1 Mc/s and 100 kc/s TRANSISTORISED COUNTER

Type 9908-00 and 9907-00

INSTRUCTION MANUAL

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Counter type 9908-00 is succeeded by counter type 9908-03. There are no technical changes in the new type compared by the old type. The changes are a new two-tone front panel and new shaped knobs.

TRANSISTORISED COUNTER

TYPE 9908-00 and 9907-00

CONTENTS

Note: Type 9908-00 will be indicated as type 9908 and type 9907-00 as type 9907.

SECTION 1

INTRODUCTION

The Counter type 9908 (9907) is a high-grade instrument for the accurate measurement of time, period and frequency , and for the counting of regular or random electrical pulses at a maximum rate of one million per second. (One hundredthousand per second)

The exceptionally compact and lightweight design has been achieved by making the maximum use of transistors and printed circuit boards. The counter is self-contained and portable.

All switches and operating controls are mounted on the front panel, together with the input, start, stop and earth sockets. The mains input plug, voltage adjustor and fuse, and the battery input sockets are located at the rear of the case.

To provide easy access to all internal components, the case is arranged to open on a piano-type hinge fitted along the lower front edge. A system of unit construction has been adopted, the circuit being divided into 20 (16) sub-units, each of which is constructed on a separate printed circuit board and provided with edge connectors for soldering th the printed circuit base-board. The whole assembly of printed circuits is hinged at the lower edge to permit access to all sides.

The internal standard reference frequency is derived from a crystal oscillator, which also provides, through a frequency divider, output timing pulses at any one of eight (six) standard repetition frequencies. Selfchecking facilities are built-in to test the operation of both counter chains, and an in-line row of six (five) decade meters with vertical calibration from 0 to 9 provides an easy-to-read display with minimum circuit complication.

Provision is made for the connection of an external recorder unit.

The equipment has a very low power consumption and can be operated from a 6V battery or from the a.c. mains supply.

SECTION 2

SPECIFICATION AND FACILITIES

2.1 SPECIFICATION

Display:	9908:	the equipment will indicate a six figure number on meters with vertical calibration from 0 to 9.
	9907:	the equipment will indicate a five figure number on meters with vertical calibration from 0 to 9.
Accuracy:		the counting accuracy is ± 1 count. The accuracy of time or frequency measurement is ± 1 count ± accuracy of internal standard.
Frequency range:	9908:	from 10 c/s to 1 Mc/s
	9907:	from 10 c/s to 100 kc/s
Time measurement:	9908:	from 5 microseconds to 10^7 seconds
	9907:	from 50 microseconds to 10^5 seconds
Period measurement:	9908:	1 or 10 periods of input waveform down to 10 c/s
	9907:	1 period of input waveform down to 10 c/s
Random counting:	9908:	totalling over any period
	9907:	totalling over any period
Output timing pulses:	9908:	at eight repetition frequencies from 10^{-1} to 10^6 p.p.s. in decade steps with the MAN-AUT switch in the position "MAN". Low impedance source.
	9907:	at six repetition frequencies from 1 to 10^5 p.p.s. in decade steps with the MAN-AUT switch in the position "MAN"
Internal Standard:	9908:	1 Mc/s ovencontrolled crystal oscillator. Decade divisions of this frequency down to 0.1 c/s are obtained by seven divide-by-ten stages. The accuracy of the internal standard is ± 1 part in 10^6 at 25°C, and ± 5 parts in 10^6 for the temperature range 0 to 40°C. When operating from a battery power source, the crystal oven is inoperative and a lower accuracy is obtained. This accuracy is dependent on the crystal, but will be better than ± 15 parts in 10^6 with a temperature sensitivity not greater than 0.5 parts in 10^6 per each 1°C change below 55°C (oven operating temperature).

With the oven inoperative, the crystal frequency can be adjusted for accurate operation at any specific ambient temperature.

9907: 100 kc/s crystal oscillator. Decade divisions down to 1 c/s, by five divide-by-ten stages. The accuracy is ± 1 part in 10^5 at 20°C; -0,5 c/s per °C from 20°C to 40°C and + 0,5 c/s per °C from 20°C to 0°C. The crystal frequency can be adjusted.

Sensitivity: 9908(9907): "Input": 300 mV r.m.s. into 100K shunted with an input capacity of less than 20 pF, sinusoidal or pulse, with a maximum level of 250V a.c. or 500V d.c. "Start-stop": See figure 21.

Repetition of count: 9908: (9907) manual or automatic

Display time: 9908(9907): 0,5 to 5 seconds, or hold.

Power requirements: 9908(9907): Mains operation: 110, 127 or 220V 50c/s single phase consumption 14 VA
Battery operation: 6V, 3 watts.

Print-Out Converter type 9916: In-Line Indicator type 9917: 9908(9907): Connection by means of two 26-pins plugs.

Dimensions: 9908(9907): Length 312 mm. (12 in.), height 230 mm. (9 in.), depth 152 mm. (6 in.)

Weight: 9908(9907): 5,5 kg. (12 lbs.)

2.2 FACILITIES

9908(9907) An 8-way (6-way) selector on the front panel provides the following facilities:

Test:

9908: The 100 kc/s signal, derived from the crystal oscillator is counted for a period of 10 seconds to check the operation of both counter chains.

9907: The crystal frequency is counted for a period of 1 second to check the operation of both counter chains.

Frequency:

9908: x 0.1, x 1.0, x 10.0. In these three positions, the unknown frequency is counted for one-tenth, one and ten seconds, respectively.

9907: x 0.1, x 1.0. In these two positions, the unknown frequency is counted for one-tenth and one second, respectively.

Period:	9908 (9907)	x 1. During one period or cycle of the input signal, the crystal frequency is fed to the counter via the gate. The counter then indicates the inverse of the frequency, and provides a more accurate method of measuring low input frequencies.
	9908	x 10. The crystal frequency is measured during 10 periods of the input signal to provide the most accurate method of measuring low input frequencies.
Time:	9908	The counter indicates the time lapse between positive pulses fed to the START and STOP sockets, or between the operations of the START and STOP buttons. The units of time can be selected in decade steps from 1 micro-second to 10 seconds, and thus the maximum period of time that can be measured is 10^7 seconds.
Count:	9908 (9907)	Regular or random pulses can be counted over any period of time determined by the operator. This period can be iniated and ended by means of start and stop pulses or by the operation of the appropriate buttons. When the buttons are used, the counter can be made to integrate a number os such operations.
External Reset:	9908 (9907)	It is possible to set the counter in its initial state by means of an external negative going pulse, fed to the "rest socket" on the rearside of the counter. This pulse has to be supplied to the reset socket via a capacitor (0,01 µF). Rise-time pulse: approx. 100 µsec. Pulse height: approx. 6 Volt p.t.p. For this purpose the "Man-Aut." switch has to be set in the position "MAN". By using two counters of the mentioned types it is possible to reset both counters at the same moment, by connecting the reset sockets one to the other, and by setting one counter in the position "MAN" and the other one in the position "AUT." or by setting both in the position "MAN" . In the latter case a reset pulse is obtained by pushing the reset push buttons on one of the counters.

SECTION 3

TECHNICAL DESCRIPTION

3.1 GENERAL

9908 (9907) The instrument is composed of two main sections, the counter and the time generator. The counter consists of an input circuit, an electronic gate, and six (five) decade counting circuits; the time generator consists of a 1 Mc/s (100 kc/s) crystal oscillator followed by a pulse shaping circuit and seven (five) divider stages. The divider circuits and the decade counting circuit are similar in design and operation.

Incoming signals are amplified, converted into pulses of a suitable shape, and passed to the electronic gate. This gate is opened and shut by pulses from a start-stop circuit, and the signal pulses which are allowed to pass are registered on the counter. The gate can be operated by:

(a) signals fed to the START/STOP sockets

(b) signals generated by operating the START and STOP buttons

(c) signals obtained from the crystal controlled time generator

(d) incoming signals via the input amplifier.

In (a), (b) and (d) the time interval can be arbitrary, but in (c) the intervals between the pulses are either 0.1, 1 or 10 seconds. (0.1 and 1 second).

The arrangement of the individual circuits for each mode of operation is described in Section 4.

3.2 INPUT CIRCUIT (fig. 1)

9908 (9907) The input circuit consists of a conventional cascade a.c. amplifier, TR1 to TR4, followed by a trigger circuit, TR5 and TR6. The trigger circuit converts the input waveform to a square wave, and imparts the necessary sharpness to the leading edges.

3.3 START-STOP CIRCUIT (fig. 2)

9908 (9907) The transistor pairs TR1 and TR2, TR3 and TR4, TR5 and TR6 form binary circuits. These are bistable multivibrators which change their state with every incoming positive-going signal.

Initially TR1, TR3 and TR5 are conducting. With the first positive going pulse from the timing generator TR1 is cut-off and TR2 becomes conducting. A positive potential is fed via AB and C5 to out-off TR3, and the resulting positive-going signal is fed via the start terminal to the gate circuit, which is thus opened.

The second positive-going pulse from the timing generator cuts-off TR2. A positive potential is now fed via CD and C9, and cuts-off TR5. The change of state sends a positive-going signal via the stop terminal to close the gate circuit and a negative-going signal to the display timer to initiate the display period.

Resistor R 23 has been added between TR4 collector and TR5 base to keep TR5 and TR6 in their reset position until a start pulse arrives. This is done in order to prevent TR5 and TR6 changing their condition too early when external start- and stoppulses are fed to the counter (time measurement).

3.4. GATE CIRCUIT (fig. 3)

9908 (9907) TR1 and TR2 constitute a bistable multivibrator with TR1 non-conducting initially. The base of amplifier TR3 is connected to the collector of TR1 and its collector to the collector of TR4.
In the initial state amplifier TR3 is conducting.
Therefore its collector has zero potential, causing that the collector of TR4 is being kept on earth potential. Initially trigger circuit TR4 and TR5 is blocked by amplifier TR3.

Incoming pulses are fed to a second trigger circuit TR6 and TR7 where they are amplified and shaped. From TR7 the pulses are passed on to the base of TR4. With the arrival of a positive start pulse from the start-stop circuit, TR1 and TR2 change their state and TR1 becomes conducting. Amplifier TR3 is cut-off then.

Now the pulses coming from TR7 are able to trigger this pulse shaping circuit TR4 and TR5. Its output pulses are passed on to the counter chain. The positive stoppulse brings the gate circuit into the initial state again. The trigger circuit TR4 and TR5 is blocked again and no pulses are available at the output of this trigger circuit.

3.5. DECADE AND METER CIRCUITS.

9908 (9907) Figure 4 shows the circuit diagram of the medium frequency decade, figure 5 the circuit of a 1 Mc/s decade and figure 6a (6b) the interconnections of all the switches and sub-units in the counter, including the meter circuits.

It will be seen that a decade circuit consists basically of 4 pairs of transistors, each pair constituting a binary stage which changes its state with every positive input pulse. At some time later each positive pulse is associated with a negative pulse, which has little effect upon the circuit. In the circuit formed by TR1 and TR2 in figure 4, the positive pulse goes via either C2 and D2 or C3 and D3 to the transistor base. The purpose of the diodes D1 and D4 is to nullify the hole storage effect of the transistors (fig. 5).

Assuming an initial state with TR2 conducting and TR1 out-off, C2 will charge via R1 to the negative supply potential while C3 will only charge to the bottoming voltage of TR2.

With the arrival of a positive pulse the bias across D2 cannot be overcome, but the bias across D3 is only the difference between the base and collector potentials of TR2 so that D3 conducts and TR2 is cut-off, the circuit then changing its state. The arrival of a second positive pulse will initiate a similar action, but this time TR1 will be cut-off and the circuit will revert to its original state.

The output from TR2 collector thus consists of a negative swing with the arrival of the first positive input pulse, and a positive swing with the arrival of the second positive input pulse. As only one positive output pulse is provided for every two pulses fed in, the circuit can be said to divide by two. Four of such circuits connected in cascade are capable of dividing by sixteen before the circuit reverts entirely to its original state, but for this application some modifications have been made so that the circuit divides by ten.

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Figure 7 shows the potential at points R1, R2, R3 and R4 with each input pulse, and transfer pulses are indicated by an arrow. Initially transistors 2,4,6 and 8 are conducting, and with each successive pulse the action is as follows:

Pulse 1 changes the state of TR2.

TR's 1, 4, 6 and 8 conducting.

Pulse 2 changes TR1, TR8 (via C 16) and tries to change TR4, but TR7 is initially imposing a heavy bias via R23 to keep TR4 in conduction.

Pulse 3 changes TR2.

TR's 1, 4, 6 and 7 conducting.

Pulse 4 changes TR1 and TR4, but has no effect on TR8 since it is already cut-off.

TR's 2, 3, 6 and 7 conducting.

Pulse 5 changes TR2.

TR's 1, 3, 6 and 7 conducting.

Pulse 6 changes TR1, TR3 and TR6.

TR's 2, 4, 5 and 7 conducting.

Pulse 7 changes TR2.

TR's 1, 4, 5 and 7 conducting.

Pulse 8 changes TR1 and TR4.

TR's 2, 3, 5 and 7 conducting.

Pulse 9 changes TR2.

TR's 1, 3, 5 and 7 conducting.

Pulse 10 changes TR's 1, 3, 5 and 7 via C14 so that the circuit reverts to its original condition.

Points R1, R2, R3 and R4 are connected to a common meter terminal via resistors R6, 7, 16, 26, 27 and R36, so that when TR1 is conducting, one unit of current passes through the meter: TR3, two units, TR5, four units and TR7, two units. With the arrival of each pulse the meter current increases by one unit and the meter reading by one digit. While a circuit is counting, the voltage on the common meter connection appears as a staircase waveform.

Associated with each meter is a pre-set potentiometer (R19 to R24, fig. 6a) used to set the meter reading to 9 when the circuit is passing nine units of current. (Fig. 6b for type 9907).

The high frequency decades (1Mc/s), however, suffer serious waveform distorsion after the first binary, since this stage is working at high speed, and is also driving the second and fourth stages. A amplifier TR9, is therefore included in the circuit to improve the waveform after the first binary stage.

The decades are reset to their starting (zero) condition by means of a negative pulse applied to the reset line, which brings transistors 2, 4, 6 and 8 into conduction. This negative pulse is derived automatically from the display timer, and manually when the RESET button is pressed, by which a negative going trigger pulse is fed to the second monostable circuit of the display timer (Fig. 9).

3.6 OSCILLATOR CIRCUIT (Fig. 8a; Fig. 8b)

TR 1 and TR 2 form the oscillator circuit, with positive feedback applied between the emitter of TR 2 and the emitter of TR 1. The crystal XL 1 forms a very low impedance at its series resonant frequency and a high impedance at any other frequency. The attenuation is lowest and the gain highest at this series resonant frequency and this determines the frequency of oscillation. Within the oscillator loop, however, there is some lag in phase due to transistor characteristics, and this is corrected by means of the series trimmer capacitor C 4. Adjustment of C 4 corrects the inherent phase shift and also imparts a variable phase shift which allows the freqeuncy of oscillation to be pulled accurately to 1 Mc/s (100 kc/s).

TR 3 is an emitter follower circuit which presents a very little load to the oscillator and also acts as a buffer between the oscillator and the pulse shaper output stage TR 4 and TR 5. This last stage is a trigger circuit which converts the oscillator waveform to square wave and gives the necessary degree of sharpness to form the pulse shape required to operate the decades.

3.7 DISPLAY TIMER (Fig. 9).

9908; 9907. The display timer circuit is operated by a negative going pulse from the stop circuit, the complementary positive pulse being held back by the blocking diode D 1.

TR 1 and TR 3 form a monostable multivibrator circuit where TR 2 is normally conducting. The negative pulse brings TR 1 into conduction and the resulting drop in collector potential drives the base of TR 3 (via TR 2) heavily positive. TR 3 is cut-off and remains so until the charge on C 2 has leaked away via R 2 and R 9; the time constant being variable by adjustment of R 2.

When C 2 is discharged, the circuit reverts to its original condition and a negative going output pulse is produced. C2, however, requires about 0,4 seconds to re-acquire its charge, and under certain condition of use on automatic re-set this short period of time would not be allowed. For this reason, a similar circuit, TR 4 and TR 5, is included to delay the pulse for a further 0,1 second.

Following TR 5 is an output stage TR 6, which amplifies and inverts the positive-going pulse produced by TR 5, and passes it to the reset line.

3.8 OUTPUT CIRCUIT (Fig. 10)

The required output from the time generator decades is selected by the OUTPUT FREQ. switch.

Type 9908: (Fig. 10) A pulse shaping circuit TR 2 and TR 3 preceded and followed by emitter followers has been inserted between the switch and the output socket to assure a low impedance output.

Type 9907: Has not been provided with an output circuit.
The output socket is connected to the switch OUTPUT FREQ. via a resistor of 10 K Ω.

NOTE: Great care must be taken to avoid short-circuiting this output, as such action may damage the emitter follower.

3.9 STABILIZED POWER SUPPLY (Fig. 11)

9908: 9907. The range of operating voltages for the transistor circuits is quite large, but a stabilized supply is necessary for meter accuracy.

T 1, D 1, D 2 and C 1 constitute a conventional full-wave power supply, providing approximately 12 V. Z 1 is a Zener diode, which, irrespective of mains and load variations, maintains a constant 6 V reference potential at the junction of R 1 and R 2. This potential is divided to provide a reference voltage for TR 3 base, and a stable voltage with low source impedance at the junction of the emitters of TR 3 and TR 4. The base of TR 4 is taken to the slider of a potentiometer R 7, connected across the stabilized output. R 4 is the load resistor for TR 4, and the stage is d.c. coupled to the emitter follower TR 2. TR 2 is in turn d.c. coupled to the emitter follower TR 1, which has a low impedance output.

An increase in the negative voltage at the base of TR 4, by adjustment of R 7, results in a drop in voltage at the collector of TR 4. Since TR 2 and TR 1 are emitter followers, the output voltage follows this drop. R 7 is normally set to give -6 V output.

When a variation in the mains voltage occurs, for example when the mains voltage increases, there is an increase in voltage at TR 4 collector. But TR 4 base is connected to the unstabilized supply via R 6, and the increased conductivity of TR 4 then results in a drop in voltage at TR 4 collector, which is compensatory.

SECTION 4

OPERATION

4.1 GENERAL

9908; 9907. The counter will operate from a 6 V battery, or from a suitable a.c. mains supply. A 6 V accumulaor is recommended for use where an a.c. mains supply is not available, as the power consumption of 3 watts represents a rather high current drain (0.5 A) for dry batteries. The battery sockets are at the rear of the case, below the mains input socket, and correct battery polarity must be observed.

A mains voltage adjustor is provided to enable instrument to operate from a range of a.c. supply voltages. These are:

adjustor setting 110 V, range 100 to 120 V
adjustor setting 125 V, range 115 to 135 V
adjustor setting 220 V, range 200 to 250 V

When despatched from the factory, the counter is normally set to operate from 200 to 250 V. Adjustment of the setting is made by means of a screwdriver, and the action is "press and turn".

4.2 INITIAL ADJUSTMENTS

Before switching on the counter, set the MAINS/BATT switch to the appropriate position. To prepare the counter for use:

(a) set the OFF/ON switch to ON

(b) Switch the selector control to COUNT, and the Reset Switch to Manual.

(c) press the SET 0 button and check that the meters each read at the centre of the 0 digit, (any adjustment required can be made by means of the meter set-zero controls at the side of the meter escutcheons).

(d) press the SET 9 button and check that the meters each read at the centre of the 9 digit. (A series of slotted control spindles are located beneath the meters, and adjustment can be made by means of a small screwdriver).

These adjustments, once made, should not require further attention while the counter is operating from the a.c. mains supply. On battery operation, however, the SET 9 adjustment will depend on the battery condition.

Should there be any doubt about the correct operation of the instrument the self-checking facility detailed in para. 4.7 should be adopted.

4.3 FREQUENCY MEASUREMENT 9908:9907

Fig. 12a;b shows a block schematic diagram of the arrangement of the counter circuits for the purpose of frequency measurement.

The amplitude of the input signal should be at least 300 mV r.m.s. and not greater than 250 V r.m.s. If the input consists of short unidirectional pulses, the pulse polarity must be positive.

The selector switch shows three positions for frequency measuring:

A. 9908:9907 FREQUENCY x 10^{-1}. The input frquency is counted for only 1/10th second, the meters showing a tenth of the frequency of the incoming signal. This is the least accurate method of measurement, but the rapid sampling time in conjunction with a short display time gives an almost continuous indication of frequency. This is useful if the input frequency is being continuously adjusted, as, for example, when setting an oscillator to a given frequency.

B. 9908:9907 FREQUENCY x 1. The input frequency is counted for 1 second, thus providing greater accuracy. Since the counter accuracy is ± 1 count, the error on FREQUENCY x 10^{-1} (sub.para.(A)) could be ± 10 cycles, here it will be only ± 1 cycle.

C. 9908 FREQUENCY x 10. The input frequency is counted for 10 seconds, reducing the possible counter error to 1/10th of a cycle at 1 Mc/s input. Since the counter shows only six digits, and the indicated frequency is ten times the input frequency, for frequencies above 100 kc/s the first digit is lost (carried over) and must be found initially by switching to the x 1 position.

Due to the possible error of ± one count, the absolute accuracy (ignoring crystal accuracy) becomes progressively less as the input frequency is decreased. The best accuracy at 1000 c/s on FREQUENCY x 10 is thus ± 0.01%.

For frequencies below 1000 c/s it is advisable to use period measurement. On PERIOD x 10 the same accuracy is achieved at 1000 c/s as on FREQUENCY x 10, but below 1000 c/s the accuracy increases progressively.

Repetitive readings are obtained with the RESET switch at AUT. (automatic). The length of time for which a reading is displayed is controlled by the DISPLAY TIME control, being variable between 0,5 and 5 seconds. Longer display times may be achieved by switching to

MANUAL. It is then necessary to use the MANUAL RESET push button which sets the meters to zero and initiates a counting period. At the end of the counting period the meters indicate the frequency until the push-button is again operated.

4.4 PERIOD MEASUREMENT 9908:9907

To obtain an accurate determination of low frequencies it is better to measure the period of the signal, that is, the time elapsing between two consecutive zero transits of the signal in a positive direction. This is performed when the selector switch is set to PERIOD x 1. A block diagram of the arrangement is shown in figure 13.

9908: The meters indicate the time period in microseconds, and it is necessary to take the inverse of this reading to obtain the frequency. For example a frequency of exact 50 c/s would theoretically be read as 20 000 ± 1. Because the exact triggering moment depends on the slope of the input signal, i.e. on the ratio of amplitude to period, there will be an additional inaccuracy at lower frequencies due to variations in the triggering level. In practice this inaccuracy is of the order of 0.1%.

An even more accurate measurement is obtained with the selector switch at PERIOD x 10. Here the time indicated on the meters is the time elapsing between the first positive going zero transit of the input signal and the tenth subsequent transit. The selection of the tenth transit is made by using the last decade of the timing pulse generator to divide by ten the pulses from the input circuit. A block diagram is shown in figure 14.

In the x 10 position of the switch, the accuracy with the example quoted, ignoring the crystal accuracy, will be 200.000 $\pm$ 1 microsecond, or 50 c/s $\pm$ 0.0005%. Due to the aforesaid reasons, the practical accuracy will be better than or 0.01%.

9907: The unit of time in which the period of the unknown frequency will be counted is 10 µsec.
For instance: a frequency of exact 50 c/s would theoretically be indicated as 2000 $\pm$ 1. In practice an accuracy of 0.5% will be obtained.

4.5 TIME MEASUREMENT (Fig. 15a : 15b)

Type 9908: When the selector switch is at TIME, the counter will measure the time interval between two pulses applied to the START and STOP sockets, or alternatively between the operation of the START and STOP push buttons.
It should be noted that the start-stop pulses cannot have a common source, that is, each pulse must be fed only to its appropriate socket.

The pulses should be positive-going to initiate the start-stop circuit, and should have a terminal voltage of to 10 V. For further details of the sensitivity of the START and STOP circuits see para 2.1 page 2.

The units of time registered on the meters may be selected, by means of the UNIT TIME switch, to be 1 µS, 10 µS, 100 µS, 1 mS, 10 mS, 100 mS, 1 or 10 seconds, and practically it will be seen that the smallest time interval that can be measured is 5 µS, to an accuracy of + 1 µS, and the longest time 107 seconds to an accuracy of $\pm$ 10 seconds.

Type 9907: For this type the units of time which may be selected, are 10 µseconds, 100 µseconds, 1 msecond, 10 mseconds, 100 mseconds or 1 second. The smallest time interval that can be measured between a START and a STOP pulse will be 50 µseconds, and the longest time 10^5 seconds to an accuracy of $\pm$ 1 count, that is $\pm$ 1 second. It should be noted that when the start-stop is initiated by means of pulses, the electronic circuits in the start-stop circuit will require to be reset. This can be done manually by means of the push-button, or automatically at the end of the display time. In either case the readings will then revert to zero. However, when the start-stop is initiated by means of the push-buttons it is possible, by leaving the reset switch at MANUAL, to add a number of time periods to the first. This occurs automatically as the START and STOP push buttons are operated successively for each period. The counter can then be made to indicate the total of a number of time periods.

4.6 COUNTING (Fig. 16)

Type 9908 (Fig. 16). The operation for counting is similar to that for time measurement except that instead of timing pulses being fed to the counting system, pulses of external origin, which may be random in nature, take their place. The selector switch must be set to COUNT and the meters will then indicate the total number of pulses fed to the equipment either between start and stop pulses, or between the operation of the START and STOP buttons. In the latter case, as in para 4.5, the total of a number of such operations may be added.

The pulses may be of any length, but successive pulses must be separated by an interval of at least 1 microsecond for all pulses to register.The pulses must be positive in polarity and greater than 450 mV or less than 350 V in amplitude.

Type 9907 (Fig. 16). The operation for counting is similar to that of the type 9908. However, the successive pulses must be separated by an interval of at least 10 microseconds for all pulses to register. The pulses must be positive in polarity, and greater than 450 mV or less than 350 V in amplitude.

4.7 SELF-CHECKING FACILITY (Fig. 17a : 17b)

Type 9908 (Fig. 17a). When any doubt exists as to the correct functioning of the instrument, the selector switch should be set to TEST, the REST switch to AUT.

Type 9907 (Fig. 17b). In the conditions mentioned before, test signals from 100 kc/s crystal oscillator are fed to both counter chains. A series of 10 μS pulses are fed to the counting system for a period of 1 second as dertermined by the timing pulse generator. At the end of this counting period, if the equipment is functioning correctly, the meters will indicate 00000 $\pm$ 1 count (i.e. 99999, 00000 or 00001) for the display period of five seconds, and then resume counting.

4.8 PRINT-OUT CONVERTER (POC)(9916)
IN-LINE INDICATOR (ILI)(9917)

Type 9908 and 9907. Outputs obtained from the collectors of the decades are available at two 26-pins sockets at the rear side of the instrument. The connections of these sockets are shown in Fig. 22.

The voltages at these sockets vary between -0.5 V and -5 V.

The Print-Out Converter and the In-line Indicator can be connected directly to the counters.
The Print-Out Converter can be coupled to any electric tabulator provided with energizing coils (appr. energization voltage 48 V)

4.9 SPECIAL APPLICATIONS

4.9.1 General

The 9908 and 9907 counters are exceedingly versatile instruments, their applications in industry and commerce, scientific investigations, research, and in many other fields, are very numerous. Frequency and time measurements, period duration and counting are the basic facilities offered, providing a fundamental approach to many problems.

For example, the velocity of almost any moving part, missile or vehicle can be measured over a fixed distance by generating start and stop pulses at the commencement and completing of the distance, and timing the interval between these two pulses. The time interval between the energization of a relay coil and the operation of its contacts can be measured, and the outputs from radio-activity detectors such as Geiger-Muller tubes and scintillation probes can be readily counted.

Four special applications of type 9908 are selected for description on the following paragraphs.

4.9.2. Phase Measurements

Measurement of phase requires the generation of a positive pulse to the START socket from the reference phase at the moment of zero transit and a similar pulse to the STOP socket from the phase requiring measurement. The instrument should be set for TIME measurement, usually with microsecond time units.

Once the period of the input frequency has been accurately measured the phase lag in degrees may be found from:

$$\frac{\text{time} \quad (\mu S)}{\text{period} \quad (\mu S)} \times 360^\circ = \emptyset^\circ \text{ lag.}$$

Assuming the generation of the start and stop pulses to be accurate, the phase can be calculated to 1° accuracy (± 1 microsecond) with a frequency whose period is 360 microseconds, i.e. 2780 c/s.

4.9.3. Tachometry

For this purpose, a means is required of producing a pulse or sine wave whose p.r.f. or frequency bears a fixed relationship to the speed of the shaft in cycles per second. These devices can be photo-electric, magnetic or capacity pick-ups.

In general the frequencies to be measured in tachometry will be lower than 1000 c/s, so that for extreme accuracy, the period and not the frequency should be measured. Shaft speeds are usually quoted in r.p.m. so that a conversion is necessary by either method. If the period is measured, the better accuracy is obtained by producing only one pulse output for every shaft revolution. If the frequency is measured, greater accuracy is obtained by producing a large number of signals at each revolution of the shaft.

4.9.4. Torque Measurements

As an extension to the previous two applications and in view of the improved accuracy of phase measurement at lower frequencies, comes the measurement of torque. A torque bar of known characteristics should be utilized which, under conditions of zero torque, produces coincident pulses or pulses of known angular displacement at either end. These are the start and stop pulses. The period of revolution is first measured using either the start or stop pulse only, then the time separating the two pulses under torque. The phase angle may be calculated and a correction made for any displacement angle to find the angular twist of the torque bar. From this may be found the torque figure.

4.9.5. Viscosity Measurement

The viscosity of a fluid may be measured by allowing a ball to roll down an inclined tube which has been filled with the fluid under test. The velocity of the ball at low roll speeds and under laminar flow conditions is then a measurement of viscosity. Contacts can be provided at each end of the tube, and the instrument calibrated for temperature and inclination.

SECTION 5

MAINTENANCE

5.1 GENERAL

Unlike thermionic valve circuits, transistor circuits such as are used in the types 9908 and 9907 have no recognized limit to their life. For this reason, when used without abuse the instrument should operate indefinitely without requiring attention.

The instrument is protected against accidental short circuits by two fuses, F 1 in the mains supply, and F 2 in the stabilized d.c. power supply and battery circuits. F 1 may be removed by rotating the mains adjustor until the key comes of the slot. F 2 is mounted internally on an small printed circuit board at the lower centre of the front panel.

Access to the internal components is obtained by removing the five screws at the top rear of the case which is then free to open on the hinge at the lower front edge. For ease of access the whole printed circuit assembly is also hinged about the same edge. Figure 18a is a view of the counter type 9908 opened to show the location of the major components. For a view of the type 9907 see figure 18b. In the unlikely event of a circuit failure it is advisable to return the equipment to the manufacturer for attention.

The instrument does not possess a supply indicator, but even if all the meters are standing at zero a quick check of the supply can be made by pressing the set 9 button, whereupon all the meters will read "9" if the supply is correct.

5.2 SCHEDULE OF COMPONENTS

Tables 1 to 11 list the component values and rating for all subunits and for the general assembly.

SECTION 6
FAULT DETECTION

Counter has been switched on and there is mains voltage.

Trouble	Fault	Test	Solution
1. Counter does not function at all.	1.1 Fuse F1 or F2 faulty.	1.1 Push button "Test". If no "9" indication test fuse F1 and F2.	
	1.2 Transformer faulty or interruption in connection.	1.2 Test the voltage of transformer and diodes OA 210 (on power-supply unit)	1.2 Replace power-supply unit.
	1.3 -6 V stabilised power supply faulty.	1.3 Measuring -6 V on fuse F2 (with respect to mass). If F1 and F2 are correct and there is no -6 V, power-supply unit is faulty then.	
2. <u>Frequency measuring</u>.			
2.1 Frequency x 0,1 and frequency x 1 are correct. <u>Frequency x 10 no measurement</u>.	2.1 Time unit for 10 secs. faulty.	2.1 Switch SW3 in position "TEST". Counter does not gauge.	2.1 1. Time unit for 10 secs. faulty (replace) 2. Interruption in connection from timing unit to switches and from switches to START STOP circuit (see fig. 6a and fig.17a). 3. Interruption in connection from output "1 sec.timing unit" (via SW3d; fig.6a) to input "10 secs.timing unit".

2.2 Frequency x 0,1 correct Frequency x 1 and frequency x 10 no measurement.	2.2 Time unit for 1 sec. faulty.	2.2 Switch SW3 in position "TIME". Time unit switch SW2 in position "1 sec.". Push button "START" for starting counter. Meter M 6 has to make steps by intervals of 1 sec. (see fig.15a; fig.6a).	2.2 No steps on M6, time unit faulty then. Replace time unit.
2.3 Frequency x 0,1 Frequency x 1 and frequency x 10 no measurement.	2.3 1. One of the time units faulty. 2. Imput amplifier faulty. 3. Gate circuit faulty. 4. START-STOP circuit faulty. 5. 1st counting decade faulty.	2.3.1 Switch SW3 in position "TEST"(see fig. 17a;6a) a. Counter gauges normally.	2.3.1 a. Time units correct. START-STOP circuit correct. GATE circuit correct.
		(2.3.2)2.3.1 a. Correct: b. Counter does not gauge. Test time units. Use an oscilloscope. Connect the "OUTPUT-frequencies" in successive to the scope by means of switch SW1(see fig.6a). Switch "MAN-AUT" in position "MAN".	(2.3.2)(Fault in "IMPUT AMPLIFIER") b. If time units are correct, then fault in GATE circuit or in START-STOP circuit.
		2.3.3.1 Test GATE circuit. Switch SW3 in position "TEST". Start counter by means of push-button "START". The counter has to count now. (see fig.6a;2)	2.3.3.1 If counter does no count, then fault i: a. GATE circuit b. Wiring.

2.3.3.2	After pushing button "START" the counter does count.	2.3.3.2	START-STOP circuit faulty.
2.3.4	Test START-STOP circuit. Switch SW3 in position "TIME". Time unit switch in (e.g.) position 10-5 secs. Start and stop stop the counter electrically, e.g. with output pulses of the counter.		
	1. Counter starts and stops.	2.3.4	1. Gate correct. Binair stages before start and stop pulse in START-STOP circui correct. <u>First binair stage faulty.</u>
	2. Counter does not count.		2.a. Binair stage before START-pulse faulty. b. GATE circuit faulty. (see fig.15a;6a;2,3)
2.3.5	Test 1st counting decade on output and input with the aid of an oscilloscope. Start-counter with push button "START". Check signal on output of first counting decade (see fig.6a)	2.3.5	No signal on output of first counting decade (HF6): this decade is faulty then and has to be replace.

3. Counter gives incorrect indication, e.g. by measuring a 1 Kc/s signal.	3.1 Fault in one of the counting decades. N.B. Mostly it will be dividing by 8. In that case the indication on the meters always will be greater than the right one.	3.1 Switch SW3 in position "TIME". Switch "MAN-AUT" in position "MAN". Time unit switch successively in positions 1 sec.; 10^{-1} secs. and 10^{-2} secs. Start counter by means of button "START".	
		<u>Time unit:</u> <u>1 sec.;M6</u> has to make steps with intervals of 1 sec.	By frequency measuring (1 Kc/ the indication is 1250.
		If the belonging counting decade is dividing by 8, the indication on meter M6 will be:0-1-4-5 a.s.o.	1st counting decade faulty (divides by 8),replace.
		<u>10^{-1} secs.:</u> <u>M5</u> has to make steps with intervals of 1 sec.	By frequency measuring (1 Kc/ the indication is 1260.
		If the belonging counting decade is dividing by 8, the indication on meter M5 will be:0-1-4-5 a.s.o.	2nd counting decade faulty (divides by 8),replace.
		<u>10^{-2} secs.:</u> <u>M4</u> has to make steps with intervals of 1 sec. If the belonging counting decade is dividing by 8, the indication on meter M4 will be:0-1-4-5 a.s.o.	3rd counting decade faulty (divides by 8),replace.

3.2 Fault in one of the Time units (dividing by 8)

3.2 Measuring frequency (1 Kc/s), the indication is 0,8 x 1 Kc/s, so 800 instead of 1000.

Test OUTPUT frequencies of the counter with the aid of an oscilloscope. Test eventually the input signal of each Time unit in respect of its output signal (double beam scope)(see fig.6a)

3.2 Time unit faulty, replace.

Example: For tracing of a "divider by 8" in the counter part.
Function switch SW3 in position "TEST".

Divider by 8	Indication on meters
1st Counter decade (HF6)	250.000
2nd Counter decade (MF4)	250.000
3rd Counter decade (MF4)	250.000
4th Counter decade (MF4)	250.000
5th Counter decade (MF4)	260.000
6th Counter decade (MF4)	400.000

For testing the 1st, 2nd, 3rd and 4th counting decade (indication on M6, M5, M4 and M3 respectively) see by 3.1.
For testing the 4th counting decade take the time unit 10^{-3} and for frequency measuring 10 Kc/s.

4. Measuring of periods.

4.1 Period x 1
No indication:
other functions correct.

4.1.1.1 START-STOP circuit does not work properly.

4.1.1.1 Vary the frequency of the input signal between e.g. 10 c/s and 1 Kc/s.
If there is a range where measuring can be effected, then the START-STOP circuit is not correct.
(see fig. 13; 6a; 2).

4.1.1.1 Replace START-STOP circuit (see fig.2; 6a).

	4.1.1.2 Interference on input signal.	4.1.1.2 Test the input signal with the aid of an oscilloscope.	4.1.1.2 Interference on the input signal.
	4.1.2 Gate circuit does not let pass 1 Mc/s pulses.	4.1.2 Test the gate circuit.(see fig.3; 6a; 13) Function switch in position "TIME". Time unit switch in position 10^{-6} secs. Start counter with push button "START". Counter has to count 1 Mc/s pulses now. If counter does not count, the GATE circuit is faulty. If after testing as given under 4.1.1 and 4.1.2 no result has obtained, test wiring.	4.1.2 Replace gate circuit (fig. 6a) Test wiring (see fig. 13; 6a)
4.2 Period x 10: no measurement. Period x 1: correct.	4.2 Time unit for 10 secs. faulty. N.B. In position "Period x 10" this unit is used to divide by 10 the input signal first.(see fig. 14; 6a).	4.2.1 Function switch SW3 in position "TEST". If time unit for 10 secs. is faulty there will be no measurement.	4.2.1 Replace time unit for 10 secs. (see fig. 6a
		4.2.2 If there is a measurement, test wiring.	4.2.2 Check wiring (see fig 6a; 14).

5. Time measuring. With electrical START and STOP pulse. a. Counter starts but does not stop.	5.1 START-STOP circuit not correct (fig. 2; 15a). 2. Gate circuit not correct (fig. 3; 15a).	5.1.a Start and stop counter with the push button "START" and "STOP". Time unit at choice.	
		I. Counter does stop.	5.1.a.I. START-STOP circuit faulty; has to be replaced.
		II. Counter does not stop.	II. Gate circuit faulty; replace this.
		5.1.b Start and stop counter with push button "START" and "STOP".	
		I. Counter does start.	5.1.b.I. START-STOP circuit faulty; replace this
		II. Counter does not start.	II. Gate circuit faulty; replace this.
6. Count: (fig. 16) With electrical START and STOP pulse. a. Counter does not start. b. Counter does start.	6.1 START-STOP circuit faulty (fig. 2). 2. Gate circuit faulty (fig. 3). 3. Input amplifier faulty (fig. 1).	6.1.a See at 5.1.a 6.1.b See at 5.1.b	
		6.3 Test input amplifier. Function switch SW3 in position "frequency x 1" If testing as mentioned at 6.1.a and 6.1.b. gives correct result and frequency/measuring gives no result, the input amplifier will be faulty.	6.3 If no indication in position "frequency x 1", input amplifier is faulty; replace this.
7. RESET. 7.1 RESET AUT. does not work.	7.1.1	7.1.1 Check whether there is a negative stop pulse on the input "Display timer".	

	7.1.2 Display timer faulty.	7.1.2 Switch "MAN-AUT" in position "MAN". Push the button RESET MANUAL. 1. If the counter comes to zero and makes a new measurement, then there is a fault in the first monostable multivibrator of the Display timer (fig. 9).	7.1.2. 1. Display timer faulty; replace this.
7.2. Push the button "TEST 9". 1. Meters indicate the digit 9. RESET with button "RESET MAN". Meters does not come back to zero. 2. Meters do not indicate the digit 9 but 5. Fault in output amplifier of Display timer.	7.2. Display timer faulty; replace this. 2. Display timer faulty: replace this.	7.2. No reset in position reset "MAN" and reset "AUT".	7.2. Display timer faulty.
7.3 Check: a. Push button RESET MAN SW6 (fig. 6a). b. R27 (fig. 6a). c. C3 (fig. 6a). d. Wiring (fig. 6a).	7.3. If necessary replace SW6, R27 or C3.	7.3. RESET "MAN" does not work. RESET "AUT" correct.	7.3. Push button "RESET MAN faulty. R27 faulty C3 faulty break in wiring.
8. Check whether there is a signal on the socket "OUTPUT" (with the aid of an oscilloscope).	8. No signal on socket "OUTPUT", then output circuit faulty; replace this.	8. No output signals on output socket. Counter operates well.	8. Output circuit faulty.

9. See point 7.2.2.		9. "TEST 9" not possible. Meters indicate 4 or 5.	9. Fault in Display timer.
	10. Faulty decade, belonging to the meter, which does not indicate the digit "0"; replace decade.	10. "TEST 0". One of the meters does not indicate the digit "0", but any other digit.	10. Fault in counting decade.

TABLE 1.

SCHEDULE OF COMPONENTS - INPUT CIRCUIT (D 868 50)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in ohms)	Part No.
R. 1	100K	D 774 60
R. 2	15K	D 774 50
R. 3	2.7K	D 774 41
R. 4	1.5K	D 774 38
R. 5	220	D 774 28
R. 6	33K	D 774 54
R. 7	2.7K	D 774 41
R. 8	3.9K	D 774 43
R. 9	220	D 774 28
R.10	100	D 774 24
R.11	15K	D 774 50
R.12	2.7K	D 774 41
R.13	1.5K	D 774 38

Cct.Ref.	Value (in ohms)	Part No.
R.14	220	D 774 28
R.15	27K	D 774 53
R.16	2.7K	D 774 41
R.17	1.8K	D 774 39
R.18	150	D 774 26
R.19	10K	D 774 48
R.20	10K	D 774 48
R.21	1K	D 774 36
R.22	1K	D 774 36
R.23	100	D 774 24
R.24	15K	D 774 50
R.25	10K	D 774 48

CAPACITORS
(all except electrolytics ± 20%)

Cct.Ref.	Value	Working Voltage	Part.No.
C. 1	100n	500V	D 214 05
C. 2	1n	125V	E 350 20/1K
C. 3	2n	125V	E 350 20/2K
C. 4	Elec. 25uF	25V	AC 5715/25
C. 5	Elec. 25uF	25V	AC 5715/25
C. 6	2n	125V	E 350 20/2K
C. 7	2n	125V	E 350 20/2K
C. 8	Elec. 25uF	25V	AC 5715/25
C. 9	2n	125V	E 350 20/2K
C.10	2n	125V	E 350 20/2K
C.11	Elec. 25uF	25V	AC 5715/25
C.12	2n	125V	E 350 20/2K
C.13	Elec. 25uF	25V	AC 5715/25
C.14	1n	125V	E 350 20/1K
C.15	4,7pF	500V	E 103 00/L4E7

MISCELLANEOUS

Cct. Ref.	Description	Part No.
TR1 to TR6	Transistor OC 44	

NOTE: R1 and C15 are shown on the sub-unit inter-connection diagram, fig. 6a.

TABLE 2.

SCHEDULE OF COMPONENTS - START-STOP CIRCUIT (D 868 60)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in ohms)	Part.No.
R. 1	10K	D 774 48
R. 2	10K	D 774 48
R. 3	6.8K	D 774 46
R. 4	1K	D 774 36
R. 5	1K	D 774 36
R. 6	10K	D 774 48
R. 7	6.8K	D 774 46
R. 8	10K	D 774 48
R. 9	10K	D 774 48
R.10	10K	D 774 48
R.11	6.8K	D 774 46
R.12	1K	D 774 36
R.13	1K	D 774 36

Cct.Ref.	Value (in ohms)	Part.No.
R.14	10K	D 774 48
R.15	6.8K	D 774 46
R.16	10K	D 774 48
R.17	10K	D 774 48
R.18	6.8K	D 774 46
R.19	1K	D 774 36
R.20	1K	D 774 36
R.21	10K	D 774 48
R.22	6.8K	D 774 46
R.23	1K	D 774 36
R.24	100	D 774 24
R.25	100	D 774 24
R.26	100	D 774 24

CAPACITORS (all ± 20%)

Cct.Ref.	Value	Working Voltage	Part.No.
C. 1	1n	125V	E 350 20/1K
C. 2	560 pf	125V	E 350 20/560E
C. 3	560 pf	125V	E 350 20/560E
C. 4	1n	125V	E 350 20/1K
C. 5	2n	125V	E 350 20/2K
C. 6	1n	125V	E 350 20/1K
C. 7	1n	125V	E 350 20/1K
C. 8	1n	125V	E 350 20/1K
C. 9	2n	125V	E 350 20/2K
C. 10	1n	125V	E 350 20/1K

MISCELLANEOUS

Cct.Ref.	Description	Part.No.
D.1 to D.6	Diode	OA 70
TR.1 to TR.6	Transistor	OC 44

TABLE 3

SCHEDULE OF COMPONENTS - GATE (55 195 821)

RESISTORS (all rated at ± 5%; 1/4 watt)

Cct.Ref.	Value (in Ohms)	Part.No.
R. 1	10 K	D 774 48
R. 2	8K2	D 774 47
R. 3	4K7	D 774 44
R. 4	1K	D 774 36
R. 5	1K	D 774 36
R. 6	4K7	D 774 44
R. 7	8K2	D 774 47
R. 8	10K	D 774 48
R. 9	6K8	D 774 46
R. 10	15K	D 774 50
R. 11	33K	D 774 54
R. 12	470	D 774 32

Cct.Ref.	Value	Part.No.
R. 13	47	D 774 21
R. 14	470	D 774 32
R. 15	15K	D 774 50
R. 16	10K	D 774 48
R. 17	10K	D 774 48
R. 18	10K	D 774 48
R. 19	1K	D 774 36
R. 20	100	D 774 24
R. 21	1K	D 774 36
R. 22	15K	D 774 50
R. 23	10K	D 774 48
R. 24	10K	D 774 48

CAPACITORS

Cct.Ref.	Value	Working Voltage	Part No.
C. 1	390 pF	125 V	E 350 20/390E
C. 2	1n	125 V	E 350 20/1K
C. 3	390 pF	125 V	E 350 20/390E
C. 4	1n	125 V	E 350 20/1K
C. 5	160 pF	125 V	E 350 20/160E
C. 6	330 pF	125 V	E 350 20/330E
C. 7	2,7n	125 V	E 350 20/2K7
C. 8	1n	125 V	E 350 20/1K
C. 9	330 pF	125 V	E 350 20/330E

MISCELLANEOUS

Cct. Ref.	Description	Part No.
D1 to D3	Diode	OA 70
TR1 to TR7	Transistor	OC 44

TABLE 4

SCHEDULE OF COMPONENTS - M.F. 4 DECADE (D 868 64)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in ohms)	Part. No.
R. 1	10 K	D 774 48
R. 2	10 K	D 774 48
R. 3	6.8 K	D 774 46
R. 4	1 K	D 774 36
R. 5	1 K	D 7[illegible] 56
R. 6	47 K	D 7[illegible] 56
R. 7	47 K	D 7[illegible] 56
R. 8	10 K	D 774 48
R. 9	6.8 K	D 7[illegible] 46
R.10	10 K	D 7[illegible] 48
R.11	10 K	D 7[illegible] 48
R.12	10 K	D 7[illegible]
R.13	6.8 K	D 7[illegible]
R.14	1 K	D 774 [illegible]6
R.15	1 K	D 77[illegible]
R.16	47 K	D 77[illegible] 56
R.17	10 K	D 77[illegible] 48
R.18	6.8 K	D 77[illegible] 4[illegible]
R.19	10 K	D 77[illegible] [illegible]8
R.20	10 K	D 77[illegible] [illegible]
R.21	10 K	D 77[illegible] [illegible]
R.22	6.8 K	D 774 [illegible]

Cct.Ref.	Value (in ohms)	Part. No.
R.23	1K	D 774 36
R.24	1K	D 774 36
R.25	1K	D 774 36
R.26	47K	D 774 56
R.27	47K	D 774 56
R.28	10K	D 774 48
R.29	6.8K	D 774 46
R.30	10K	D 774 48
R.31	10K	D 774 48
R.32	10K	D 774 48
R.33	6.8K	D 774 46
R.34	1K	D 774 36
R.35	1K	D 774 36
R.36	47K	D 774 56
R.37	10K	D 774 48
R.38	6.8K	D 774 46
R.39	10K	D 774 48
R.40	100	D 774 24
R.41	100	D 774 24
R.42	100	D 774 24
R.43	100	D 774 24

CAPACITORS (all [illegible] 20%)

Cct.Ref.	Value	Working Voltage	Part.No.
C.1 to C.16	390 pF	125 V	E 350 20/390E

MISCELLANEOUS

Cct.Ref.	Description	Part.No.
D.1 to D.8	Diode	OA 70
TR.1 to TR.8	Diode	OA 70

TABLE 5

SCHEDULE OF COMPONENTS - HF 6 DECADE (55 195 824)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in Ohms)	Part No.	Cct.Ref.	Value (in Ohms)	Part No.
R. 1	10K	D 774 48	R. 26	47K	D 774 56
R. 2	10K	D 774 48	R. 27	47K	D 774 56
R. 3	6.8K	D 774 46	R. 28	10K	D 774 48
R. 4	1K	D 774 36	R. 29	6.8K	D 774 46
R. 5	1K	D 774 36	R. 30	10K	D 774 48
R. 6	47K	D 774 56	R. 31	10K	D 774 48
R. 7	47K	D 774 56	R. 32	10K	D 774 48
R. 8	10K	D 774 48	R. 33	6.8K	D 774 46
R. 9	6.8K	D 774 46	R. 34	1K	D 774 36
R. 10	10K	D 774 48	R. 35	1K	D 774 36
R. 11	10K	D 774 48	R. 36	47K	D 774 56
R. 12	10K	D 774 48	R. 37	10K	D 774 48
R. 13	6.8K	D 774 46	R. 38	6.8K	D 774 46
R. 14	1K	D 774 36	R. 39	10K	D 774 48
R. 15	1K	D 774 36	R. 40	15K	D 774 50
R. 16	47K	D 774 56	R. 41	470	D 774 32
R. 17	10K	D 774 48	R. 42	470	D 774 32
R. 18	6.8K	D 774 46	R. 43	47	D 774 21
R. 19	10K	D 774 48	R. 44)	not used	
R. 20	10K	D 774 48	R. 45)		
R. 21	10K	D 774 48	R. 46	100	D 774 24
R. 22	6.8K	D 774 46	R. 47	100	D 774 24
R. 23	1K	D 774 36	R. 48	100	D 774 24
R. 24	1K	D 774 36	R. 49	100	D 774 24
R. 25	1K	D 774 36			

CAPACITORS (all ± 20%)

Cct.Ref.	Value	Working Voltage	Part No.
C. 1	160 pF	125 V	E350 20/160E
C. 2	220 pF	125 V	E350 20/220E
C. 3	220 pF	125 V	E350 20/220E
C. 4	160 pF	125 V	E350 20/390E
C. 5 to C. 16	390 pF	125 V	E350 20/390E
C. 17	220 pF	125 V	E350 20/220E

MISCELLANEOUS

Cct.Ref.	Description	Part No.
D1 to D16	Diode	OA 70
TR1 to TR9	Transistor	OC 44

n.

TABLE 6a

SCHEDULE OF COMPONENTS - GENERAL ASSEMBLY (1Mc/s)

RESISTORS (all, except potentiometers, rated at ± 5%, 1/4 watt)

Cct. Ref.	Value (in ohms)		Part.No.
R.1,3,4,6,7,9,10, 12,13,15,16,18		4.7K (5.6K)	D 774 44 (D 774 45)
R.19-24	Variable	10K	13 928 94
R.13-18		4.7K	D 774 44
R.19-24		560	D 774 33
R.25	Not used		
R.26	Variable	50K	AR 9525/GE 50K
R.27		10K	D 774 48

CAPACITORS (all ± 20%)

Cct.Ref.	Value	Working Voltage	Part No.
C. 2	1μF	150 V	D 212 88
C. 3	0.01μF	150 V	D 212 86

MISCELLANEOUS

Cct.Ref.	Description	Part No.
F. 1	Fuse Miniature cartridge 100 mA	GE 105 24
F. 2	Fuse Miniature cartridge 500 mA	GE 105 35
M. 1 to M. 6	Meter 250 μA	D 925 27

TABLE 6b

SCHEDULE OF COMPONENTS - GENERAL ASSEMBLY (100 kc/s)

RESISTORS (all except potentiometers rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in ohms)		Part No.
R.1,3,4,6,7,9, 10,12,13,15		4.7K	D 774 44
R.16-20	Variable	10K	13 928 94
R.2,5,8,11,14		560	D 774 33
R.21	Not used		
R.22	Variable	50K	AR 9525/GE 50K
R.23-24		10K	D 774 48

CAPACITORS (all ± 20%)

Cct.Ref.	Value	Working Voltage	Part No.
C. 2	1 µF	150 V	D 212 88
C. 3	0.01 µF	150 V	D 212 86

MISCELLANEOUS

Cct.Ref.	Description	Part. No.
F. 1	Fuse Miniature cartridge 100 mA	GE 105 24
F. 2	Fuse Miniature cartridge 500 mA	GE 105 35
M. 1 to M. 5	meter 250 µA	D 925 27

TABLE 8a

SCHEDULE OF COMPONENTS - 1 Mc/s OSCILLATOR (D 868 54)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct. Ref.	Value (in ohms)	Part No.	Cct. Ref.	Value (in ohms)	Part No.
R. 1	6.8K	D 774 46	R. 7	33K	D 774 54
R. 2	1K	D 774 36	R. 8	1K	D 774 36
R. 3	3.9K	D 774 43	R. 9	1K	D 774 36
R. 4	1K	D 774 36	R.10	15K	D 774 50
R. 5	1K	D 774 36	R.11	10K	D 774 48
R. 6	1K	D 774 36			

CAPACITORS

Cct.Ref.	Value	Working Voltage	Part No.
C. 1	Elec. 25µF	25 V	AC 5715/25
C. 2	1 n	125 V	E 350 20/1K
C. 3	100 n	500 V	D 212 90
C. 4	Trimmer 25pF	-	C 005BA/25E
C. 5	Not	Used	
C. 6	800pF	125 V	E 350 20/800E
C. 7	560pF	125 V	E 350 20/560E

MISCELLANEOUS

Cct.Ref.	Description	Part No.
TR. 1 to TR. 5	Transistor	OC 44
XL. 1	Crystal 1Mc/s (S.T.C.crystal)	D 923 71
Oven	Cathodeon Ltd. type MCO-2M set to +55°C.	D 923 20-1

9908-9907

TABLE 8b

SCHEDULE OF COMPONENTS - 100 Kc/s OSCILLATOR (D 868 56)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in ohms)	Part No.
R. 1	6.8K	D 774 46
R. 2	1K	D 774 36
R. 3	3.9K	D 774 43
R. 4	1K	D 774 36
R. 5	1K	D 774 36
R. 6	1K	D 774 36

Cct. Ref.	Value (in ohms)	Part No.
R. 7	33K	D 774 54
R. 8	1K	D 774 36
R. 9	1K	D 774 36
R.10	15K	D 774 50
R.11	10K	D 774 48

CAPACITORS

(all except electrolytics ± 20%)

Cct.Ref.	Value	Working Voltage	Part No.
C. 1	Elec. 25μF	25 V	AC 5715/25
C. 2	1 n	125 V	E 350 20/1K
C. 3	100 n	500 V	D 212 90
C. 4	Trimmer25pF	-	C 005Ba/25E
C. 5	56pF	125 V	E 350 29/56E
C. 6	800pF	125 V	E 350 20/800E
C. 7	560pF	125 V	E 350 20/560E

MISCELLANEOUS

Cct.Ref.	Description	Part No.
TR. 1 to TR. 5	Transistor	OC 44
XL. 1	Crystal 100 Kc/s	D 920 94

TABLE 9

SCHEDULE OF COMPONENTS - DISPLAY TIMER (D 868 62)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct. Ref.	Value (in ohms)	Part No.	Cct. Ref.	Value (in ohms)	Part No.
R. 1	1K	D 774 36	R.10	4K7	D 774 44
R. 2	Variable	see note AR 9525/GE50K	R.11	33K	D 774 54
			R.12	10K	D 774 48
R. 3	1K	D 774 36	R.13	2K2	D 774 40
R. 4	1K	D 774 36	R.14	1K	D 774 36
R. 5	1K	D 774 36	R.15	220	D 774 28
R. 6	10K	D 774 48	R.16	4.7K	D 774 44
R. 7	4.7K	D 774 44	R.17	220	D 774 28
R. 8	220	D 774 28	R.18	560	D 774 33
R. 9	4.7K	D 774 44			

CAPACITORS

(all except electrolytics ± 20%)

Cct.Ref.	Value	Working Voltage	Part No.
C. 1	not used		
C. 2	Elec.100uF	12,5 V	AC 5713/100
C. 3	5n	125 V	E 350 20/5K
C. 4	Elec. 25uF	25 V	AC 5715/25
C. 5	0.1uF	150 V	D 212 87

MISCELLANEOUS

Cct.Ref.	Description	Part No.
D.1 and D.2	Diode	OA 70
TR.1 to TR.5	Transistor	OC 44
TR.6	Transistor	OC 72

Note: R2 on fig. 9 - display timer circuit is

R26 on fig. 6a - sub unit-interconn.diagram

indicated as:

R22 on fig. 6b - sub unit-interconn.diagram

TABLE 10

SCHEDULE OF COMPONENTS - OUTPUT CIRCUIT (D 867 98)

RESISTORS (all rated at ± 5%, 1/4 watt)

Cct.Ref.	Value (in ohms)	Part No.
R. 1	1K	D 774 36
R. 2	15K	D 774 50
R. 3	15K	D 774 50
R. 4	1K	D 774 36
R. 5	120	D 774 25

Cct.Ref.	Value (in ohms)	Part No.
R. 6	1K	D 774 36
R. 7	1.8K	D 774 39
R. 8	6.8K	D 774 46
R. 9	1K	D 774 36
R.10	220	D 774 28

CAPACITORS

Cct.Ref.	Value	Working Voltage	Part No.
C. 1	2.7n	125 V	E 350 20/2K7
C. 2	1 n	125 V	E 350 20/1K

MISCELLANEOUS

Cct.Ref.	Description	Part No.
TR.1 to TR.3	Transistor	OC 44

TABLE 11

SCHEDULE OF COMPONENTS - STABILIZED POWER SUPPLY (D 868 61)

RESISTORS (all except potentiometers rated at ± 5%, 1/4 watt)

Cct. Ref.	Value (in ohms)	Part No.
R. 1	560	D 774 33
R. 2	4.7K	D 774 44
R. 3	1.5K	D 774 38
R. 4	8.2K	D 774 47

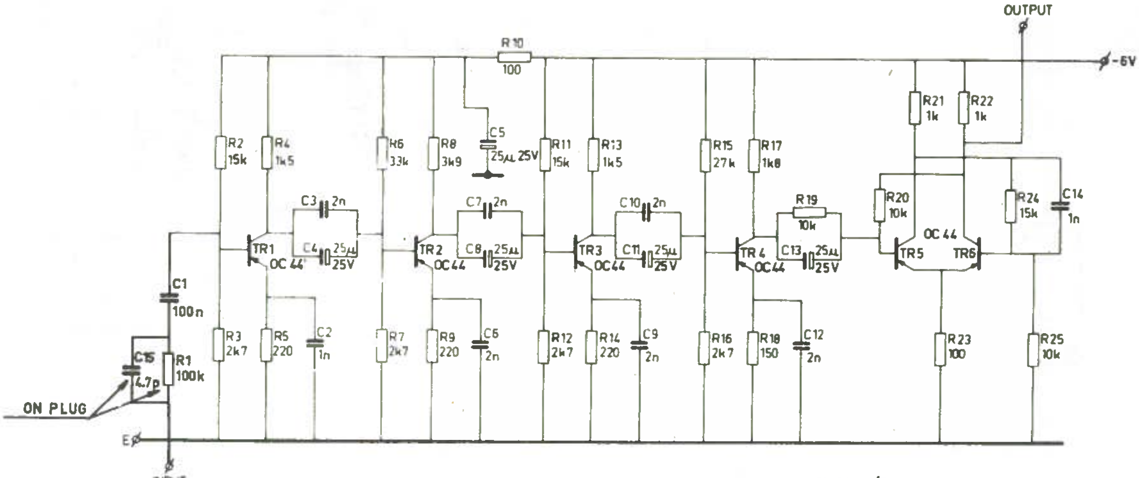
Cct. Ref.	Value (in ohms)	Part No.
R. 5	1K	D 774 36
R. 6	6.8K	D 774 46
R. 7	1K Variable	D 930 94

CAPACITORS

Cct. Ref.	Value	Working Voltage	Part No.
C. 1	Elec.500μF	25 V	D 212 89
C. 2	Elec. 25μF	25 V	AC 5715/25

MISCELLANEOUS

Cct.Ref.	Description	Part No.
D. 1	Diode	OA 210
D. 2	Diode	OA 210
Z. 6	Zenerdiode	D 906 22
TR.1	Transistor	ASZ 16
TR.2	Transistor	OC 72
TR.3	Transistor	OC 44
TR.4	Transistor	OC 44



NOTE: IN COUNTER 100KC/S C15 NOT USED.

FIG.1 - INPUT CIRCUIT.

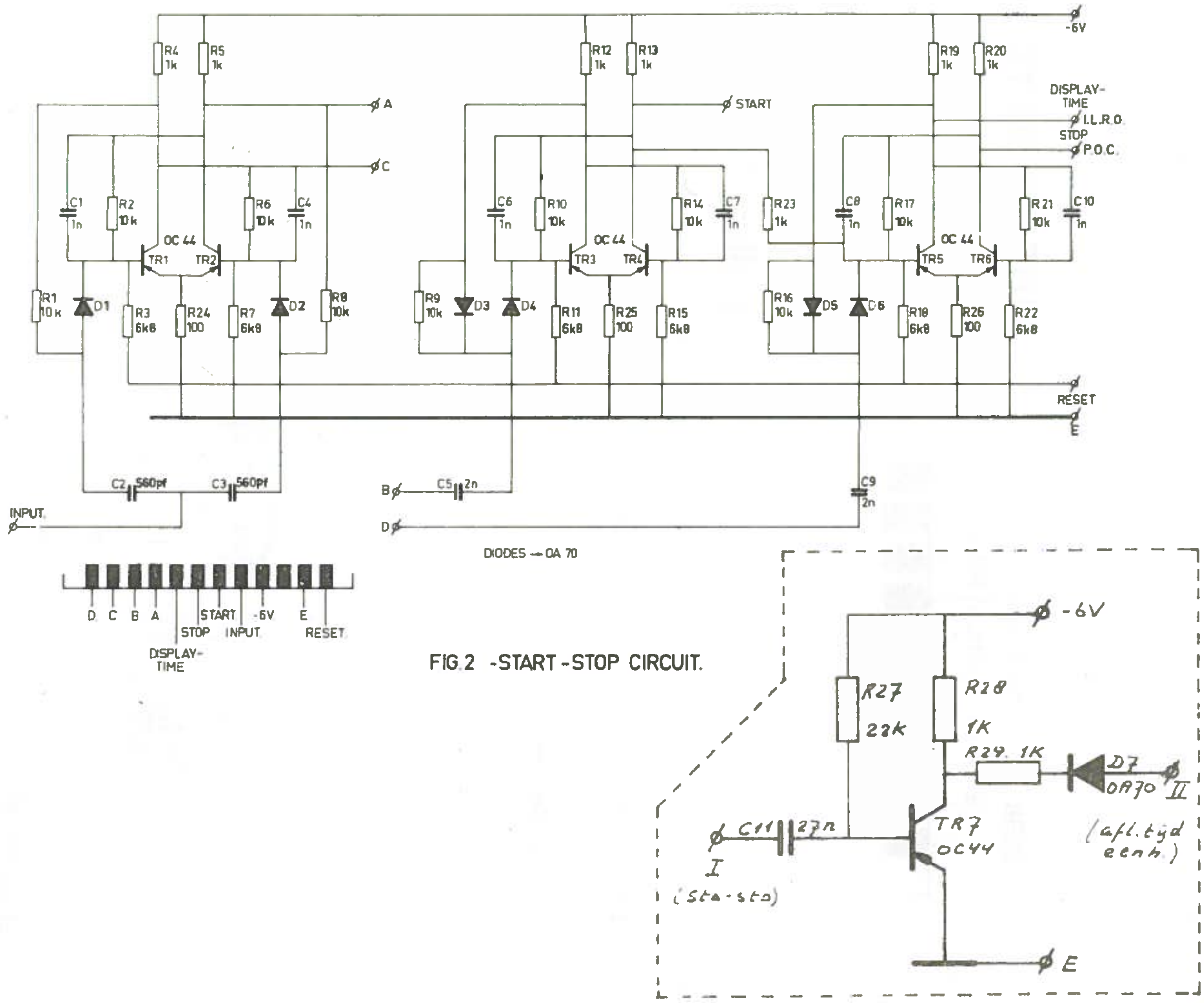


FIG.2 -START-STOP CIRCUIT.

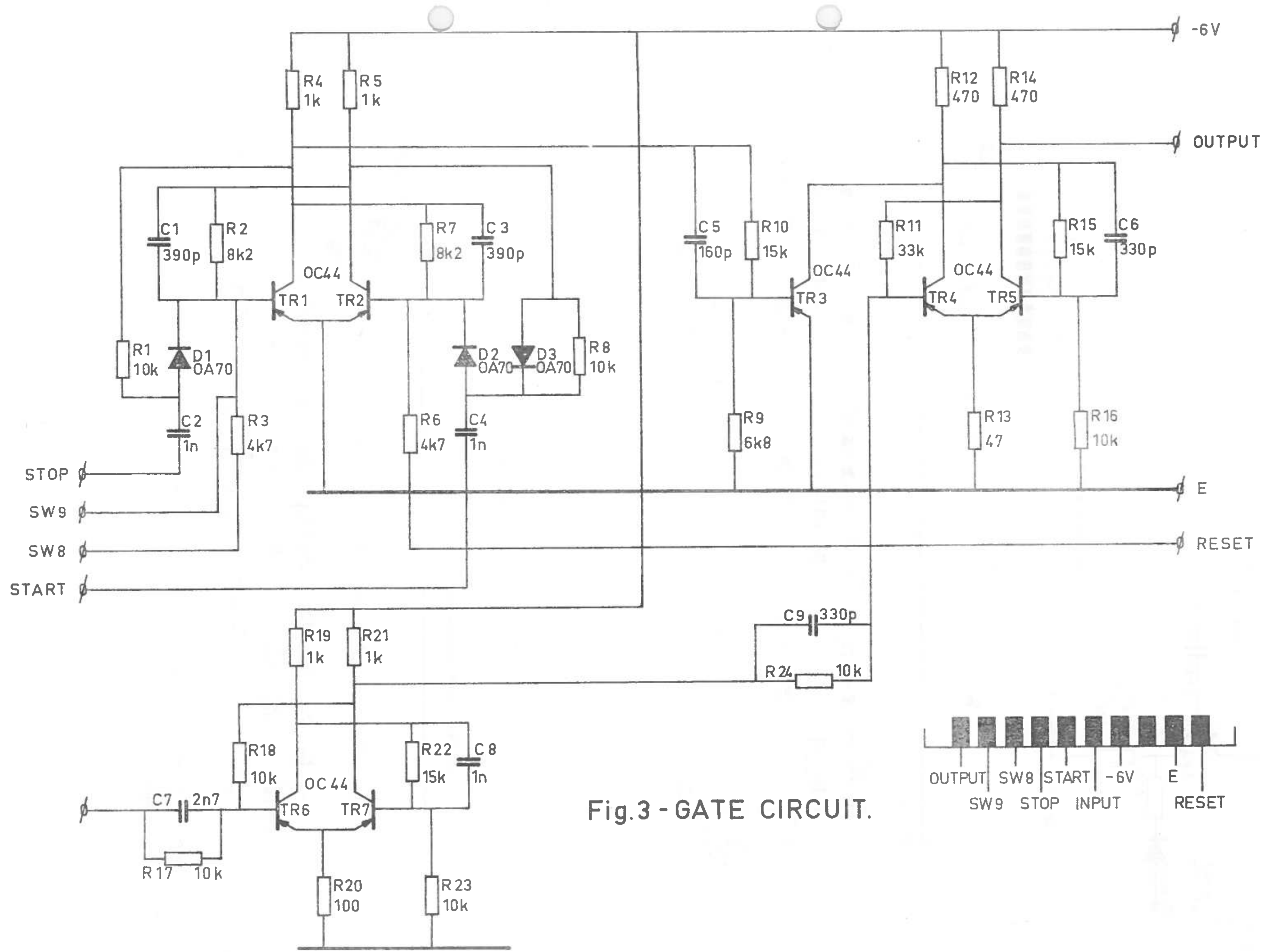


Fig.3 - GATE CIRCUIT.

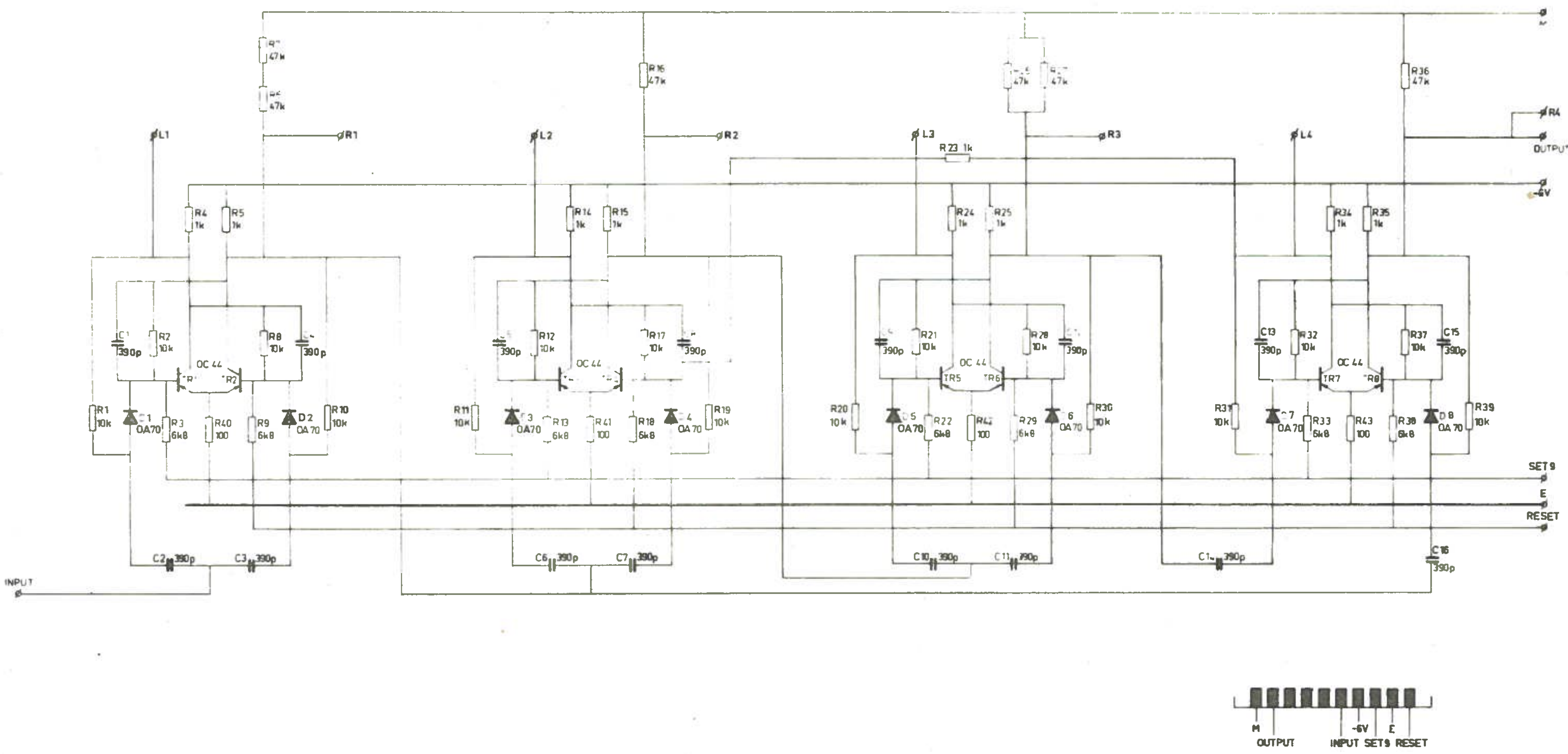


FIG.4 - MEDIUM FREQUENCY DECADE , CIRCUIT

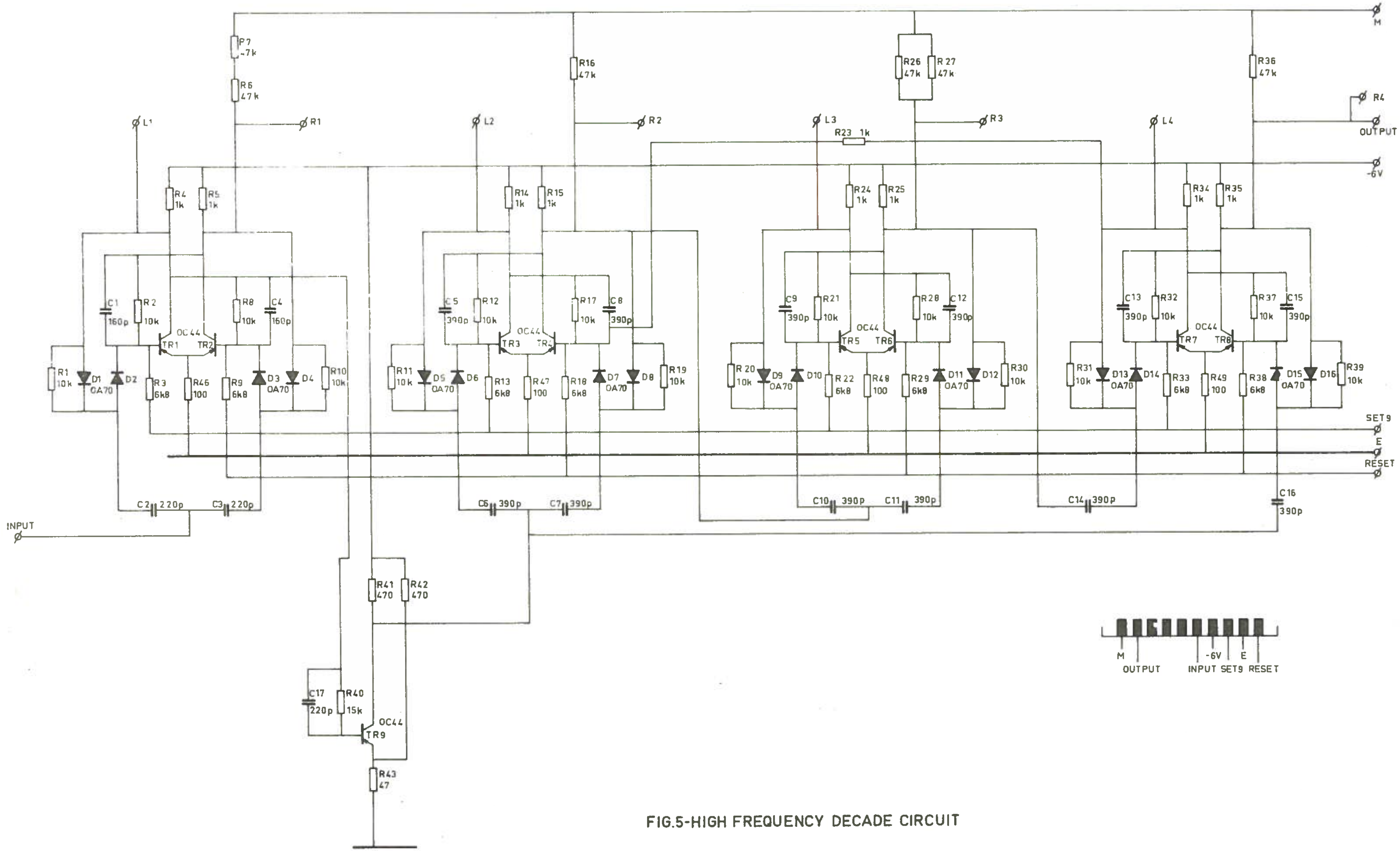


FIG.5-HIGH FREQUENCY DECADE CIRCUIT

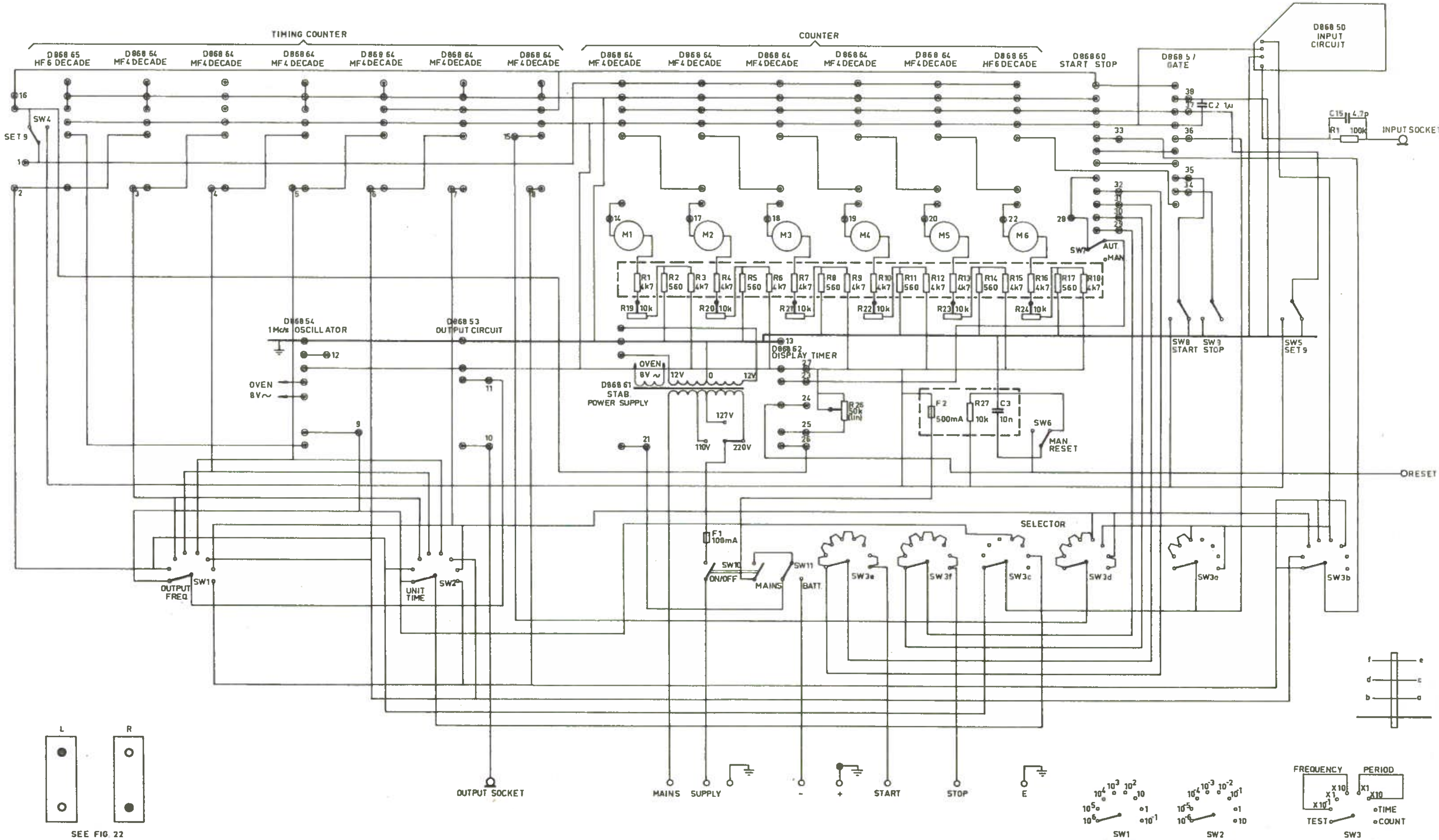


FIG. 6a.-SUB-UNIT INTERCONNECTION DIAGRAM.

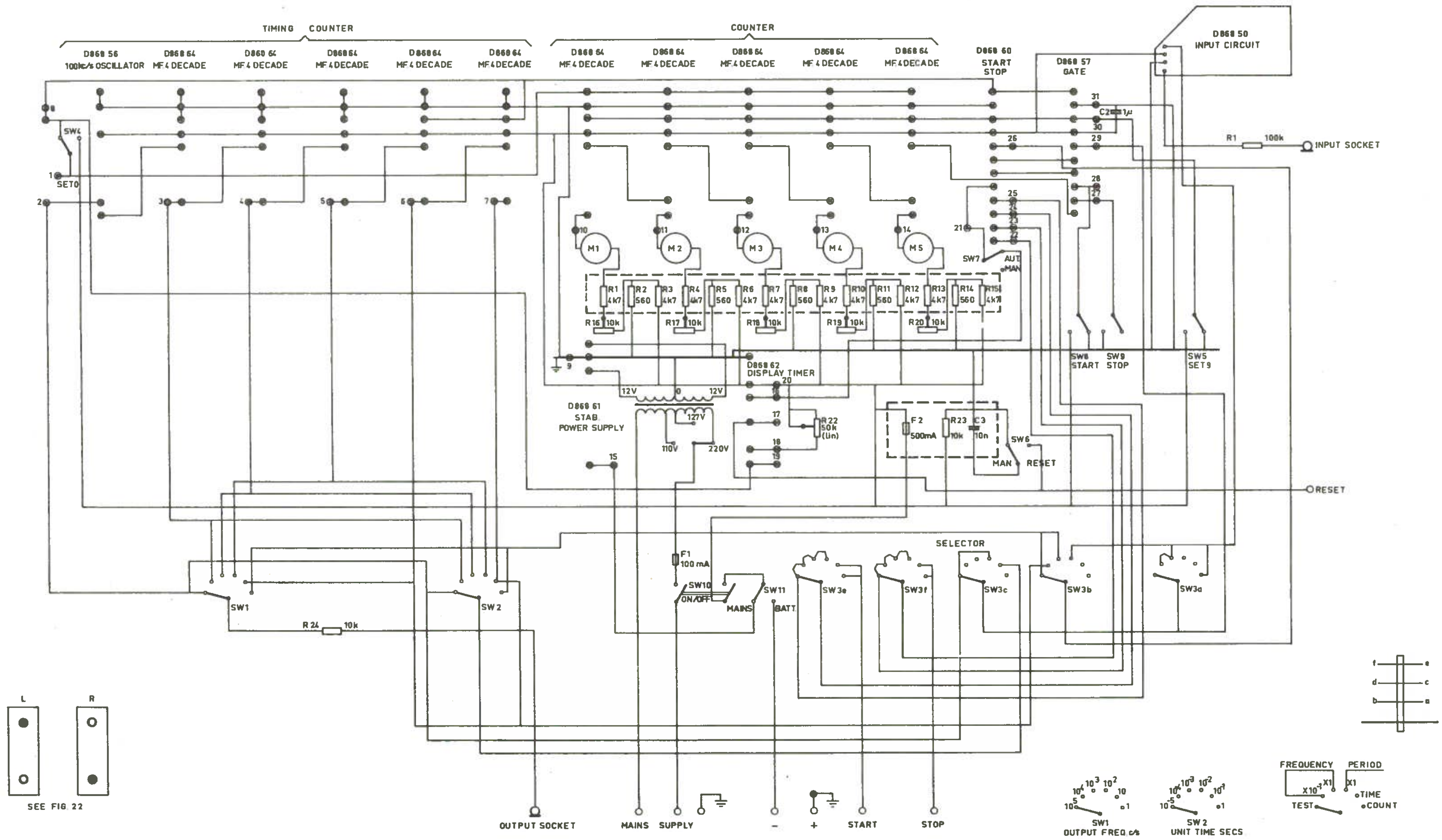


FIG. 6b-SUB-UNIT INTERCONNECTION DIAGRAM

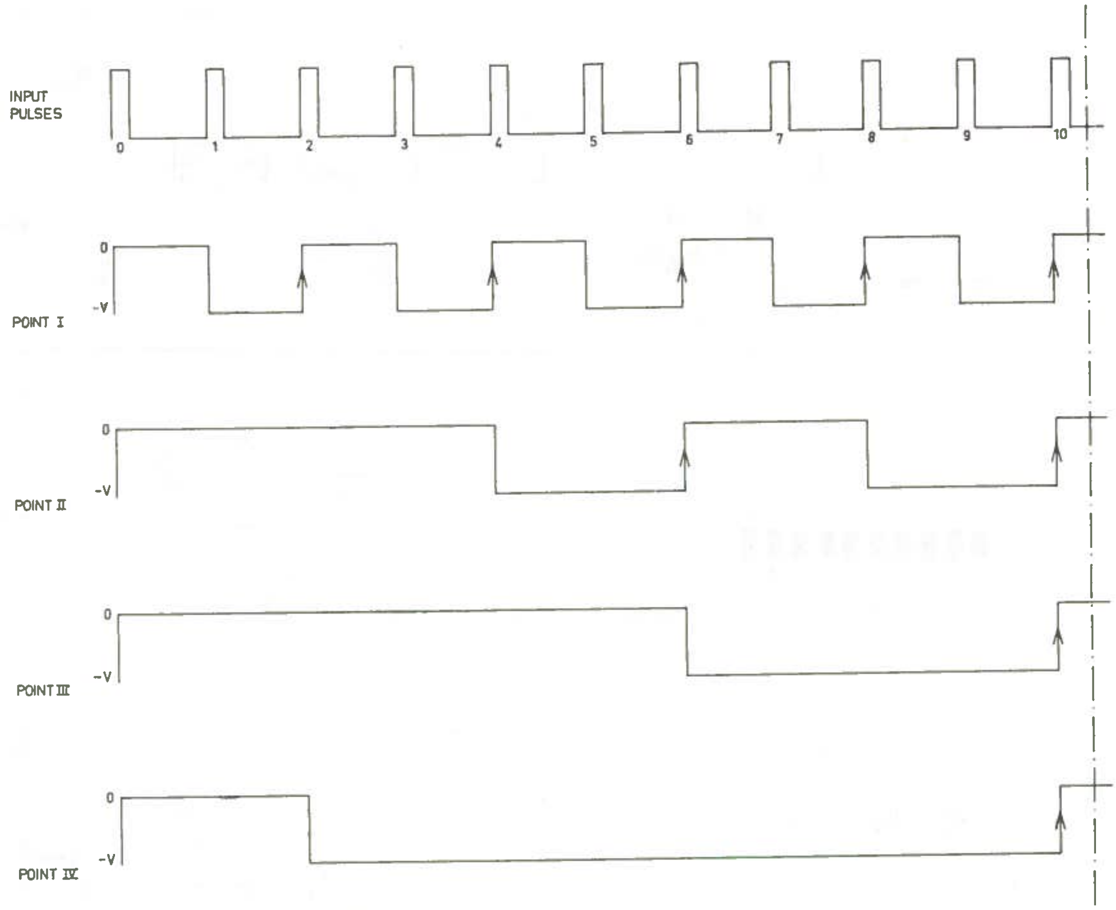


FIG. 7 - DECADE WAVEFORMS.

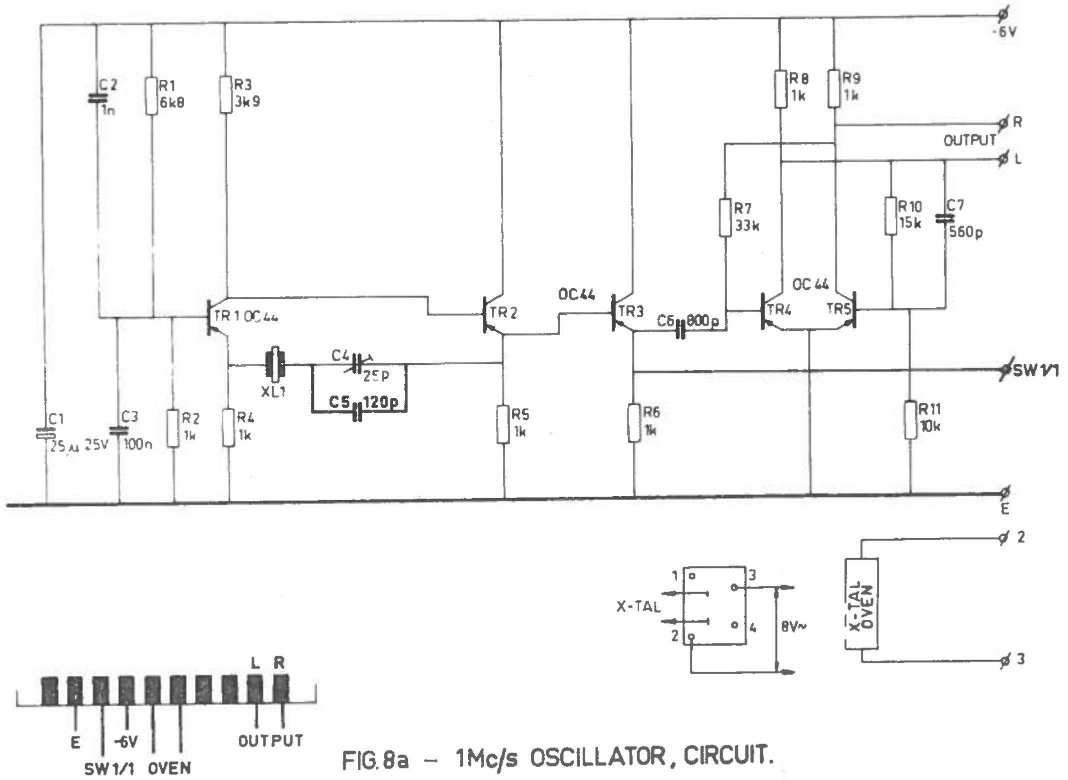


FIG. 8a – 1Mc/s OSCILLATOR, CIRCUIT.

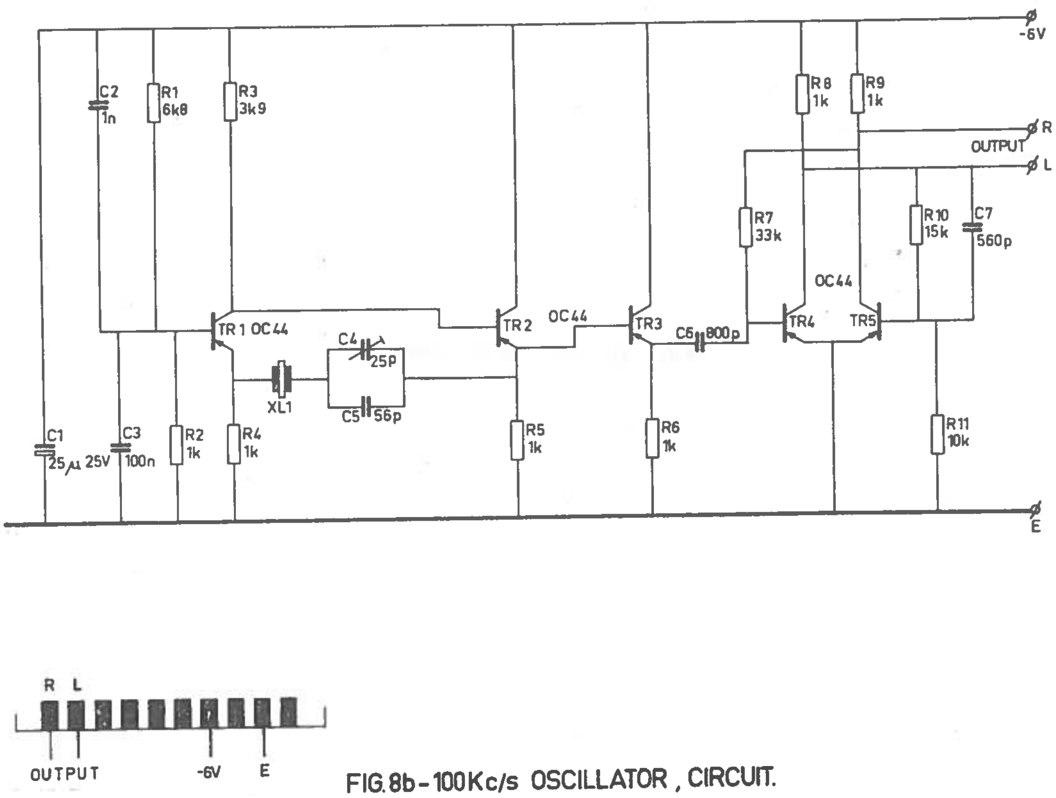
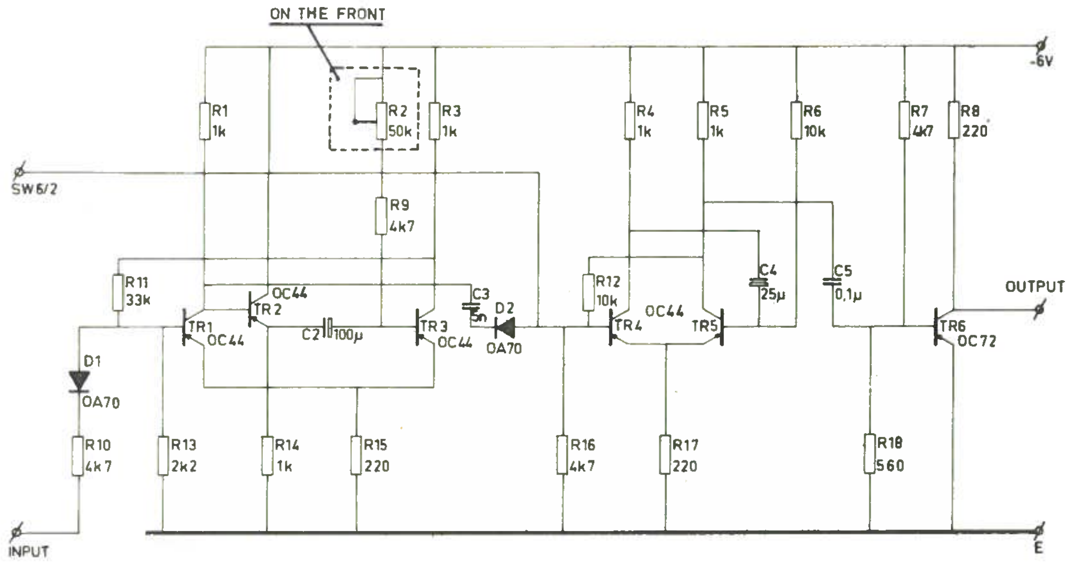


FIG. 8b - 100Kc/s OSCILLATOR, CIRCUIT.



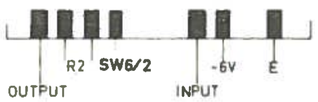
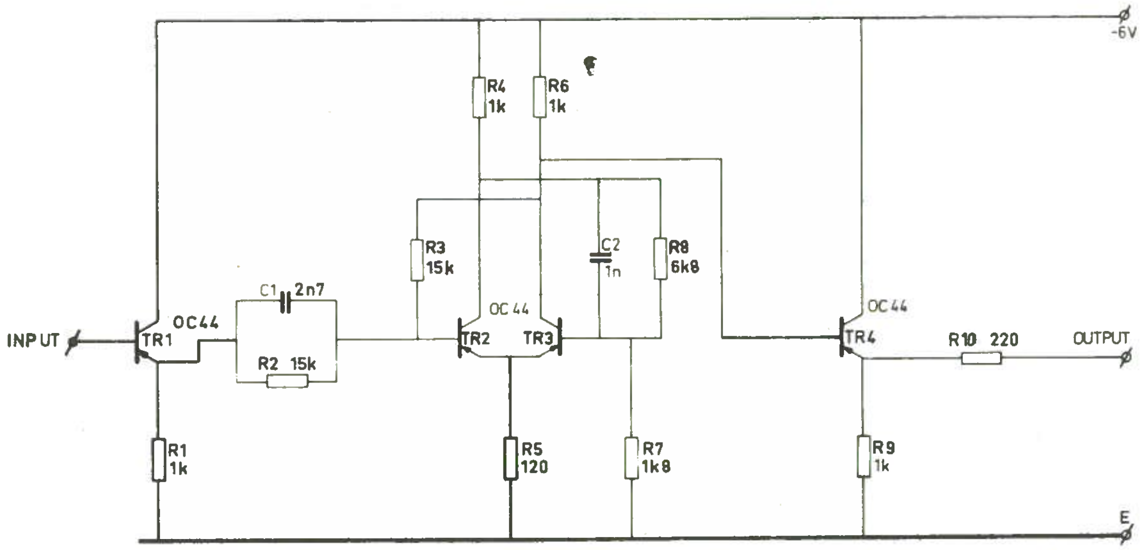


FIG.9-DISPLAY TIMER. CIRCUIT.



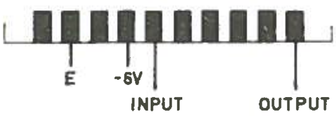


FIG.10 - OUTPUT CIRCUIT.

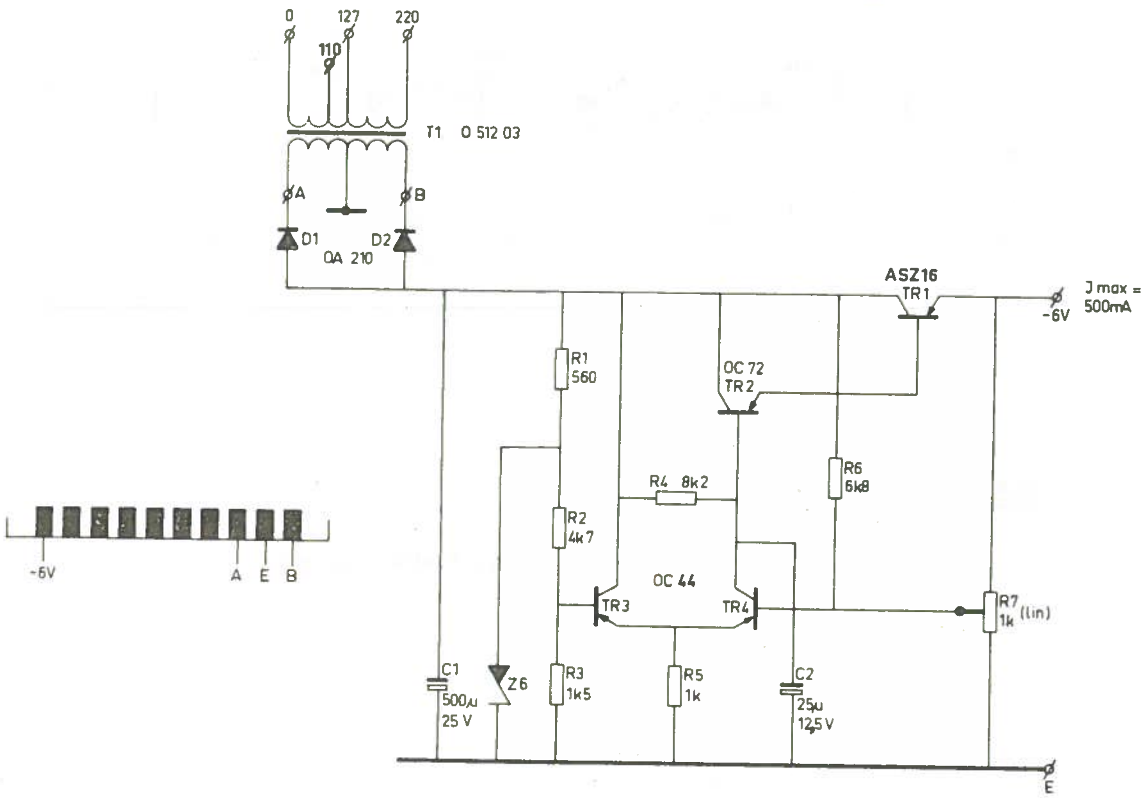


FIG.11 - STABILIZED POWER SUPPLY, CIRCUIT.

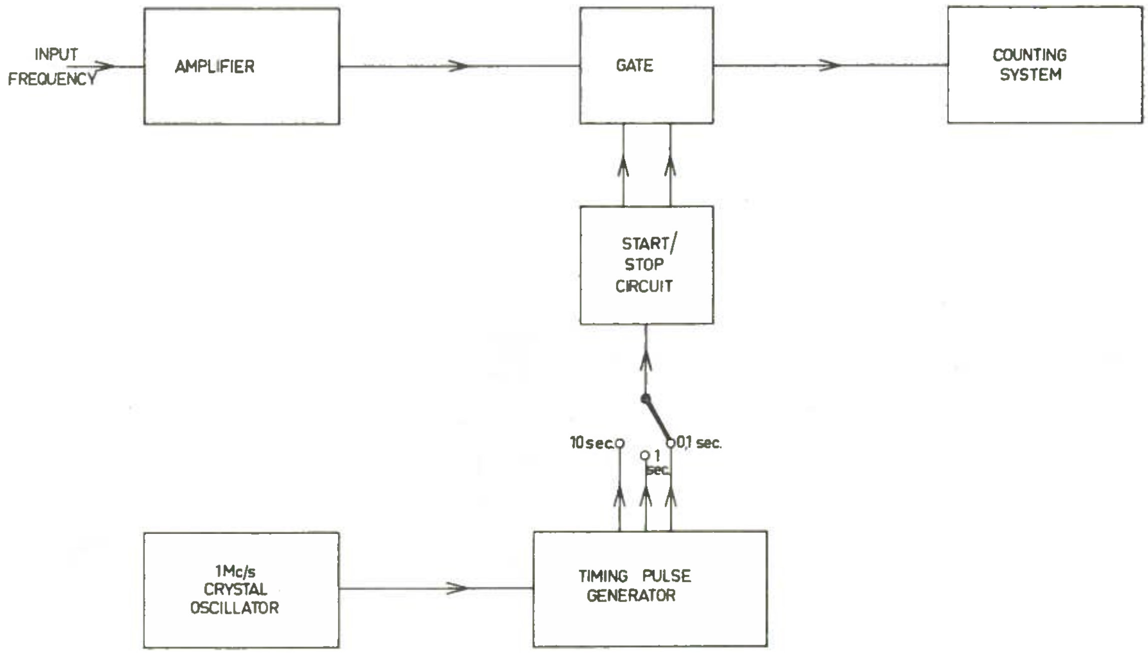


FIG.12a - FREQUENCY MEASUREMENT, BLOCK DIAGRAM.

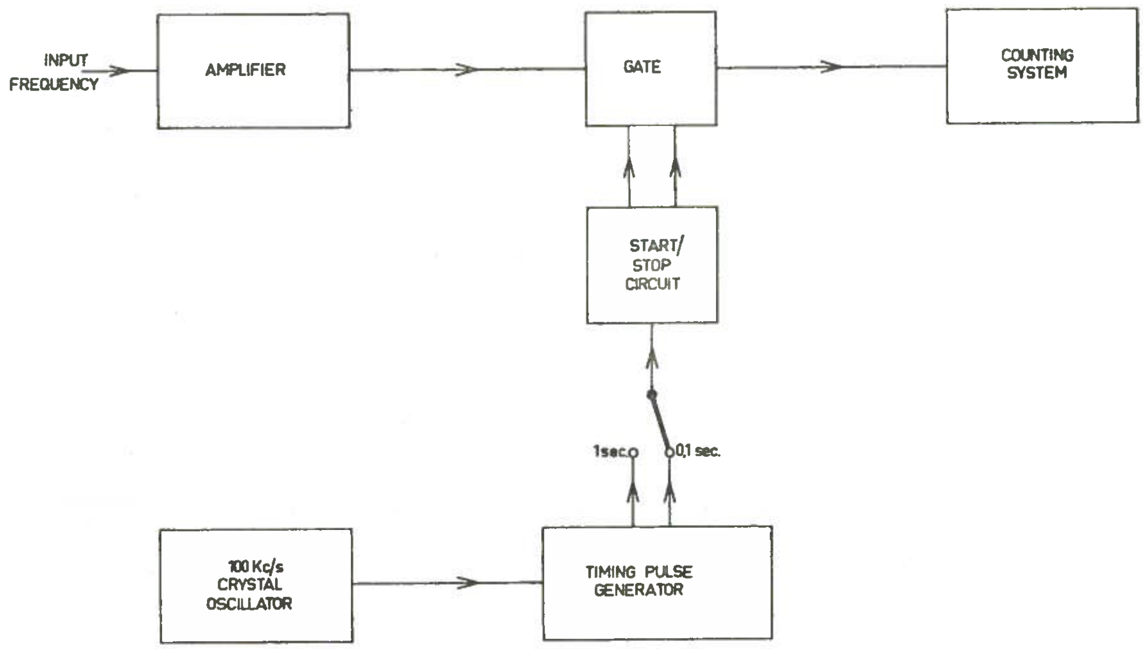


FIG.12b - FREQUENCY MEASUREMENT, BLOCK DIAGRAM.

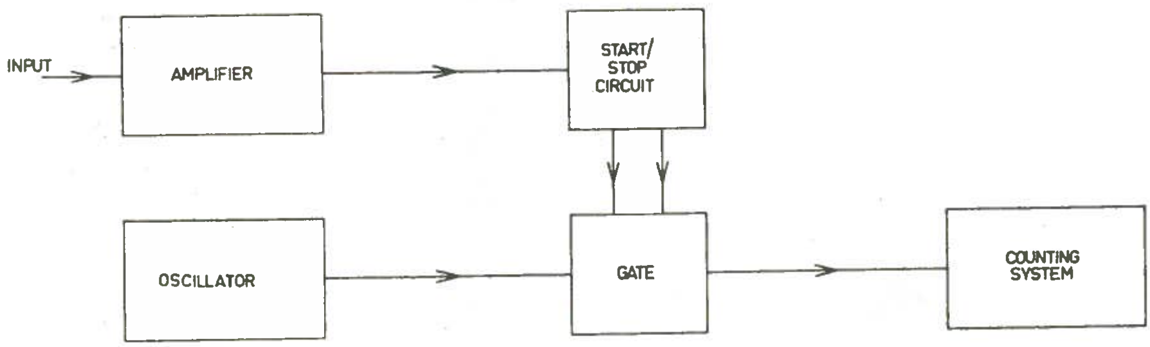


FIG.13 - PERIOD (x1) MEASUREMENT, BLOCK DIAGRAM.

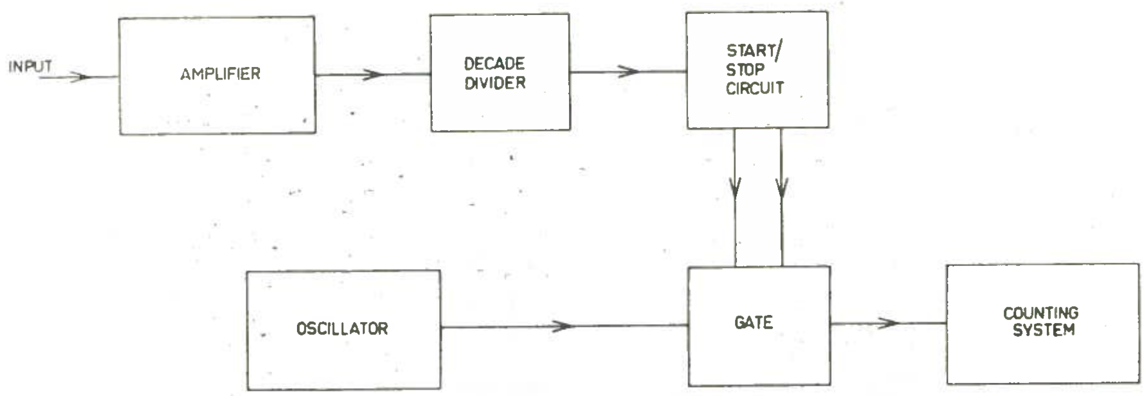


FIG.14- PERIOD (x10) MEASUREMENT, BLOCK DIAGRAM.

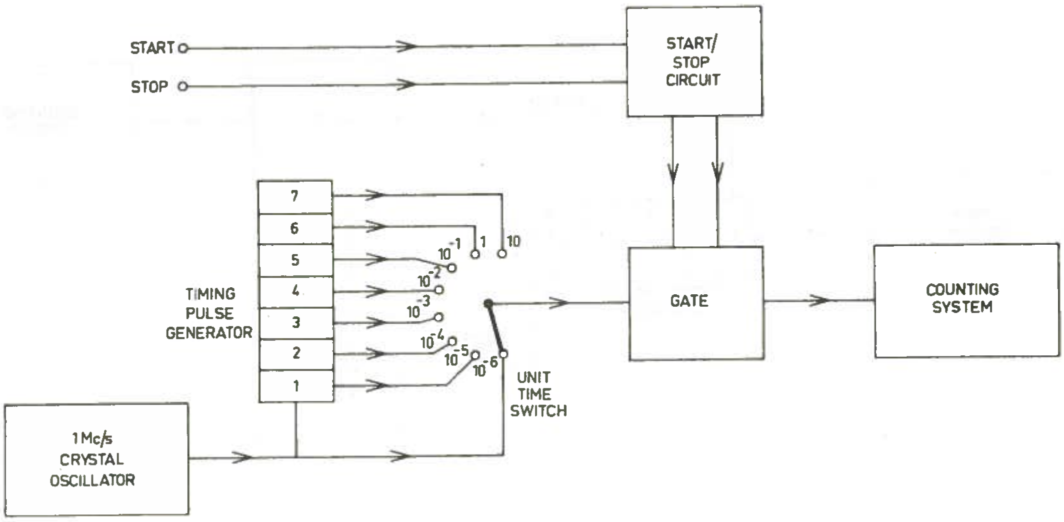


FIG.15a - TIME MEASUREMENT, BLOCK DIAGRAM

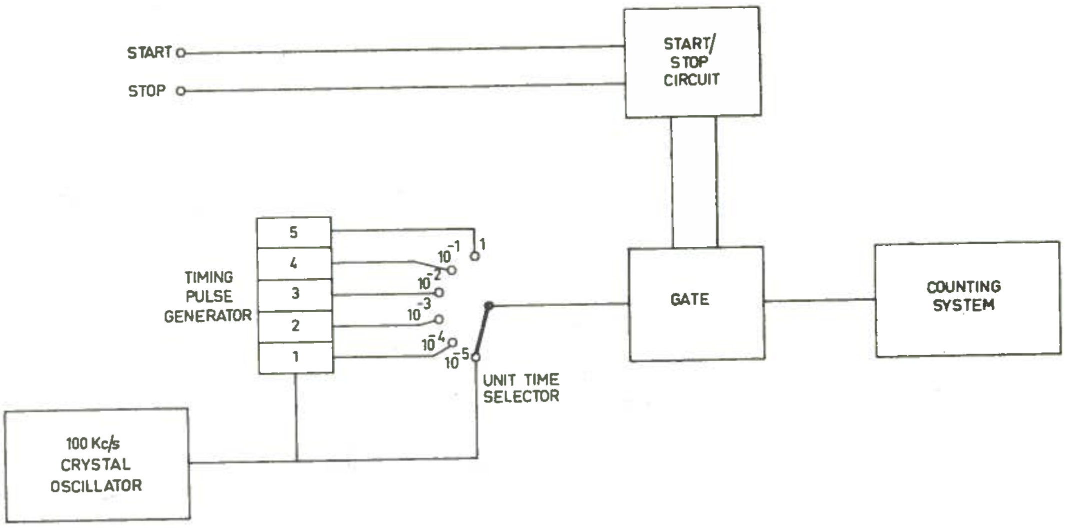


FIG. 15b - TIME MEASUREMENT, BLOCK DIAGRAM.

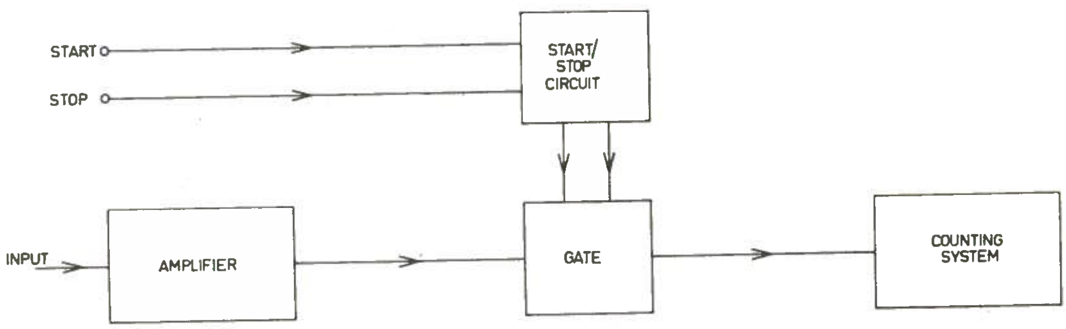


FIG.16 - COUNTING BLOCK DIAGRAM.

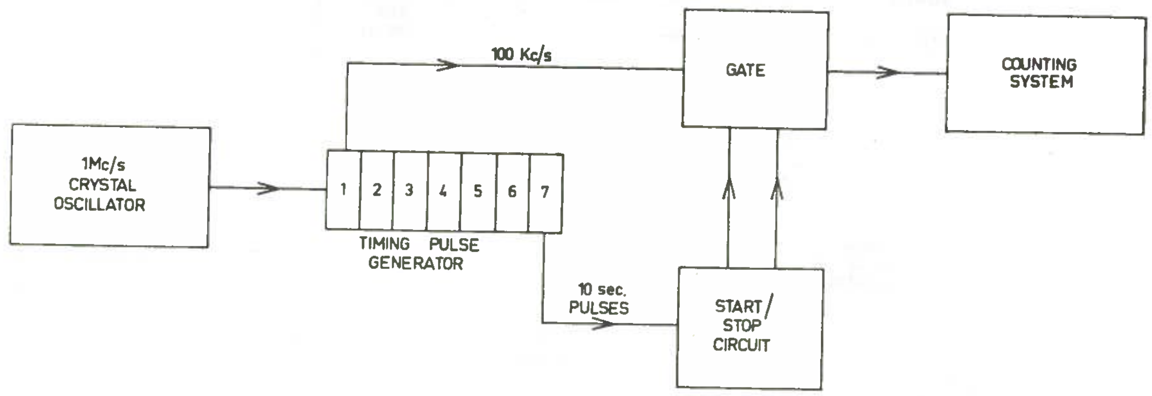


FIG.17a - TEST FACILITIES, BLOCK DIAGRAM

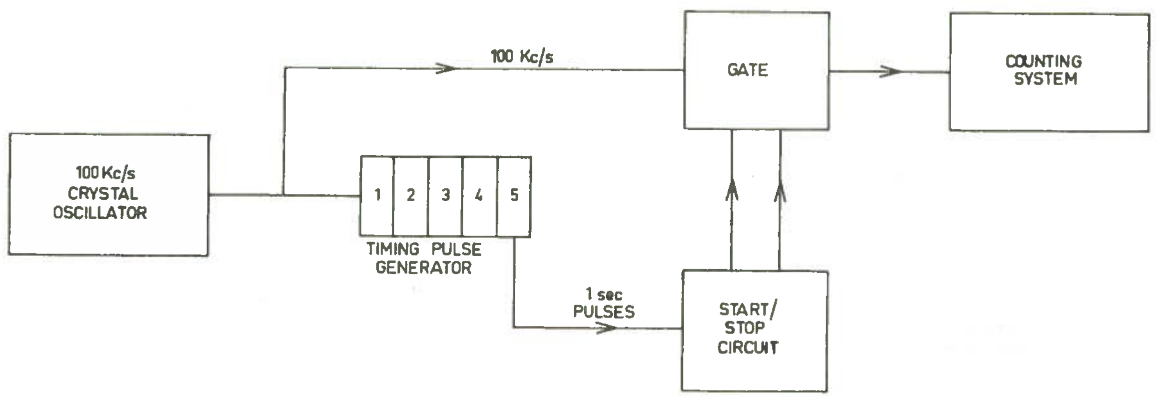
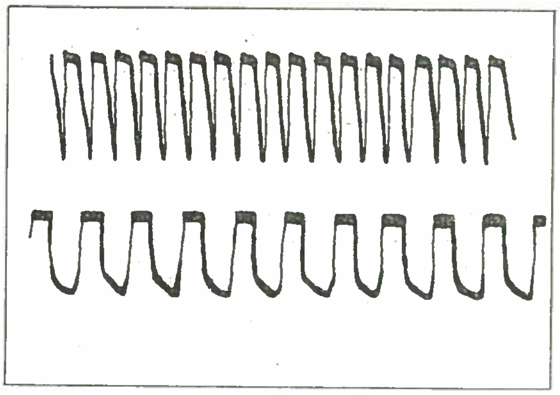
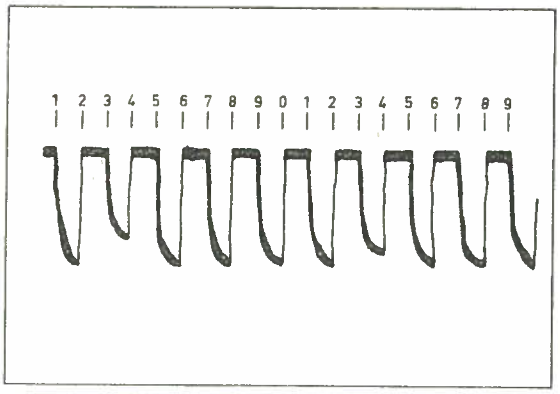


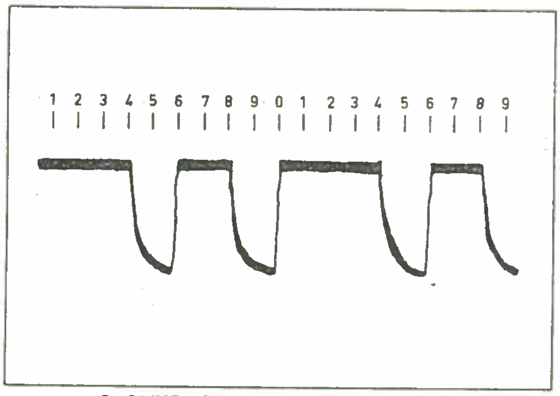
FIG.17b - TEST FACILITIES, BLOCK DIAGRAM.



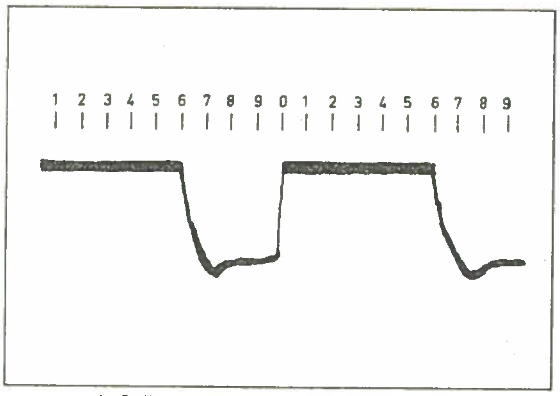
1. INPUT SIGNAL (1Mc/s) AND
1st BINARY OUTPUT
2µS/cm 2V/cm



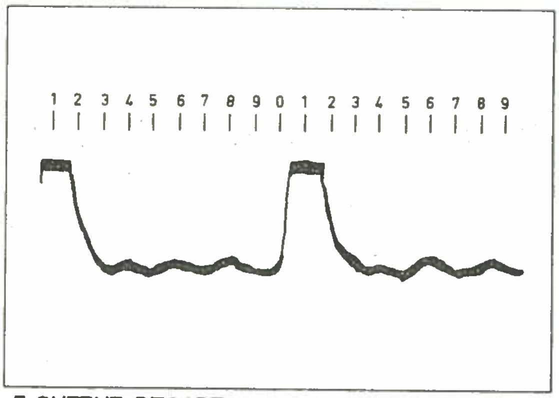
2. OUTPUT PULSE SHAPER (H.F.DECADE)
2µS/cm 2V/cm



3. OUTPUT SECOND BINARY
2µS/cm 2V/cm



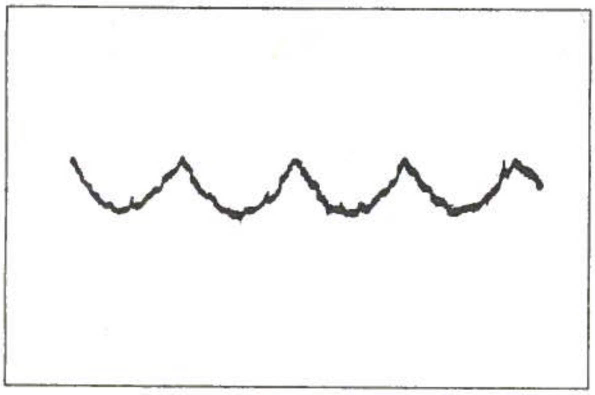
4. OUTPUT THIRD BINARY
2µS/cm 2V/cm



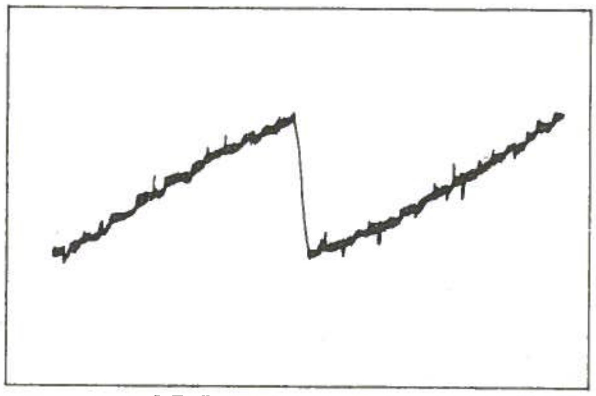
5. OUTPUT DECADE AND FOURTH BINARY
2µS/cm 2V/cm

FIG.19 - DECADE WAVEFORMS (1Mc/s INPUT)

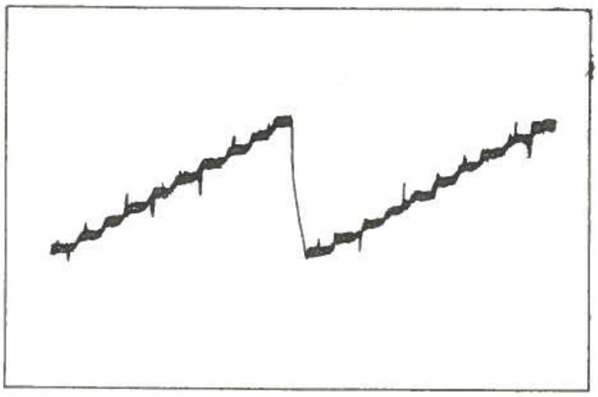
REPRODUCED 3/4 SIZE



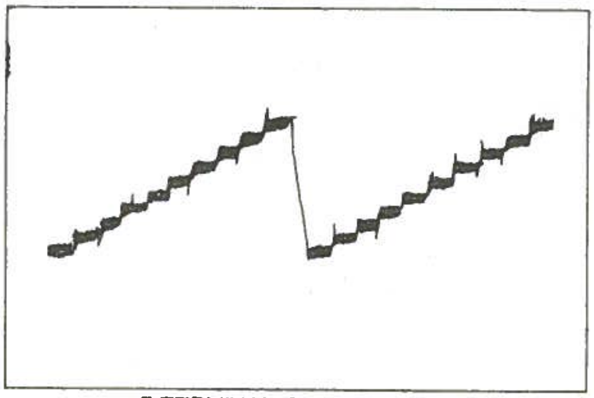
1. TERMINAL H - M6
5μS/cm 0·5V/cm



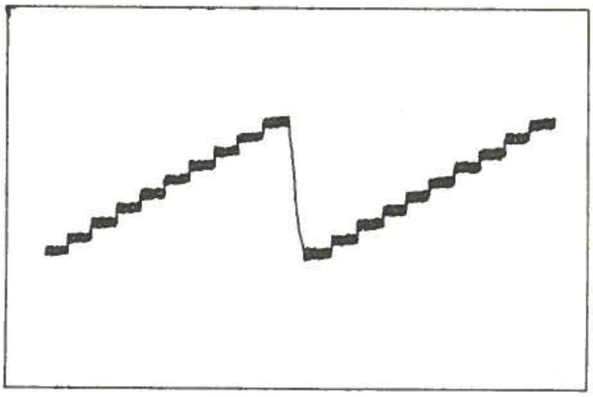
2. TERMINAL G - M5
20μS/cm 0·5V/cm



3. TERMINAL F - M4
200μS/cm 0·5V/cm



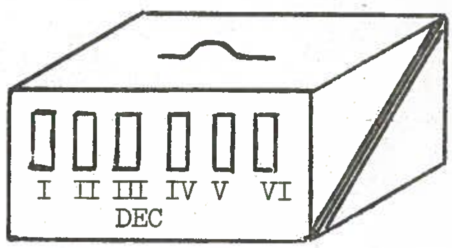
5. TERMINAL E - M3
2 mS/cm 0·5 V/cm



5. TERMINAL D - M2
20 mS/cm 0·5V/cm

REPRODUCED 3/4 SIZE

Socket L terminal			Socket R terminal		
1	L1	DEC I	1	R1	DEC I
2	L2		2	R2	
3	L3		3	R3	
4	L4		4	R4	
5	D1	DEC II	5	R1	DEC II
6	L2		6	R2	
7	L3		7	R3	
8	L4		8	R4	
9	L1	DEC III	9	R1	DEC III
10	L2		10	R2	
11	L3		11	R3	
12	L4		12	R4	
13	L1	DEC IV	13	R1	DEC IV
14	L2		14	R2	
15	L3		15	R3	
16	L4		16	R4	
17	L1	DEC V	17	R1	DEC V
18	L2		18	R2	
19	L3		19	R3	
20	L4		20	R4	
21	L1	DEC VI	21	R1	DEC VI
22	L2		22	R2	
23	L3		23	R3	
24	L4		24	R4	
25	pos.stoppulse		25	neg.stoppulse	
26			26	earth	



rear side

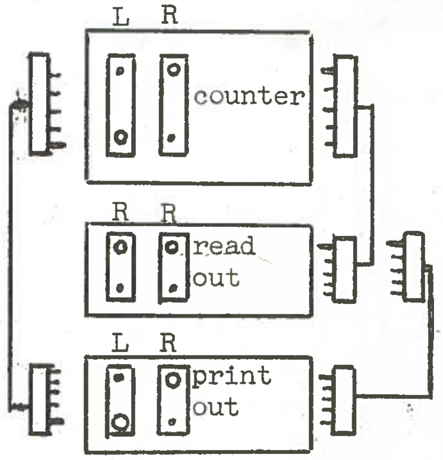


Fig.22 plugconnections