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TELEVISION

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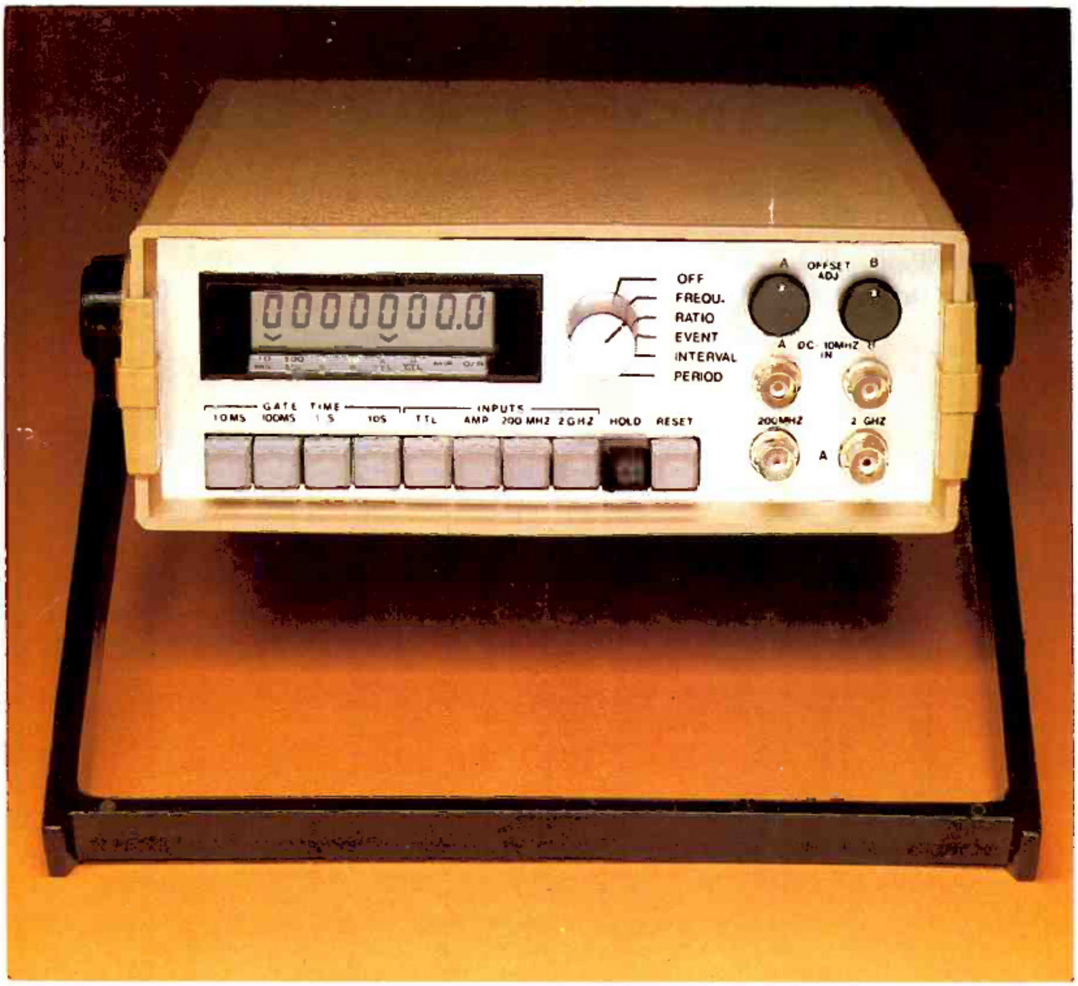
New Project: FREQUENCY COUNTER-TIMER Part 1



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Digital Counter-Timer

Tony Jenkins

Part 1

THIS instrument has been designed to provide a convenient and accurate way of measuring, counting and timing events. Applications include checking and setting clock, subcarrier and timebase oscillators, checking frequency divider circuits, measuring time delays, and batch/transient counting. The term digital frequency meter (DFM) is more commonly used, but it's pertinent to point out that a pure DFM will not perform all the functions of which the present design is capable. DFMs do not usually have timing facilities for example, being restricted to frequency measurement.

Most of the full-function counter/timers available commercially are extremely expensive. These and DFMs tend to suffer from the limitations of being either mains powered and/or capable of reading only a limited range of frequency, usually to a low resolution. The present design avoids these constraints, offering the constructor the opportunity to build a portable, battery-powered instrument of great versatility. The frequency range is from less than 1Hz to in excess of 1·5GHz with eight digits resolution. There are full counter/timer functions and a choice of switchable inputs. The basic power consumption is some 10mA (excluding the prescalers), so that well in excess of a hundred hours typical use can be expected from a PP7 battery.

In considering the design, attention was paid to cost and ease of construction in addition to the technical specification. The result is a unit which is much less expensive than comparable commercial designs. Interwiring has been kept to the minimum by using the latest display technology. This simplifies construction and makes assembly errors less likely. So we have a convenient to build, cost effective, multifunction instrument that's truly portable.

Basic Design

The design is based on the Intersil 7226A eight-digit universal counter/timer i.c. This is similar to the well known 7216 but has extra control lines that simplify interfacing with a 7231A triplexed LCD display driver. A block diagram of the complete unit is shown in Fig. 1. From this it will be seen that in addition to the main logic there are two preamplifiers, which are identical, and two prescalers. The power consumption of the prescalers and preamplifiers is considerably more than that of the main logic, so these sections are switched off when not in use, i.e. when the appropriate input switch is not depressed. The main logic is capable of operating up to 10MHz, the prescalers extending the range to some 2GHz.

In designing the input selection arrangements the aim has been for maximum versatility in use. Thus input A can be switched to accept TTL level signals (5V) while input B provides input amplification, and input B can be switched to accept TTL inputs while either of the prescalers is in use. The user's "driving experience" will doubtless suggest many useful applications for these facilities.

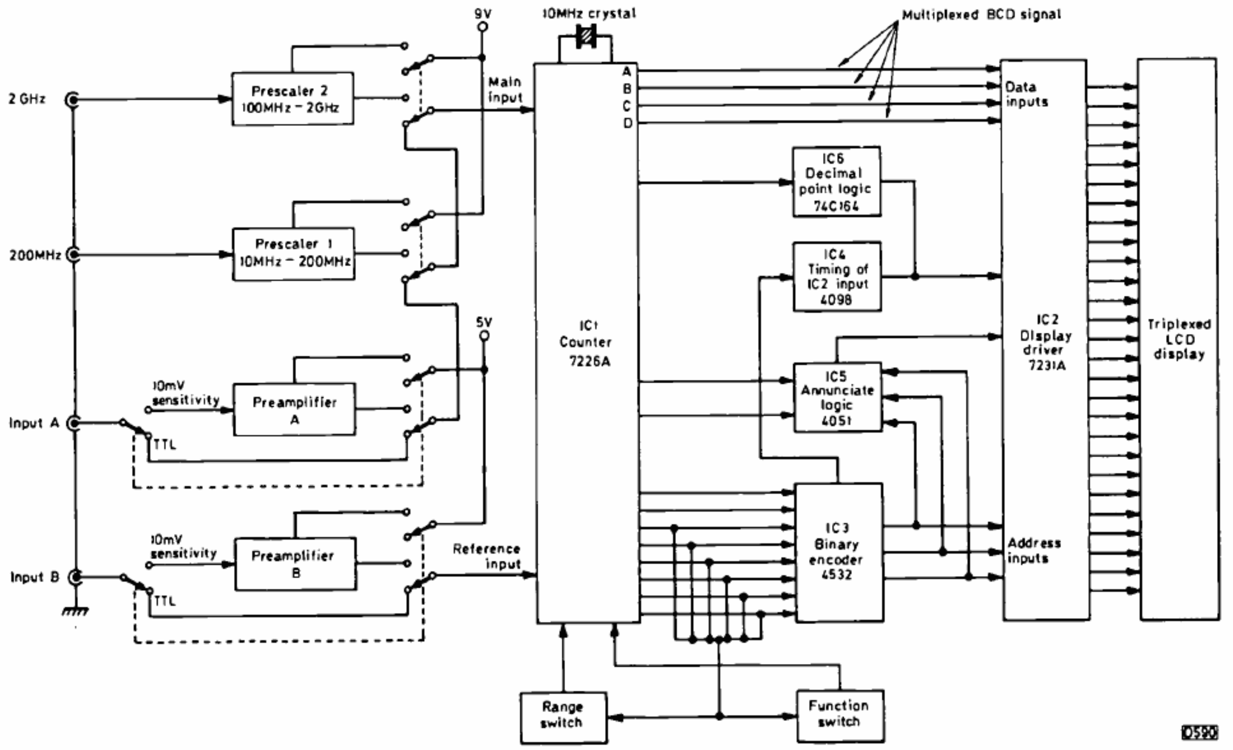

Fig. 1: Block diagram of the counter-timer.

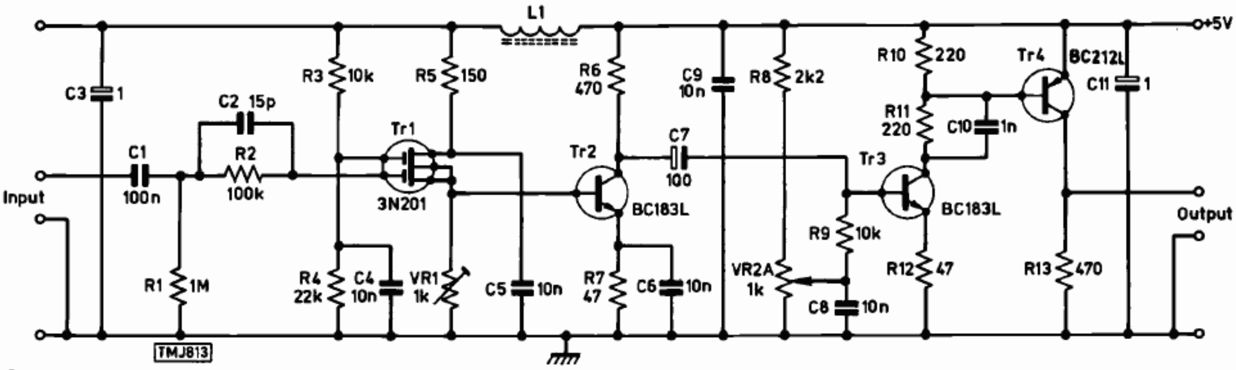

Fig. 2: Preamplifier A circuit. Preamplifier B is identical.

Fig. 6 shows the main logic circuitry. The data output from IC1 appears at pins 6, 7, 17, 18 while address outputs appear at pins 22-30. The latter drive the 4532 binary encoder IC3 which generates a binary coded output corresponding to the selected input. Pins 6, 7 and 9 of IC3 in turn control the address lines (37-39) of the 7231A display driver IC2. These lines tell IC2 how to interpret the incoming data. Each time any of IC1's address output pins (22-30) goes high (logic 1), IC3's enable output pin 15 also goes high. This triggers monostable IC4a, which produces a 50μ sec delay to allow time for the data and address lines to settle. The second monostable IC4b subsequently provides a trigger pulse which initiates writing of the information into IC2. The circuitry comprising the shift register IC6 and sections of the input selector switch maintains the decimal point in the correct position when the prescalers are in use.

Information for the display annunciators in IC2 – these indicate modes, range and measurement in progress – is selected by data selector IC5. This is driven by IC3's address outputs. Fig. 4 shows the connections between IC2 and the LCD display. Note that the display connector has one spare pin at each end – these should be ignored.

The Preamplifiers

The counter i.c.'s inputs (pins 2 and 40) are designed to be driven by TTL signals, so amplification is required for any other type of signal. There are two identical preamplifiers, for main input A and reference input B. In the design of these consideration was given to input sensitivity and impedance to enable the measurement of low-level signals using standard test leads. The preamplifier circuit is shown in Fig. 2. The initial stage consists of a dual-gate MOSFET to provide a high input impedance. This is employed as a source-follower to drive the common-emitter transistor Tr2 whose output is a.c. coupled to the base of Tr3 by C7. The bias at the base of Tr3 is controlled by VR2A, which with the complementary control VR2B in the other channel are the front panel "offset" controls.

The purpose of these controls is to allow the input

Main Board and Display Board Components

Resistors: 0.25W carbon film, ±5% except where stated

R1	10k
R2	10k
R3	47k
R4	47k
R5	10k
R6	10k
R7	15M 0·5W (metal glaze)
R8	10k
R9	100k
R10-15	10k
SIL1	2k2×8
SIL2	100k×8
VR1	220k miniature horizontal-mounting skeleton preset

Capacitors:

C1	1μF	35V	tantalum bead
C2	1μF	35V	tantalum bead
C3	68p		ceramic plate
C4	68p		ceramic plate
C5	47p		polystyrene
C6	100n	35V	tantalum bead
C7	10n		ceramic plate
C8	220p		ceramic plate
C9	1μF	35V	tantalum bead
C10	10μF	16V	electrolytic
C11	68p		ceramic plate
C12	10μF	16V	tantalum bead
TC1	5.5-65p		trimmer

Semiconductors:

D1-D4	1N4148	IC4	4098
Tr1	BC184L	IC5	4051
IC1	7226A	IC6	74C164
IC2	7231A	IC7	4069
IC3	4532	IC8	74HC14
		IC9	LM2931 25.0

Miscellaneous:

XL1	10MHz HC18/U crystal
SW1-10	See text
SW11	2-pole, 6-way p.c.b.-mounting rotary switch
LCD	8-digit triplexed display

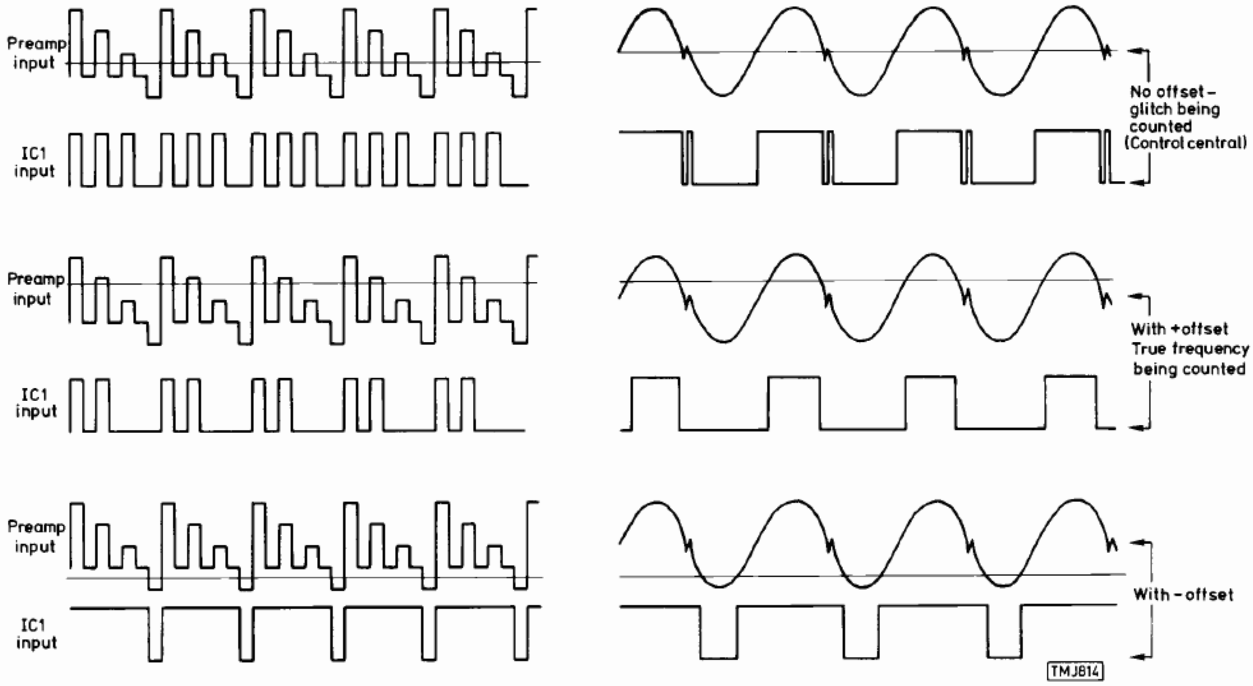

Fig. 3: Effect of the offset controls under ideal conditions.

waveform to be sliced at some point other than its average level, so that low-level noise or other unwanted signals are ignored, i.e. not counted into the reading. This desirable facility is often omitted from commercially produced instruments. The action is shown in Fig. 3.

The final gain and conversion to TTL level is provided by Tr4. Input capacitor C1 is included to block the d.c. component of signals being measured.

Either preamplifier is automatically selected and powered by the input selector switches. The display indicates when the amplifers are *off*, i.e. the switches are in the TTL position. It's sometimes useful to feed a TTL signal to one input and a low-level signal to the other. By depressing both the TTL and AMP switches the A input will provide amplification while the B input accepts a TTL signal. By *releasing* both switches, the reverse conditions apply. The B input can also be set for TTL operation while either of the prescalers is in use. To do this, depress the TTL switch and the required prescaler switch. The display indicates whichever combination has been selected, providing a useful check on the input conditions.

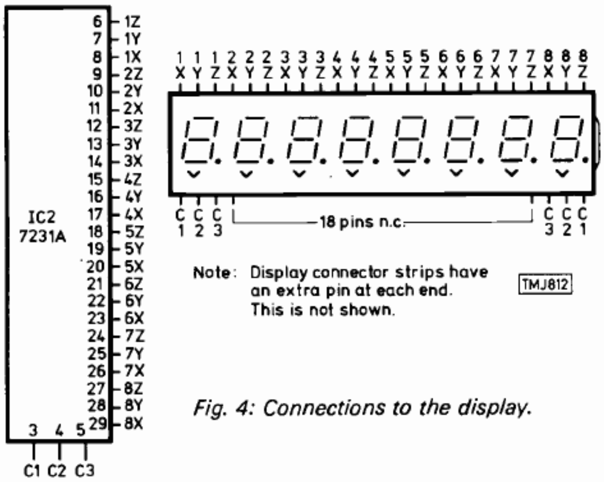

Fig. 4: Connections to the display.

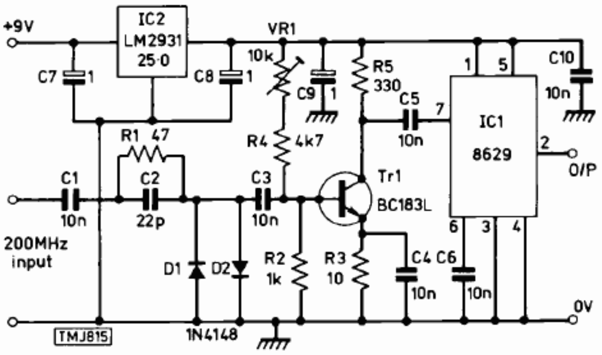

Fig. 5: Circuit of prescaler no. 1.

Prescaler No. 1

Fig. 5 shows the circuit of prescaler 1, which extends the range (set by the 7226A's 10MHz maximum capability) to 200MHz. The input signal is first amplified by Trl and then fed to the 8629 chip which divides the frequency of the input by a factor of 100. As with the preamplifiers, power is applied to the prescaler only when the appropriate input switch is selected. Selection of either prescaler automatically adjusts the position of the decimal point so that the output is read in MHz instad of kHz.

To Follow

Constructional details will start next month. Further component details and the circuit of prescaler no. 2 are also to follow. Printed boards for the project will be available from Readers' PCB Services Ltd. The unit will be available as a full kit of parts or built and tested from WKF Electronics. Further details and prices will be given in a later instalment.

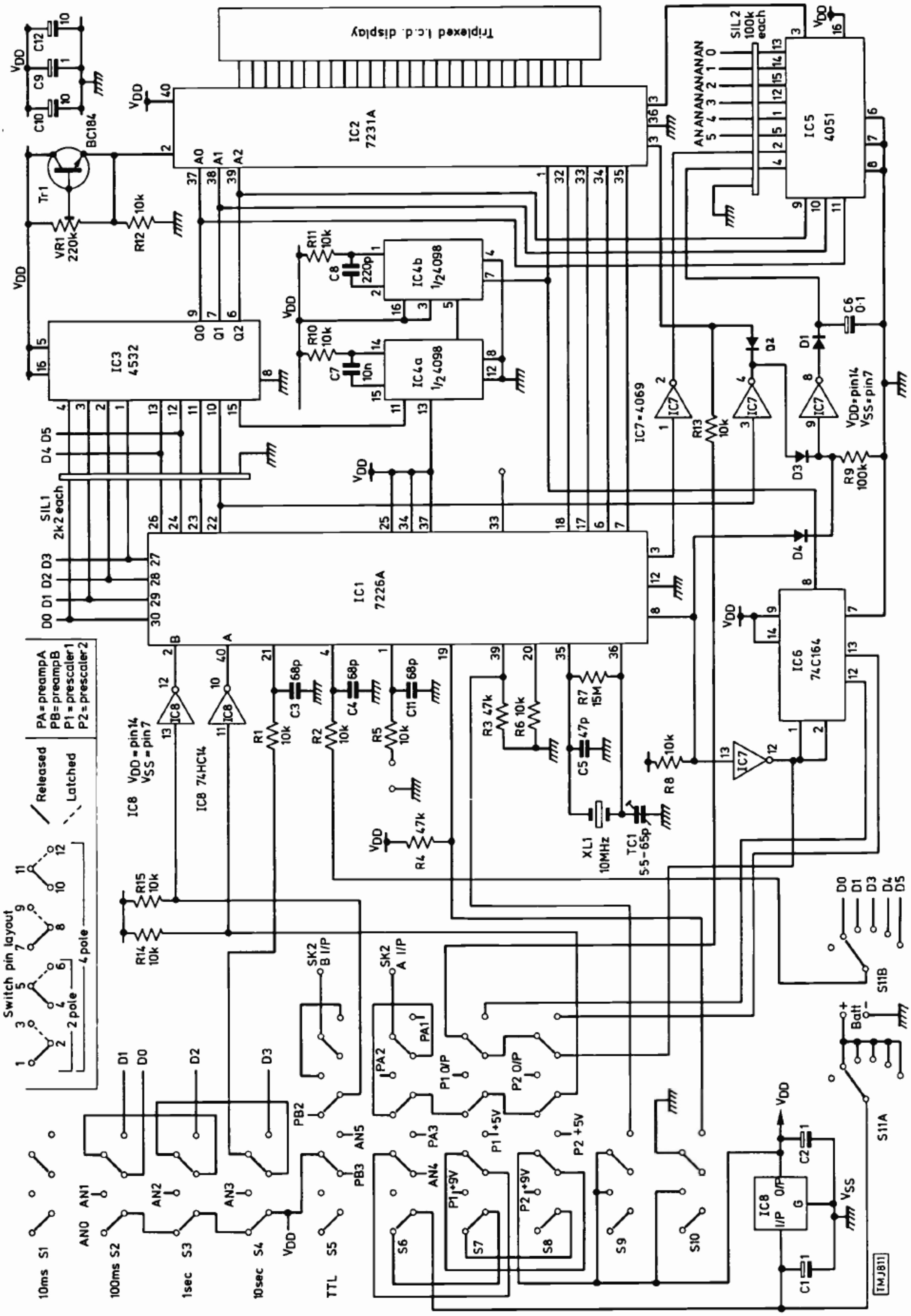

Fig. 6: The switching and logic circuitry.

Digital Counter-Timer

Part 2

Tony Jenkins, G8TBF

WE'LL assume that those contemplating the construction of the frequency counter-timer are proficient at wiring and assembly. The aim of the following notes therefore is to ensure that the unit goes together with the minimum of problems, thus saving both time and frayed nerves.

Construction

Start with the main board. Fig. 7 shows the component layout. First of all fit the two through-board links under IC1 – it's impossible to do so after fitting the i.c. socket. Now install the i.c. sockets, which must be spaced sufficiently away from the board to allow access to the pins requiring top soldering. We suggest that the four corner pins on each socket are soldered first, with only about 1mm. showing on the underside of the board. Next fit the resistors, capacitors, diodes, crystal, etc., making sure that all top-soldered connections are made. Fit the SIL resistor networks with the dot on the body matched to the "1" shown on the PCB. Then fit the transistor and preset, followed by the regulator i.c. which also needs to be secured to the board by its tab with a short 3mm. screw

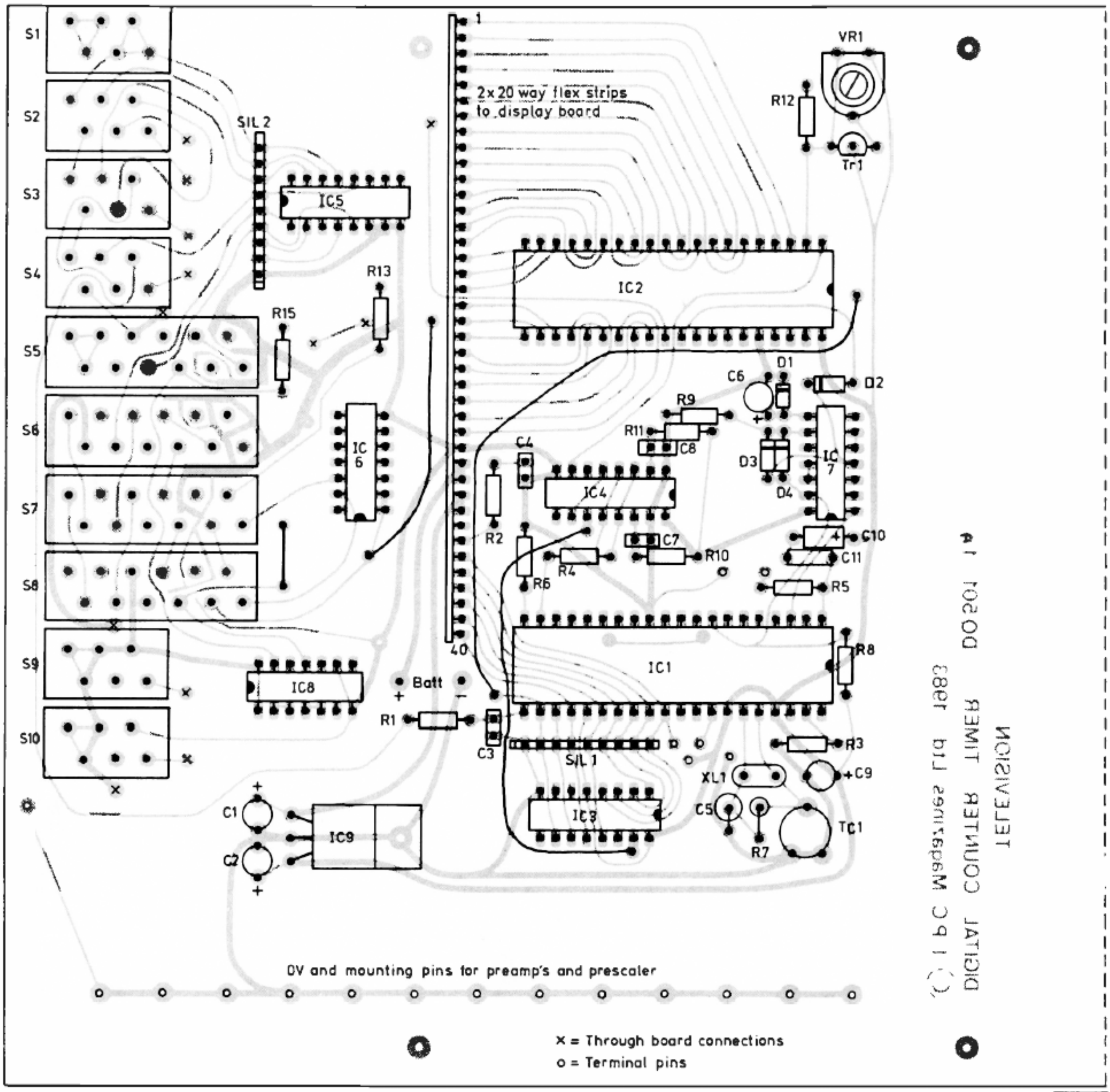

Fig. 7: Main panel component layout.

TMJ905

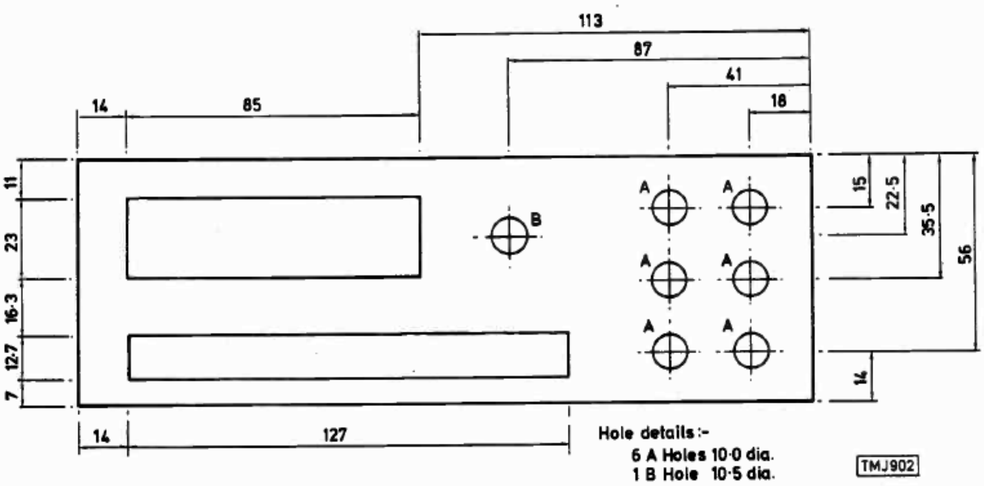

Fig. 8: Front panel cut-outs – dimensions in mm.

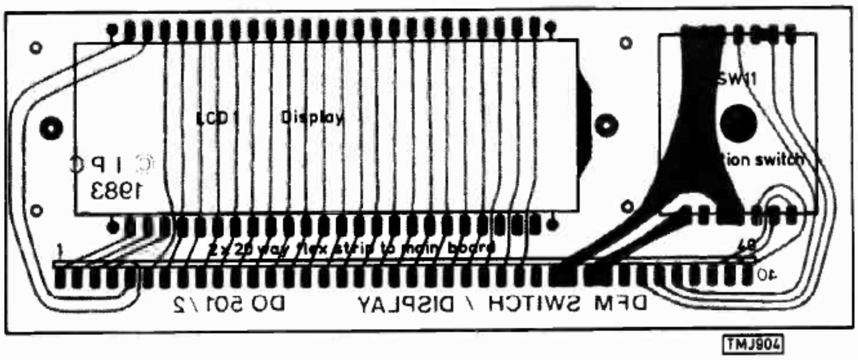

Fig. 9: Display panel layout.

COMPONENT LIST – 2

Prescaler One

Resistors: all 0.25W carbon film, ±5%, except where stated

R1	47R	R5	330R
R2	1k	VR1	10k
R3	10R	miniature horizontal-mounting	
R4	4k7	skeleton preset	

Capacitors:

C1	10n		ceramic plate
C2	22p		ceramic plate
C3-6	10n		ceramic plate
C7-9	1μF	35V	tantalum bead
C10	10n		ceramic plate

Semiconductors:

Tr1	BC183L	IC2	LM2931-Z5·0
IC1	8629		

Miscellaneous Items Required:

Set of p.c.b.s	Printed labels for front panel
I.c. sockets:	4 BNC sockets, single-hole mount, 50Ω
2 40-pin	2 20-way, 85mm Flexstrip jumpers
4 16-pin	Knob for function switch
2 14-pin	Display bezel
1 8-pin	4 3mm screws and washers
Case	PP7 battery

Preamplifiers (each of two units)

Resistors: 0.25W carbon film, ±5% except where stated

R1	1M	R10	220R
R2	100k	R11	220R
R3	10k	R12	47R
R4	22k	R13	470R
R5	150R	VR1	1k
R6	470R	subminiature cermet preset	
R7	47R	VR2	1k
R8	2k2	carbon track preset with knob	
R9	10k		

Capacitors:

C1	100n		polyester
C2	15p		ceramic plate
C3	1μF	35V	tantalum bead
C4	10n		ceramic plate
C5	10n		ceramic plate
C6	10n		ceramic plate
C7	100μF	6V	tantalum bead
C8	10n		ceramic plate
C9	10n		ceramic plate
C10	1n		ceramic plate
C11	1μF	35V	tantalum bead

Semiconductors:

Tr1	3N201
Tr2	BC183L
Tr3	BC183L
Tr4	BC212L

Miscellaneous:
L1 One turn e.c.w. on ferrite bead

and nut. Next fit the terminal pins followed by the remaining through-board links (note that there are two between sections of the switch bank). Finally fit the switch bank.

The next stage is to drill and prepare the front panel. Fig. 8 shows the cut-out details which must be adhered to. Readers purchasing PCBs from Readers' PCB Service will receive a paper template which should ease the task. The March cover showed the suggested lettering, which can be done using a suitable style and size of dry transfer lettering. Protect the finished panel with at least two coats of a suitable spray-on laquer. When the front panel is completed, letter the display bezel in the same way, then fit the bezel on to the front panel.

It's necessary to prepare the front panel prior to the display board since the function switch SW11 is not soldered flat to the board but has to be spaced away from it to provide the correct mounting distance from the front panel. More on that later. Fig. 9 shows the display board component layout. The LCD display has 24 connections on each side. The manufacturers supply it with connector strips which have 26 pins, one spare being located at each end. The socket strips to be soldered into the PCB have 25 pins. So the spare pin at one end of the display connector will go into the socket but the spare pin at the other end will be left floating. As the socket strip pins are offset, ensure that they are mounted the same way round and that the display is offset towards SW11. Then insert the display into the socket strips, making sure that it is correctly orientated and fully seated.

Insert SW11 *but do not solder.* Put the shakeproof washer on the spindle and strip off the antirotation pin (otherwise the switch will not mount flush to the front panel). Locate the whole assembly on the bezel studs, using a nut at each side for positioning. Align the board so that the display is parallel to the bezel, leaving a gap of about 1mm. Fit and tighten the securing nut on SW11, then solder the switch to the board.

The whole assembly can now be removed and the two 20-way flex strips soldered to the copper track side of the display board and then through the main board, remembering to solder the top and bottom. The flex strips are supplied cut to size, so don't insert farther than necessary through either PCB or the display may not reach the front panel. After fitting the i.c.s and the battery lead (we suggest using a PP7 battery) the assembly can be tested.

On initially switching on the display should show 00000000 with the "measurement in progress" (MIP) flag flashing. The annunciator flags should change according to the range selected. If all is in order the assembly can be put into the case – after the input sockets and offset controls have been mounted on the front panel.

The earth tags on the input sockets should be linked together, with a short lead attached for connecting to the main board. Likewise the pins at the anticlockwise end of the offset controls.

Corrections

Finally this month some corrections to Part 1. An i.c. pin number was omitted from Fig. 6: pin 5 of IC4b is connected to pin 10 (the missing number) of IC4a. Incorrect type numbers were given for the two 5V regulator i.c.s: IC9 (incorrectly shown as IC8 in Fig. 6) is type LM2931-T5·0 and IC2 (prescaler 1) type LM2931-Z5·0.

TO BE CONTINUED

Frequency Counter-Timer

Part 3

Tony Jenkins, G8TBF

This month we'll deal with completion of the construction of the basic unit. Prescaler 2 will be the subject of an article to follow later.

The component layout for the preamplifiers is shown in Fig. 12. When connecting these up the input and output cable screens are connected at the preamplifier PCB only.

Fig. 10 shows the prescaler 1 component layout. The input is fed from the 200MHz input socket via a short length of 50Ω coaxial cable. The screen of the output lead is connected at the prescaler board only.

The final task is to interconnect the whole unit. Fig. 11 shows the interwiring and connection details for the complete assembly, with the exception of prescaler 2 which has to be mounted inside a diecast box. Both preamplifiers and prescaler 1 are mounted by soldering the ground planes to the row of earth pins along the side of the main board. The input and offset grounds are connected to the front pin. Check all wiring carefully before applying power.

Setting up

VR1 on main board: This is the l.c.d. drive control. Adjust for a well contrasted display without the unwanted segments being visible.

TC1 on main board: This sets the counter chip's clock frequency and has to be accurately adjusted with a known frequency source since it determines the accuracy of the unit. The best source available to service engineers is a CTV's reference oscillator when this is locked to an off-air signal. This is specified by the broadcasting authorities as 4·43361875MHz ± 1Hz, which is pretty accurate! Adjust the trimmer to give the correct display.

VR1 on the preamplifier boards: This compensates for spreads in the MOSFET's pinch-off voltage (Tr1). Adjust for 2·5V at the collector of Tr2 with the input socket shorted to chassis.

VR1 on the prescaler 1 board: This sets the transistor's operating point. With the 200MHz input shorted to chassis, adjust for 2·5V at the collector of Tr1.

The instrument is now ready for use.

A separate article on prescaler 2 is in preparation. This extends the instrument's capability to around 2GHz. We plan to publish the article in the near future.

WKF Electronics inform us that they are able to supply a complete kit of parts for the project (excluding prescaler 2) for £170·49. Alternatively the instrument can be

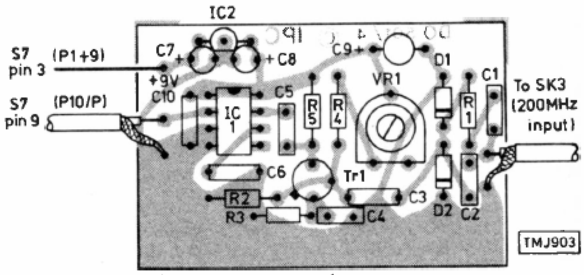

Fig. 10: Prescaler 1 component layout.

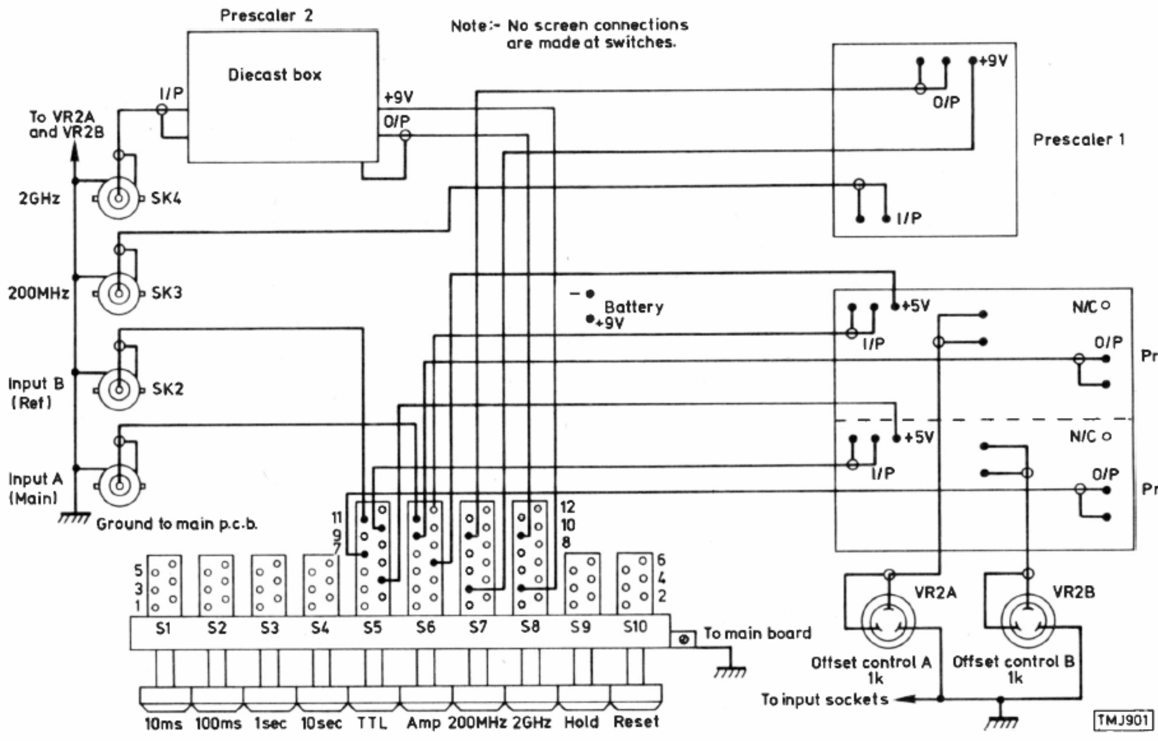

Fig. 11: Interwiring for the complete assembly.

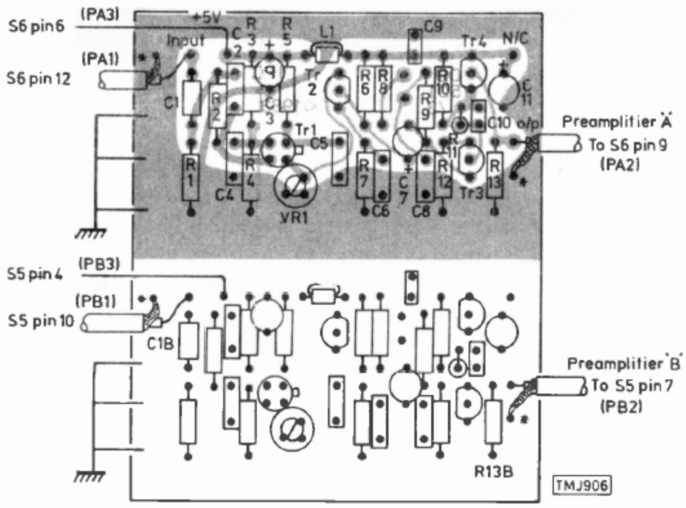

Fig. 12: Preamplifier component layout.

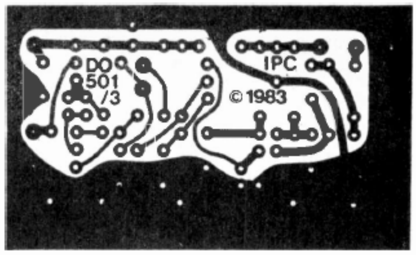

Fig. 13: Preamplifier board pattern.

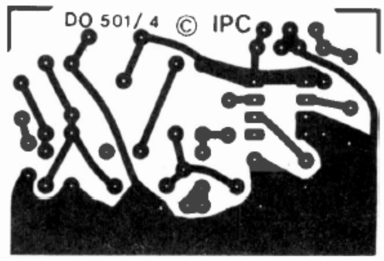

Fig. 14: Prescaler 1 board pattern.

bought fully built and tested for £190·49. Both prices are inclusive of postage, packing and VAT. The main board DO501/1 is available from Readers' PCB Service at £15 while the other boards are available at £1 each. In both cases the address is Fleet House, Welbeck Street, Whitwell, Worksop, Notts.