Diagram TC11

Fig. 4 (b) Decade and Display Circuit Diagram TC12





TOP VIEW OF INTEGRATED CIRCUITS



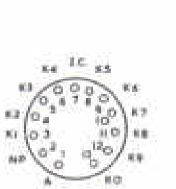
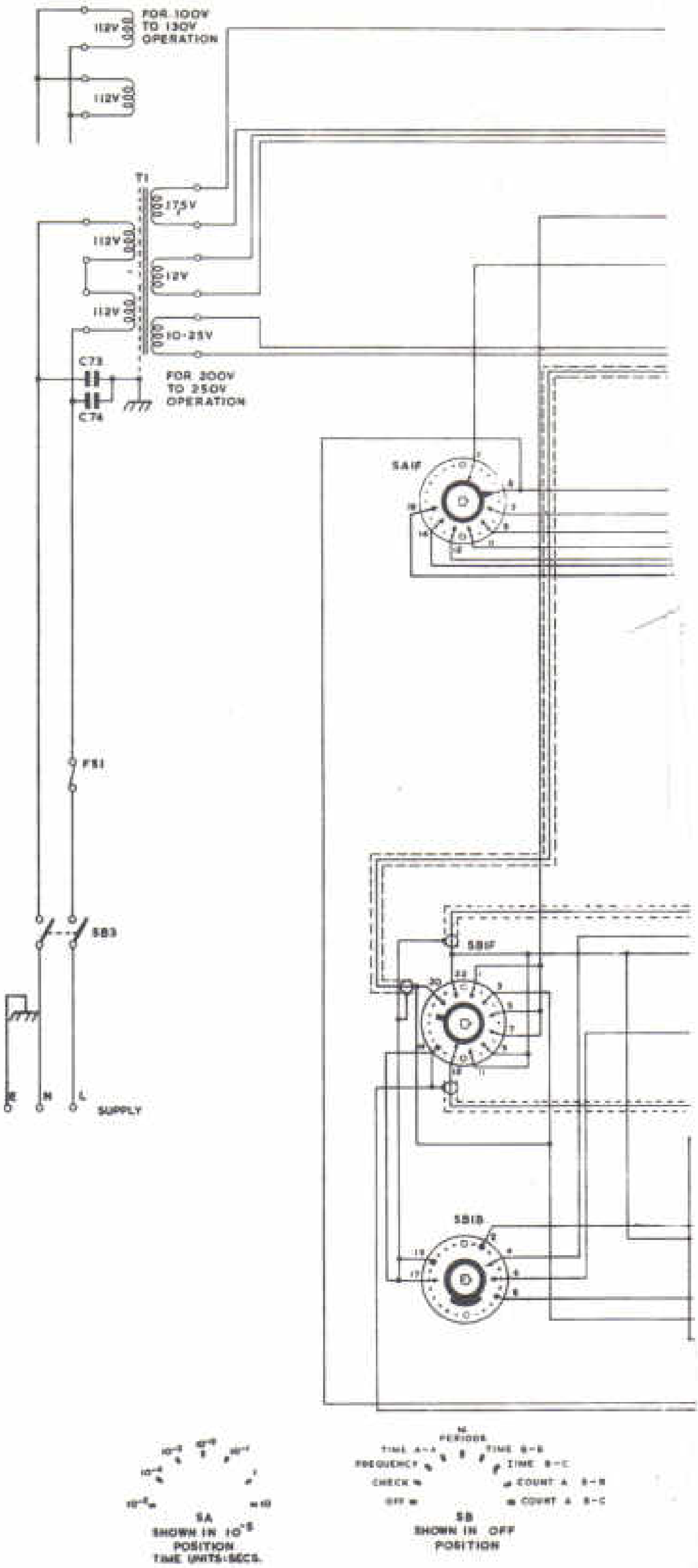


Fig. 4 (b) Decade and Display Circuit Diagram TC12

Fig. 5 Interconnection Diagram


FOR 100V TO 130V OPERATION
112V
T1
17.5V
12V
10-25V
C73
C74
FOR 200V TO 250V OPERATION
SA1F
SB1F
SB1B
FS1
SB3
E
N
L
SUPPLY
SA
SHOWN IN 10-5
POSITION
TIME UNITS-SECS.
N PERIODS
TIME A-A
FREQUENCY
CHECK
OFF
TIME B-B
TIME B-C
COUNT A B-B
COUNT A B-C
SB
SHOWN IN OFF
POSITION

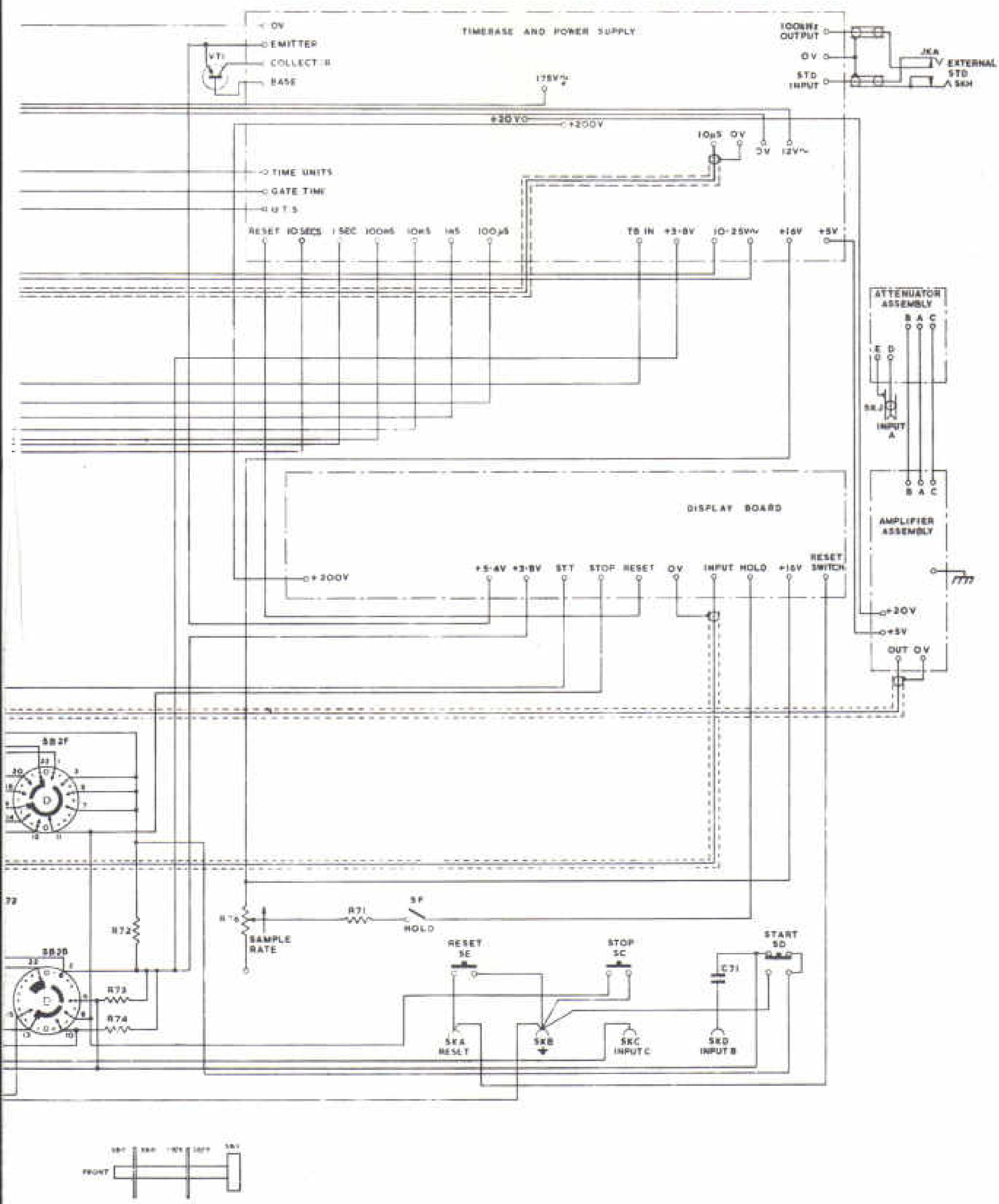


Fig. 5 Interconnection Diagram

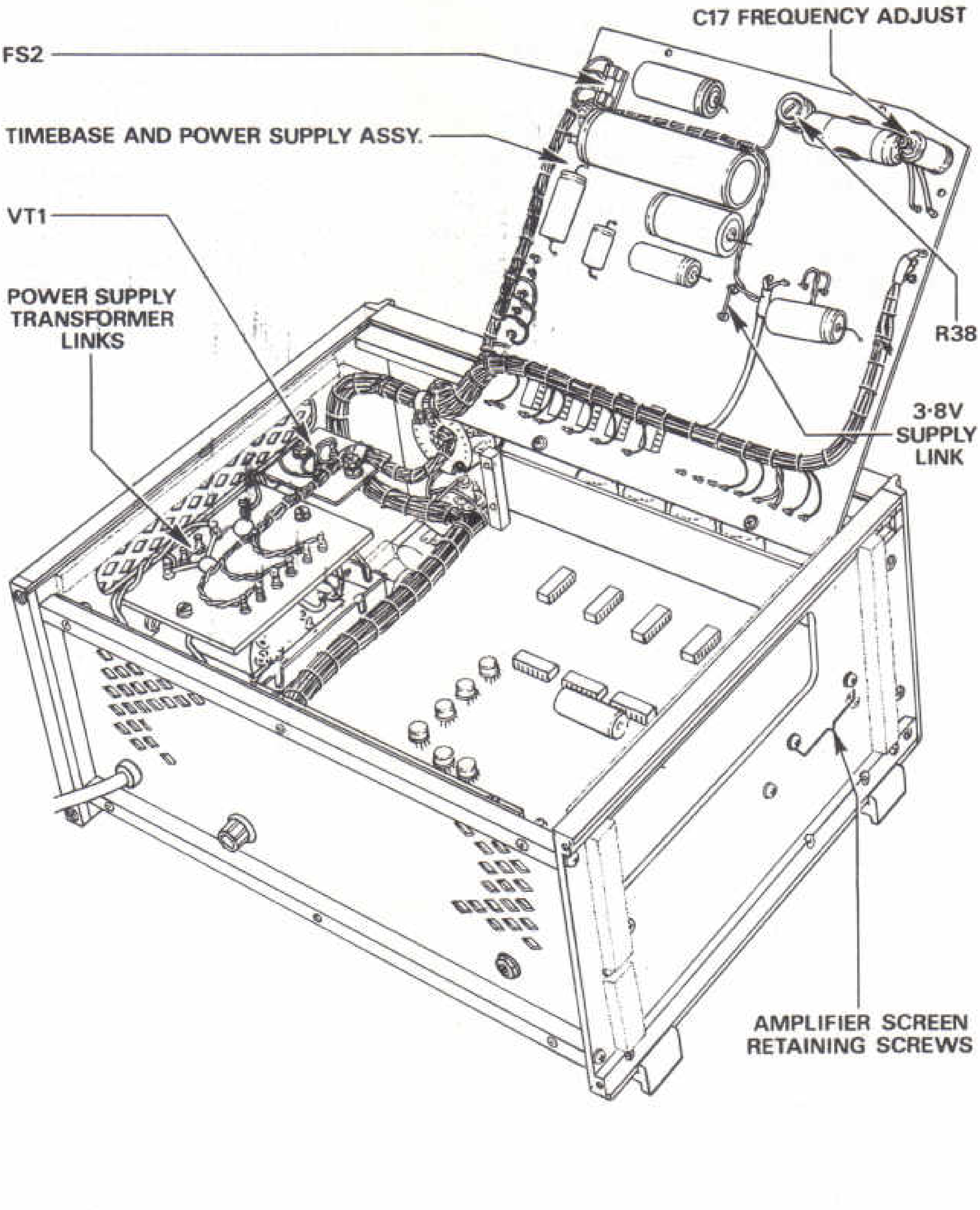


Fig. 6 Component Layout

Guarantee and Service Facilities

Section 7

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The type and serial number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS ARE READY TO ASSIST YOU AT ALL TIMES.

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