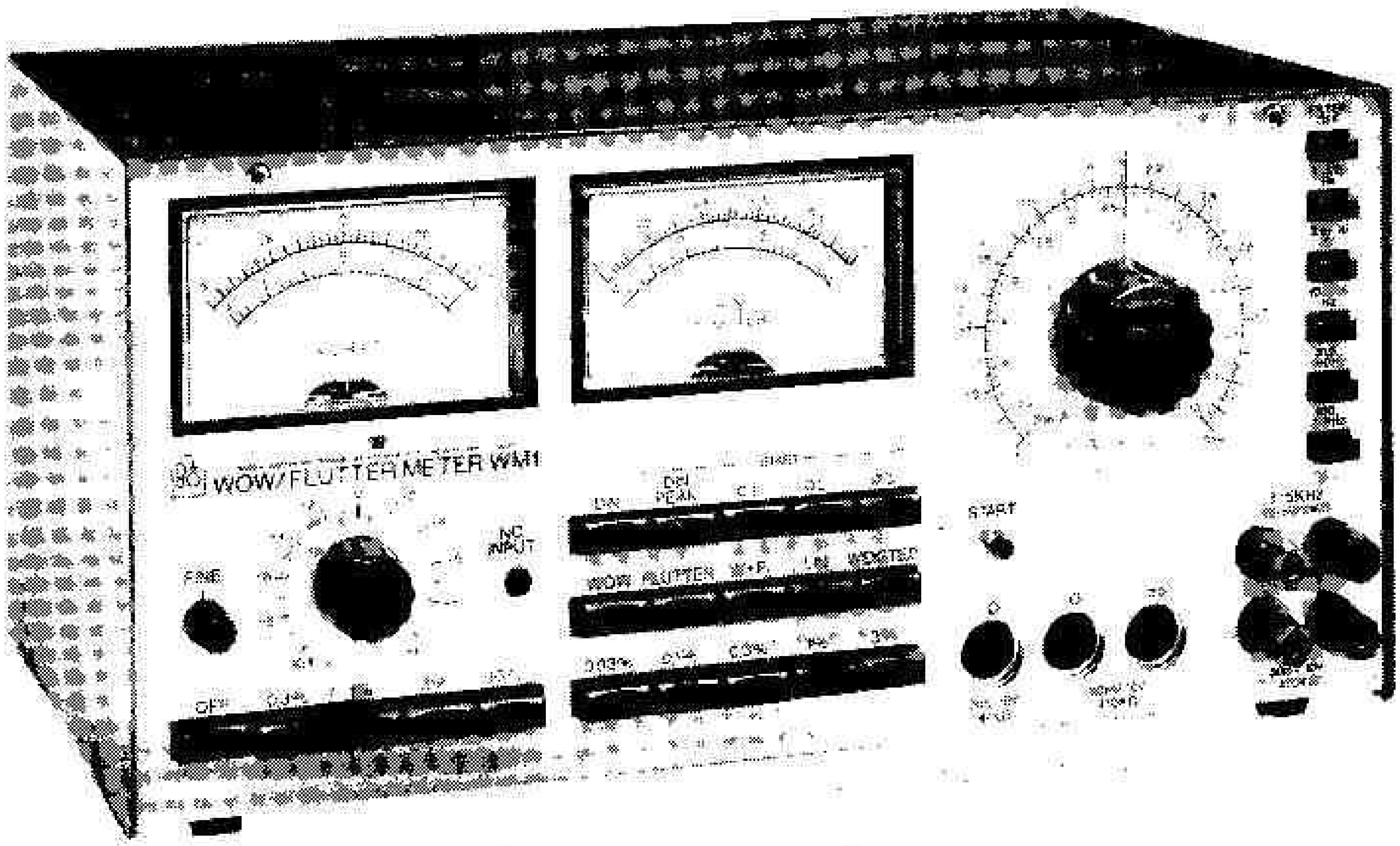


CONTENTS

TECHNICAL DATA

Oscillator:

CURVE SHAPE:	Sine-wave
FREQUENCY:	3.15 kHz
Stability:	Approx. 5×10^{-5} within 8 hours Approx. 5×10^{-4} within 1 year
OUTPUT:	
Voltage (EMF):	Approx. 100 mV_{rms}
Impedance:	10 kΩ

Drift Meter:

RANGE:	±0.316%, ±1%, ±3.16% and ±10%
Accuracy:	±3% of full scale
OFF-SET (calibrated):	0...±10%

Wow/Flutter Meter:

RANGE:	±0.0316%, ±0.1%, ±0.316%, ±1% and ±3.16%
Accuracy:	±3% of full scale

Filters:

WOW:	0.2 ... 10 Hz (−3 dB)
FLUTTER:	10 Hz ... 300 Hz (−3 dB)
LIN:	0.2 ... 300 Hz (−3 dB)
WEIGHTED:	Acc. to DIN 45 507, IEC 386, CCIR 409 and IEEE 193

Meter Circuit:

DIN:	Acc. to DIN 45 507, IEC 386, CCIR 409 and IEEE 193
DIN PEAK:	Acc. to DIN 45 507 Meter reads and automatically retains highest wow/flutter peak value occurring within measuring time of approx. 30 sec.
σ1, σ2, σ3 .	Meter reads and automatically retains highest wow/flutter peak value occurring but excludes random peaks occuring in less than 32% (σ1), 4.5% (σ2) and 0.26% (σ3) of measuring time (5 sec).

Frequency Analyser:

RANGE:	1 Hz ... 316 Hz in 5 ranges: 1 Hz ... 3.16 Hz, 3.16 Hz ... 10 Hz, 10 Hz ... 31.6 Hz, 31.6 Hz ... 100 Hz and 100 Hz ... 316 Hz
BANDWIDTH:	10% (−3 dB)
OCTAVE ATTENUATION:	40 dB
LINEARITY:	
Frequency:	Better than ±5%
Amplitude:	Better than ±1 dB
REMOTE (Option):	
Control voltage:	0 ... +10 V in all ranges (linearity better than ±5%)
Input impedance:	Approx. 10 kΩ

Inputs:	Common to drift, wow and flutter Automatic indication (»NO INPUT«) at too-low input voltage, simultaneously with switching the internal reference oscillator on.
PHONO, LOW-IMPEDANCE:	5-pole DIN
Voltage:	3 mV … 10 V
Impedance:	47 kΩ ±5%
PHONO, HIGH-IMPEDANCE:	5-pole DIN
Voltage:	30 mV … 10V
Impedance:	470 kΩ ±5%
TAPE:	5-pole DIN
Voltage:	30 mV … 10 V
Impedance:	470 kΩ ±5%
Outputs:	
DRIFT:	BNC
Voltage:	±1 V DC ±3% at full scale
Impedance:	10 kΩ ±1%
WOW/FLUTTER, AC:	BNC
Voltage:	1 VAC ±3% at full scale
Impedance:	10 kΩ ±1%
WOW/FLUTTER, DC:	BNC
Voltage:	1 V DC ±3% at full scale
Impedance:	10 kΩ ±1%
Remote (Option):	37-pole multiconnector All functions and ranges remotely controllable (TTL-compatible)
Power Supply:	110/220 VAC ±10%, 50 … 400 Hz
Power consumption:	Approx. 10 W
Temperature Range:	0 … 50° C
Dimensions:	
Width:	323 mm
Depth:	210 mm
Height:	160 mm
Weight:	5.7 kg (12.6 lbs)
Finish:	Silver grey and blue enamel
Accessory:	1 instruction manual 1 cable, 5-pole DIN/5-pole DIN
Option 1:	Remote control
Option 2:	Crystal oscillator instead of built-in RC oscillator

Subject to change without notice

INTRODUCTION

The B&O Wow/Flutter Meter WM1 is a combination instrument specially designed for use in testing and repairing record players, tape recorders and other recording and playback equipment.
It is essentially composed of:

1. Driftmeter for measurement of speed deviations within the range 0 ... ±20% in relation to a built-in 3.15 kHz reference oscillator.

2. Wow/flutter meter for measurement of wow (0.2 Hz ... 10 Hz), flutter (10 Hz ... 300 Hz) or wow plus flutter (0.2 Hz ... 300 Hz). Measurement may be carried but linearly, weighted according to DIN 45507, IEC 386, CCIR 409, IEEE 193 or according to a statistical normal distribution (sigma).

3. Spectrum analyser for checking the wow and flutter spectrum within the frequency range 1 ... 316 Hz.

On the back of the instrument are outputs for connections of oscilloscope, ink-recorder, analyser or other type of monitor.

OPERATION

The Wow/Flutter Meter WM1 is factory prewired for 220 V ±10% mains voltage but can easily be modified for 110 V ±10% by wiring the two 110 V primaries of the power transformer in parallel (Fig. 1).

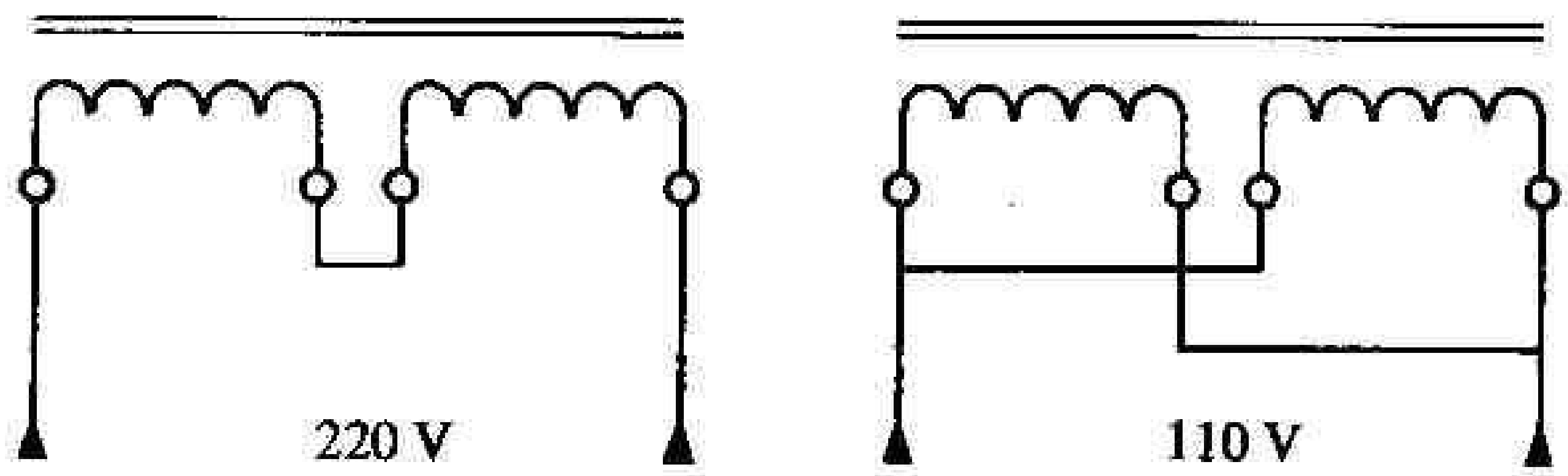


Fig. 1. Modification for 110 V mains voltage.

The mains plug is intended for a special type of outlet with protective earth terminal (»schuko«) but may just as well be plugged into a conventional wall outlet although this will cause the cabinet to float.

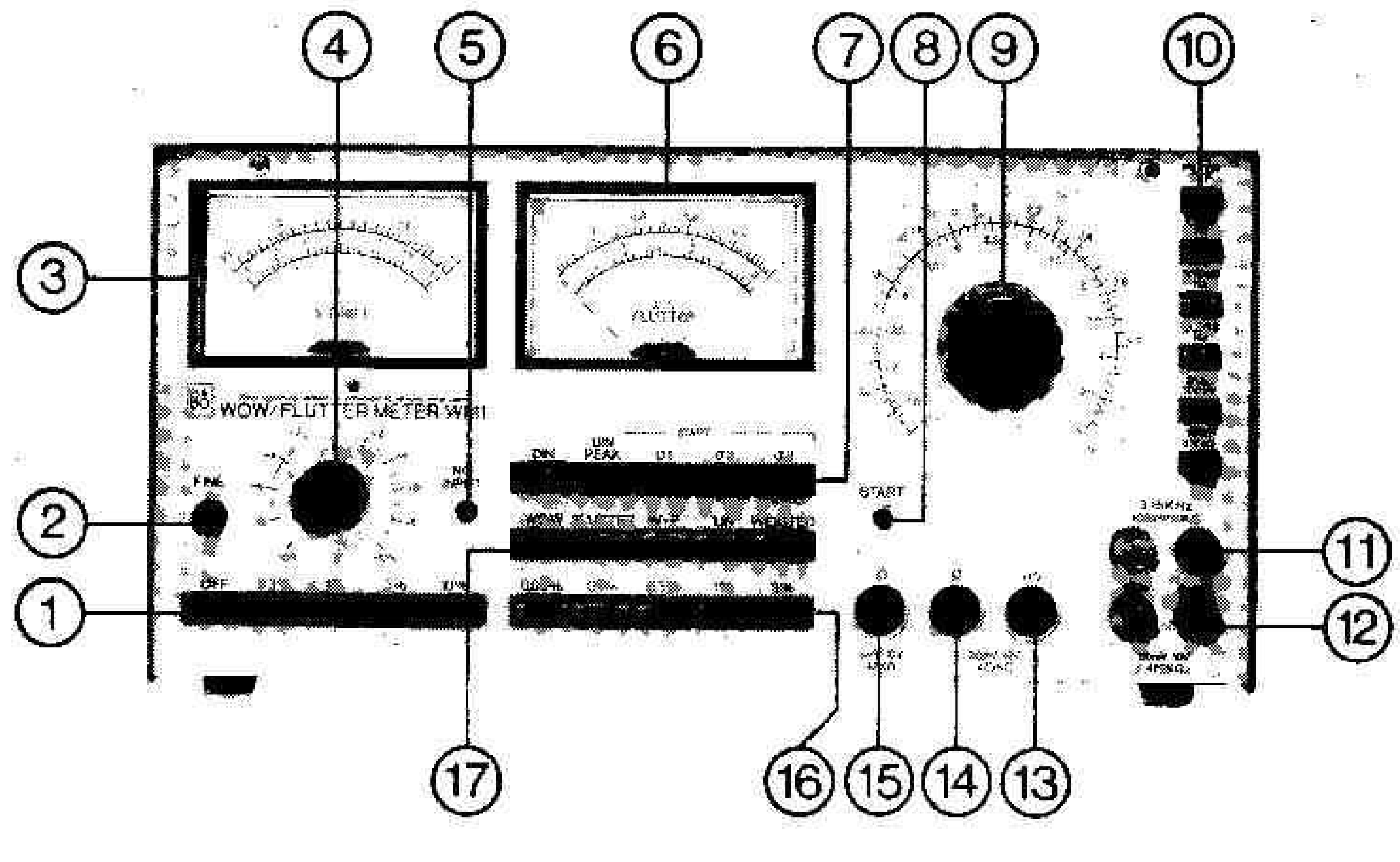


Fig. 2. Front view of Wow/Flutter Meter WM1.

The operation of the instrument appears in broad outline from the following and from Figs. 2 and 3.

1. On/off switch and drift range switch.
2. Drift-offset (speed deviation) fine adjustment. Adjustment range is approx. ±0.1%.
3. Moving-coil meter for reading drift (speed deviation) in %.
4. Drift-offset (speed deviation) adjustment. Adjustment range is approx. ±10% (ref. 3.15 kHz).
5. Input voltage indicator. Lamp lights up if input voltage is too low.
6. Moving-coil meter for reading wow and flutter in %.
7. Meter circuit selector.
8. Pushbutton to start measuring cycle with DIN PEAK, $\sigma 1$, $\sigma 2$, or $\sigma 3$ pushbutton depressed.
9. Frequency dial for spectrum analyser.
10. Switch for selecting frequency range of spectrum analyser.
11. Reference oscillator output (3.15 kHz rms).
12. High-impedance connection for record players, tape recorders and other recording/playback equipment not equipped with 5-pole DIN connector.
13. High-impedance DIN connector for tape recorders and other recording/playback equipment.
14. High-impedance DIN connection for record players with built-in RIAA amplifier.
15. Low-impedance DIN connection for record players without built-in RIAA amplifier.
16. Wow and flutter range selector.
17. Switch for selecting filter characteristic for wow and flutter and switch for selecting linear or weighted filter characteristic.

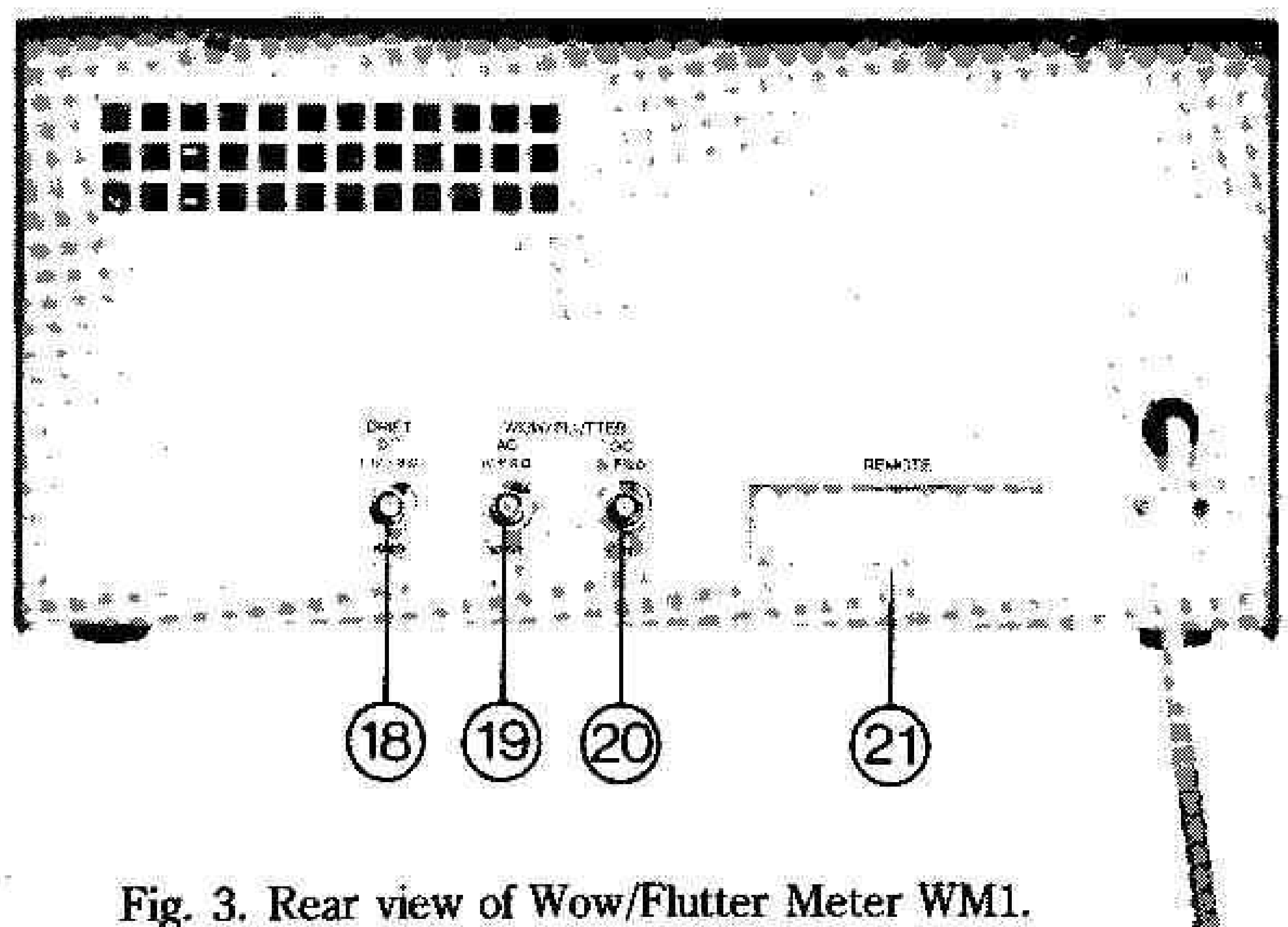


Fig. 3. Rear view of Wow/Flutter Meter WM1.

18. Analog meter output drift (speed deviation). Output voltage is proportional to deflection of DRIFT meter (±1 V at full scale).

19. Analog AC output for wow and flutter. Output voltage is proportional to deflection of FLUTTER meter (1 V at full scale).

20. Analog DC output for wow and flutter. Output voltage is proportional to deflection of FLUTTER meter (1 V at full scale).

21. Remote control (option). All functions and ranges can be remotely controlled through a 37-pole multiconnector (TTL compatible).

Preparing for Use

The instrument is switched on by depressing one of the drift range buttons (1). The NO INPUT indicator lamp (5) will then light up. Also, the internal reference oscillator is automatically connected to the input, enabling easy zeroing of the DRIFT meter (3) by means of the FINE potentiometer (2) and, if necessary, the DRIFT-OFFSET potentiometer (4). However, such adjustment should not be carried out until after the instrument has had power applied to it for approx. 15 min.

Connection

The instrument under measurement (record player, tape recorder etc.) is connected to one of the three DIN inputs. Record players without built-in RIAA preamplifier are connected to the ⚬ 47 kΩ input (15). Record players with built-in RIAA preamplifier are connected to the ⚬ 470 kΩ input (14). Tape recorders are connected to the ⚬⚬ input (13). If the instrument under measurement has no provision for DIN connection, the input provided with terminal screws (12) should be used. The built-in reference oscillator is wired to pins 1 and 4, the ⚬⚬ input (13) and to the 3.15 kHz terminals (11).

Measurement of Drift (Speed Deviation) on Record Players

A test record according to DIN 45545, such as a B&O 3621016, should be used as reference. The record player is connected to one of the ⚬ inputs (14) or (15). The NO INPUT indicator lamp (5) will then turn off if the input signal is large enough. If it is not large enough it will be necessary to connect the record player through a preamplifier.
The desired range is selected with the pushbutton switch (1), and absolute drift (speed deviation) can then beread on the DRIFT meter (3).
The relative (short-term) speed deviation can be measured all the way down into the most sensitive range (0.3%) by correcting the zero adjustment with the DRIFT OFFSET potentiometer (4) provided the absolute speed deviation is less than ±10%.

Measurement of Drift (Speed Deviation) on Tape Recorders

A prerecorded 3150 Hz test tape, such as a B&O 6780037, should be used as reference. The record player is connected to the ⚬⚬ input (13) or (12).
The same measuring procedure as for record players.

Measurement of Wow and Flutter on Record Players

A test record according to DIN 45545, such as a B&O 3621016, should be used as reference.
The desired range is selected with the pushbutton switch (16). The filter function switch (17) is set to the W+F (wow + flutter) and WEIGHTED positions. The meter circuit switch (7) is set to the DIN position. The analyser range switch (10) is set to the FILTER OFF position.
The weighted wow and flutter can then be read on the FLUTTER meter (6). Measurement should be carried out for not less than 30 sec. Within this period the maximum deflection should be read.
The meter deflection often fluctuates and therefore is difficult to read correctly. The WM1 therefore incorporates a special circuit which is capable of automatically retaining the maximum deflection within the above-mentioned measuring time of 30 sec. The automatic circuit is cut in by setting the meter circuit

switch (7) to DIN PEAK instead of DIN and depressing the START pushbutton (8). After approx. 30 sec the FLUTTER meter will deflect to the maximum value which occured during the measuring period. The meter needle will remain at that value (for several minutes). When another measuring period is started, the nedle returns to zero.

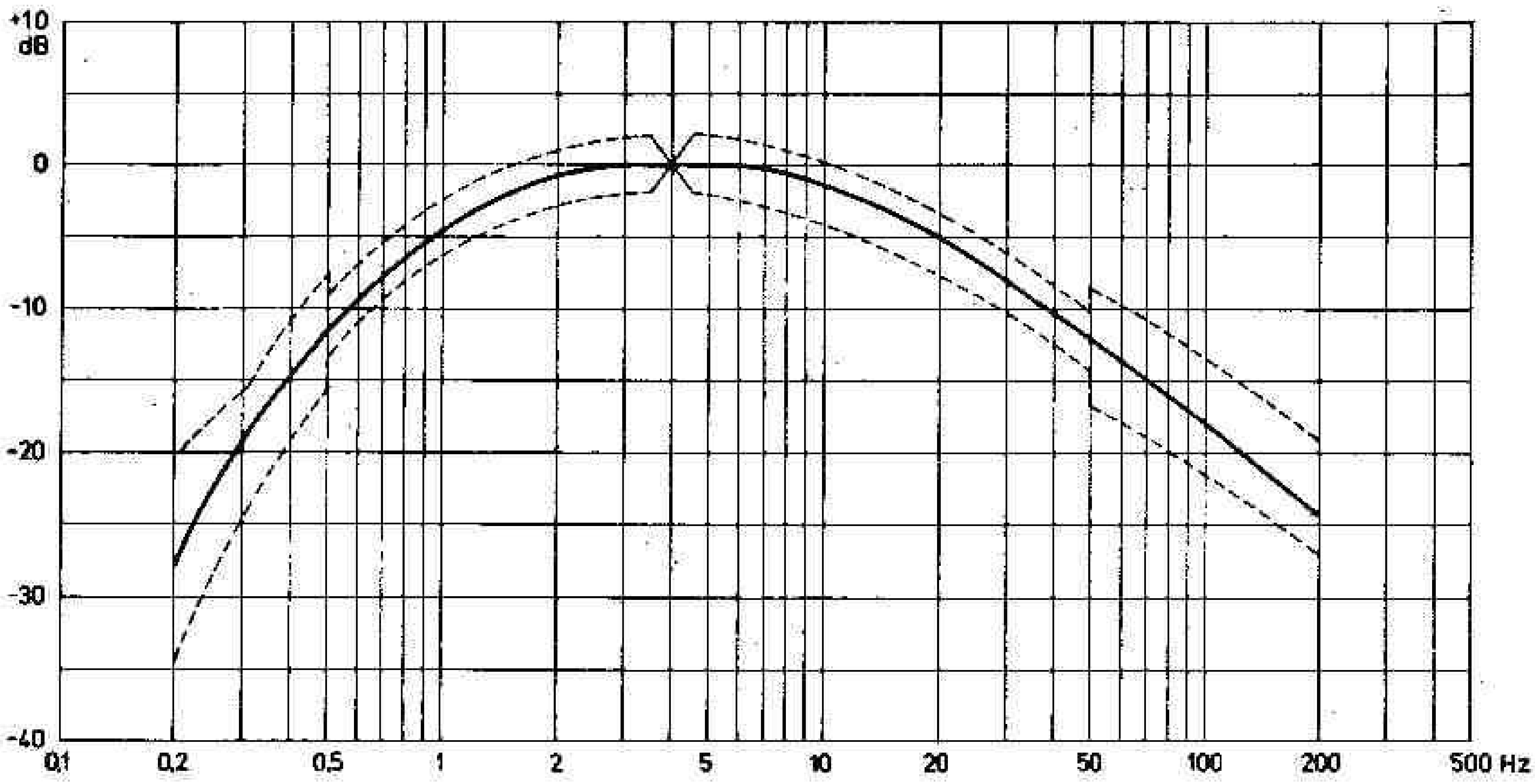


Fig. 4. Wow and flutter filter weighted (WTD).

Accordingly, the results of a DIN and a DIN PEAK measurement are basically the same for one and the same record player.
Because of the WM1's low lower limiting frequency it takes approx. 3 sec for the FLUTTER meter to come to rest after function and range switching. The START button therefore should not be depressed until 3 sec after each switching operation.

Measurement of Record/Playback Wow and Flutter on Tape Recorders

A standard tape according to DIN 45513, such as a B&O 6780043 (Fe_2O_3) or 6780040 (CrO_2), is inserted in the tape recorder whereafter a 3150 Hz signal is recorded at a recording level of VU = 0 dB. The generator incorporated in the WM1 is employed for this purpose. The signal from it is automatically applied to the tape recorder via pins 1 and 4 of the ѻѻ input (13) or, as the case may be, the 3.15 kHz terminal screws (11). Recording is carried out for approx. 2 - 3 min., followed by switching to playback. The weighted wow and flutter can now be read on the FLUTTER meter (6), following the directions given under tape recorders.

Measurement of Playback Wow and Flutter on Tape Recorders

A prerecorded 3150 Hz test tape is used as reference, e.g. a B&O 6780037. The weighted wow and flutter may then be read on the FLUTTER meter (6), following the directions given under record/playback measurement.
Measurement of playback wow and flutter should not be employed when laying down specifications but is perfectly acceptable in frequency analysis of the wow and flutter spectrum.

Measurement of Wow and Flutter on Record Players and Tape Recorders, Corrected According to a Statistic Normal Distribution

In measurements of wow and flutter according to DIN 45507, IEC 386, CCIR 409 and IEEE 193, the FLUTTER meter deflection, as previously mentioned, often is very irregular. This is because the signal is composed of varying frequencies of more or less constant amplitude, noise pulses, mains-voltage

transients etc. Also, the instrument under measurement is often affected mechanically by small jolts and vibrations from the environment. It can therefore seem a little »unjust« if the result of the measurement is too adversely affected by once-only phenomena basically unrelated to wow and flutter on the instrument under measurement.
To remedy this, the WM1 incorporates a special meter circuit which more or less excludes these once-only phenomena in regard to a statistic normal distribution so that measurements become more uniform.

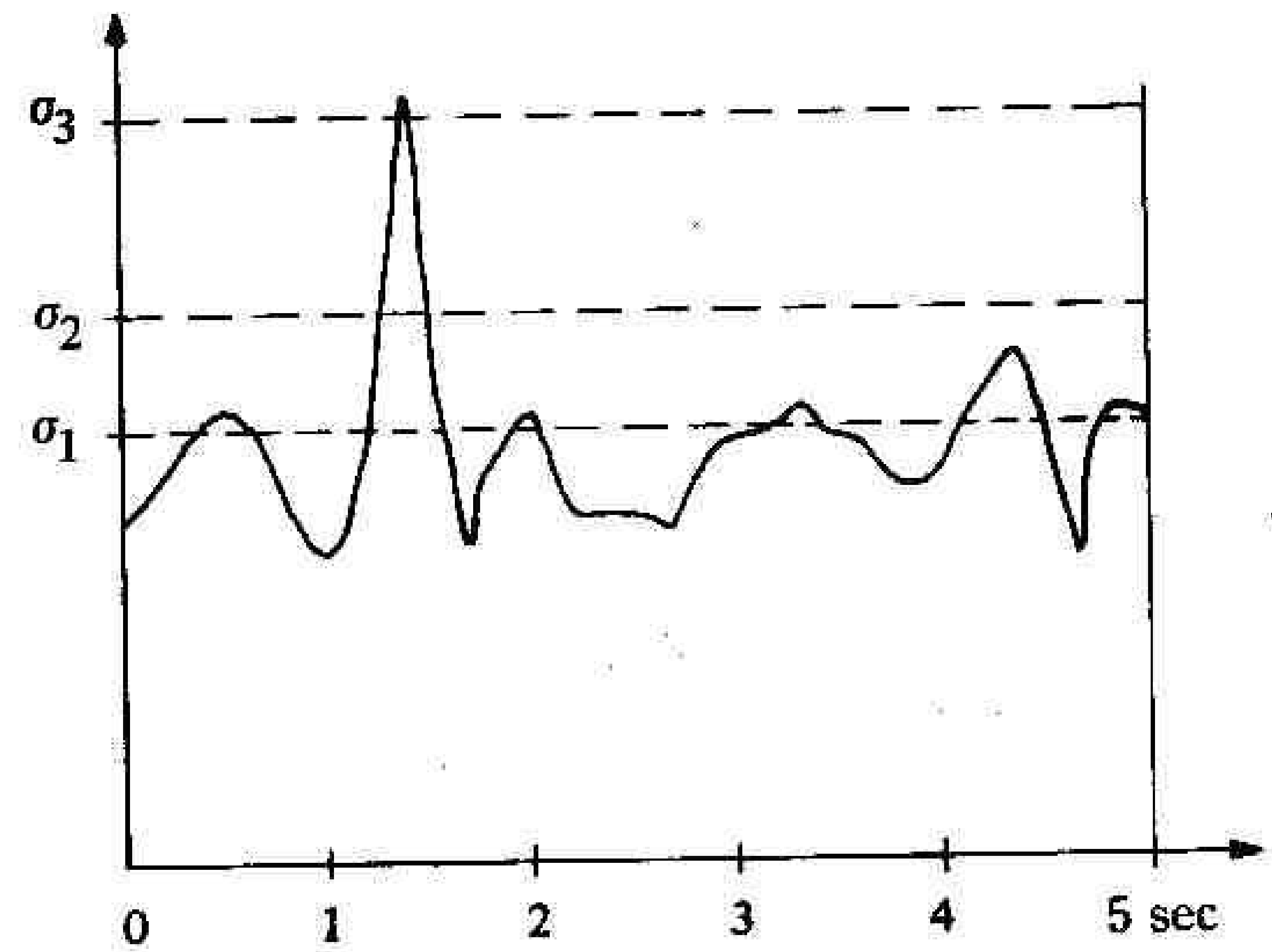


Fig. 5. Sigma meter circuit (σ)

The meter circuit selector (7) provides a choice of σ1 (32%), σ2 (4.5%) and σ3 (0.26%). To measure according to say σ2 (see Fig. 5), the following procedure is employed:
The meter circuit switch (7) is set to the σ2 position. The START pushbutton is operated. After approx. 5 sec. the FLUTTER meter (6) will deflect to a value that was exceeded for approx. 5% of the time of the measurement – that is, for approx. 0.25 sec. In other words: Random peaks occurring during less than 5% of the time of the measurement are not included in the result.
In practice, results of measurements when using the σ2 circuit are in fairly good agreement with results when using the DIN and DIN PEAK circuits.

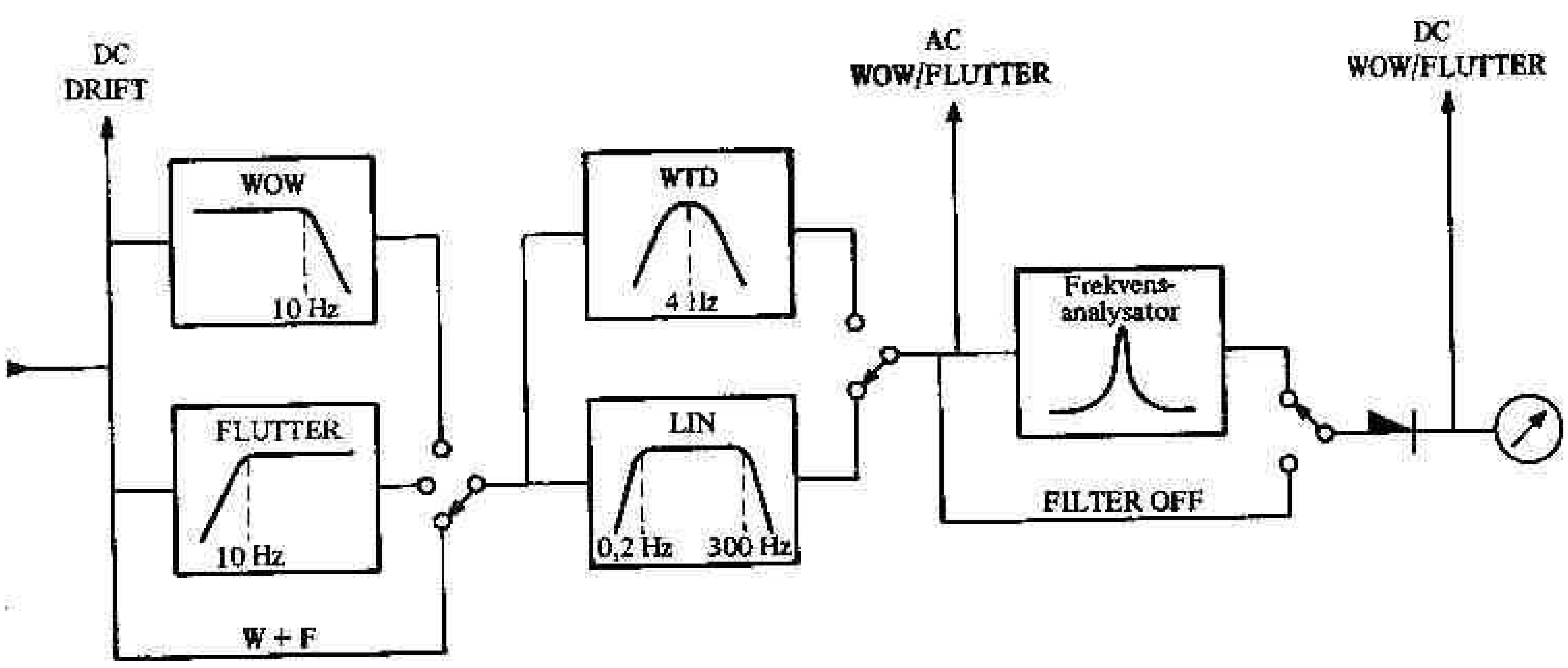


Fig. 6. Block diagram of the filter section of the WM1.

Analysis of the Wow and Flutter Spectrum

In fault-finding work on record players and tape recorders in regard to wow and flutter, being able to make the right diagnosis is very important. This can be quite difficult if not impossible when using the

previously described measuring methods. To make such a diagnosis it is necessary to be able to measure the dominant frequencies selectively – that is, separately.
The WM1 incorporates a number of filters specially intended for such analysis of the wow and flutter spectrum (Fig. 6).
The frequency spectrum can be divided into wow and flutter depressing the WOW and FLUTTER buttons of the filter function switch (17). The crossover frequency is 10 Hz. Wow thus is defined as the frequencies below 10 Hz; and flutter is defined as the frequencies above 10 Hz (Fig. 7). The weighted filter is switched off by setting the filter function switch (17) to the LIN position, providing linear measurement of the frequency spectrum.

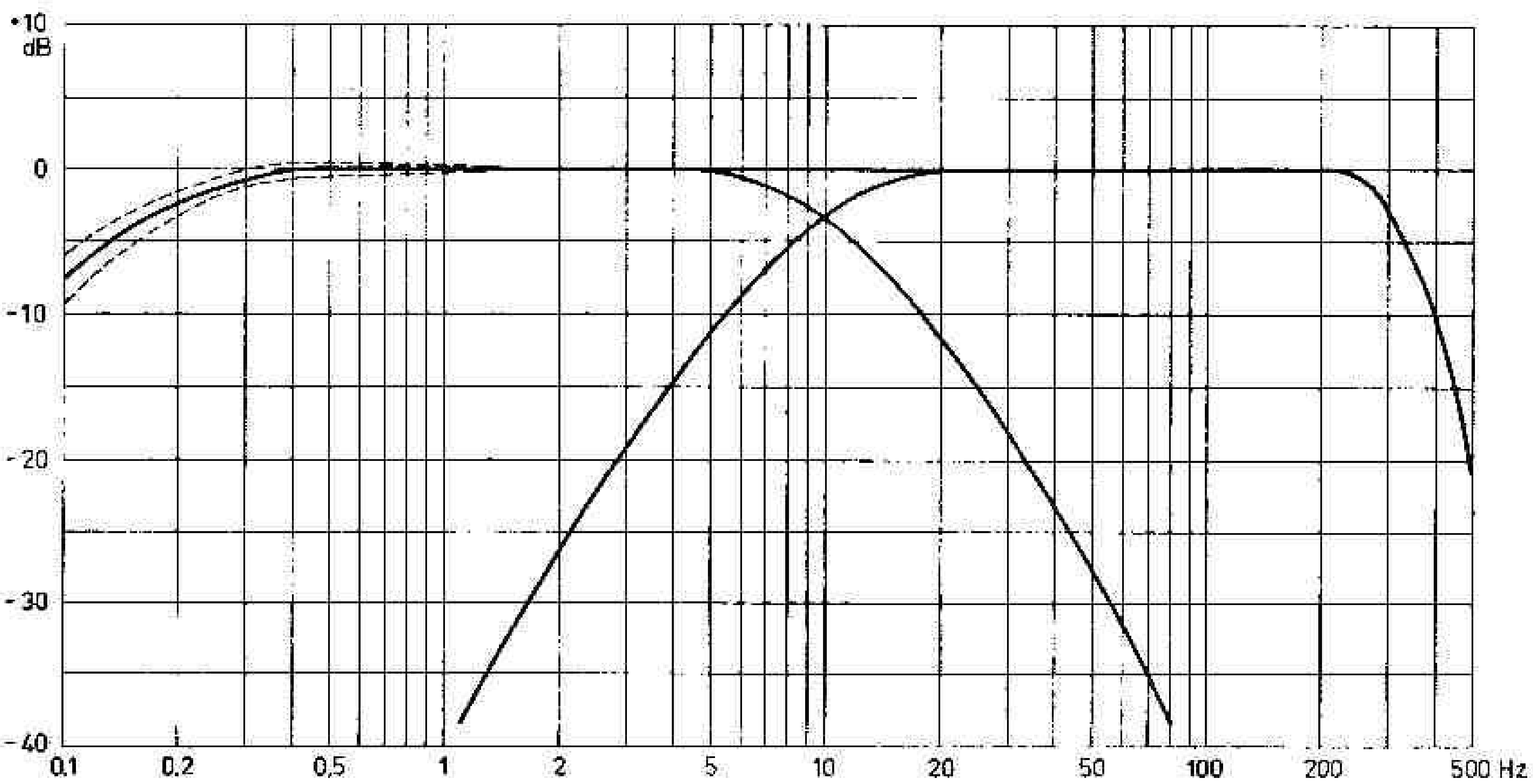


Fig. 7. Wow and flutter filter, linear (WOW, FLUTTER and W+F).

The wow and flutter spectrum is measured with the frequency analyser (9) and (10) which is a selective variable bandpass filter having a frequency range of 1 Hz ... 316 Hz. This filter makes it possible to determine which wow and flutter frequencies are dominant and to predict, on the basis of this knowledge, which rotating components – idlers, belt drive, motor, bearings etc. – should be repaired or replaced as the case may be. The manufacturer of the instrument in question is normally willing to supply information about the connection between the dominant frequencies and the rotating components. Note that the filter is relatively sluggish in the lowest ranges (1 ... 3.16 Hz and 3.16 ... 10 Hz), due to its high Q. Hence the filter should be varied slowly in these ranges so that it will have time to »swing« into place.

Monitor Outputs (Fig. 6)
On the back of the WM1 are three BNC outputs for oscilloscope, ink-recorder, analyser or some other form of monitor:

1. The DC DRIFT output voltage is analogous to the DRIFT meter (3) deflection and is equal to ±1 V DC at full scale.
2. The AC WOW/FLUTTER output voltage is analogous to the FLUTTER meter (6) deflection and identical to the wow and flutter signal before the frequency analyser (see Fig. 6). The WOW, FLUTTER, WTD and LIN filters may thus be employed in conjunction with this output. For sine-wave modulated wow and flutter the output voltage is equal to 1 VAC at full scale.
3. The DC WOW/FLUTTER output voltage is analogous to the FLUTTER meter (6) deflection and identical to the rectified signal after the meter circuit (Fig. 7). The output voltage is equal to 1 V DC at full scale.

Pin No.	Designation	Function (see Figs. 2 and 3)	Remark
1			Not connected
2	DRIFT OFFSET	(4)	Control voltage: ±1 V/%
3	START	(8)	
4	0.03%	WOW/ FLUTTER range (16)	
5	0.1%		
6	0.3%		
7	1%		
8	3%		
9	0.3%	DRIFT range (1)	
10	1%		
11	3%		
12	10%		
13	DIN	Meter circuit(7)	
14	DIN PEAK		
15	σ 1		
16	σ 2		
17	σ 3		
18	WOW	Filter function (17)	
19	FLUTTER		
20		Chassis	
21	DRIFT DC	Analog output (18)	± 1 V DC at full scale
22	WOW/FLUTTER	Analog output (19)	1 V AC at full scale
23	WOW/FLUTTER	Analog output (20)	1 V DC at full scale
24		Analyser frequency (9)	Control voltage, V_c=0...+10V $f_u = (1 + 0.216\ V_c)\ f_n$ f_l = lower filter frequency in range of interest
25	NO INPUT	Level indicator	High (on): + 15 V Low (off): − 15 V Load: max. 470 kΩ
26			Not connected
27			Not connected
28			Not connected
29	FILTER OFF	(10)	
30	1 ... 3.16 Hz	Analyser frequency range (10)	
31	3.16 ... 10 Hz		
32	10 ... 31.6 Hz		
33	31.6 ... 100 Hz		
34	100 ... 316 Hz		
35	WTD	Filter function (17)	
36	LIN		
37	W + F		

Remote Control

The WM1 is prepared for remote control of all functions and ranges. If this facitily is desired, the instrument should be sent to the factory at Struer, Denmark, for installation of a number of control circuits and a 37-pole connector, REMOTE (21).

The meaning of the individual pins of the REMOTE connector (21) appears from the table. The functions and levels listed are activated at »high« level (3, 4 ... 15 V) and not activated at »low« level (0 ... 0.4) unless otherwise specified.

CIRCUIT ANALYSIS

The Wow/Flutter WM1 consists broadly of the following sections:

(1) Input stage (3.15 kHz)
(2) Frequency detector (0.2 Hz ... 300 Hz)
(3) Filters (wow, flutter and weighted)
(4) Meter circuit according to DIN 45507, sigma circuit, and start-up automatic control circuit.
(5) Frequency analyser (1 Hz ... 316 Hz)

Input stage. The input signal passes through the emitter follower TR1 and is thereafter stepped up by a factor of approx. 230 in the AC amplifier consisting of TR2, TR3 and TR4.

Then follow a 3rd-order highpass filter buffered by TR5 and a 3rd-order lowpass filter buffered by TR6. These filters constitute a 6th-order bandpass filter with 3150 Hz as centre frequency. Unwanted frequencies are thus prevented from reaching the detector circuit.

Fig. 8 Block diagram.

The signal is limited by D3 and D4, whereafter TR11 and TR12 match the level to the Schmitt trigger IC2A. The square-wave pulses at the output of IC2A are differentiated across capacitors C20 and C21. Furthermore, a doubling of frequency is obtained by means of the two NOR-gates IC1A and IC1B.

Automatic cut-in of the internal oscillator. When the input signal is too low, the internal oscillator switches on automatically. The Schmitt trigger IC2B senses on the peak-rectified input signal and controls TR15, which turns on the NO INPUT lamp on the front panel simultaneously with TR14 going on. TR14 in turn controls FET switches TR23 and TR92, which feed the external or the internal signal, respectively, to IC2A.

AGC control. Overdriving at powerful input levels is prevented by an AGC circuit comprising TR7 ... TR10 such that the signal is first rectified and smoothed by TR8, C17 and C18 whereafter it, via the buffer, controls TR10 which clamps the signal to chassis potential between C2 and C3.

Frequency detector. The frequency detector consists of a monostable multivibrator followed by a 5th-order Butterworth lowpass filter which attenuates the fundamental by approx. 120 dB (the fundamental after doubling is 6.3 kHz). The filter's 3 dB frequency is 300 Hz, and its output level will be proportional to the immediate number of input pulses arriving from the monostable multivibrator. At the filter output it will therefore be possible to register frequency variations having a bandwidth of 300 Hz. To ensure stable amplitude of the pulses from the monostable multivibrator the signal is shaped by TR17. The lowpas filter is composed of a 1st-order section (IC5) and two 2nd-order sections (IC6A and IC6B). Offset adjustment of drift is carried out via the inverting input of IC5.

DC and AC attenuators. From the output of the lowpass filter the signal is fed to the DC and AC attenuators, respectively, controlled by means of FET switches. IC7 is buffer and output amplifier for the DC signal. The output signal is ± 1 V, corresponding to full-scale deflection on the drift meter. Before the AC signal passes through the attenuator, its DC component is filtered off by C33 and C34 which combine with R82 to form a time constant that is sufficiently large to secure a total lower band limit of 0.2 Hz. IC8 buffers this RC network in addition to providing a gain of approx. 3.5.

Weighted filter. The weighted filter (WTD) is built up around IC9, and TR27 and TR28 provide a means of selecting between weighted and linear operation. IC10 operates as buffer for the FET switches and steps up the signal by a factor of 20. The level at the output is approx. 350 mV at full scale.

Wow and flutter filter. The wow filter (IC11A) and flutter filter (IC11B) is a 2nd-order Butterworth lowpass and highpass filter, respectively, with 10 Hz as 3 dB frequency. FET switches TR29, TR30 and TR31 cut in the W + F, WOW and FLUTTER filters, respectively. FET switches TR32 and TR33 provide a means of selecting whether you want to use the variable bandpass filter or not. IC12 buffers the FET switches and provides a gain of 10.

Meter circuit (DIN 45507). Rectification of the AC signal according to DIN 45507 occurs in IC13 and IC14 so that the positive peak value will lie across C45 and the negative one across C47. IC14A functions as summing amplifier; its output will be an expression of the peak-to-peak value of the AC signal seeing that the charging time constant is approx. 20 times lower than the discharge time constant.

Meter circuit (sigma). Before entering the sigma circuit, the signal is full-wave rectified in IC7A and IC17B. The actual rectification is done in IC17A whilst IC17B sums the positive and negative halfwaves. Both in this rectifier and in the one described above the negative feedback voltage is taken off after the diodes for which reason the diode voltage drop is reduced by approximately the open-loop gain of the operational amplifiers.
The sigma circuit consists of a comparator (IC18A) controlling an integrator (IC18B). Whether positive or negative integration is carried out depends on whether the output voltage across C48 is greater or smaller than the input voltage at the non-inverting input of IC18A. The integration rate depends on which resistor – R157 (σ 1), R160 (σ 2) or R161 (σ 3) – has been cut in. TR35 and TR45 are used for zero-setting the circuit, C48 being discharged and the input of IC18A connected to chassis potential.

Automatic Start-up control circuit. Measurement involving use of the automatic start-up control circuit may be used with DIN measurements and is always used in sigma measurements.
The circuit consists of a timer (IC19 and IC20) controlling a peak-rectifying sample and held circuit (IC15). Rectification is performed via TR41A which operates as a diode having very low leakage current; this causes C50 to be charged up to the maximum voltage presents within a measuring period. TR43 and TR44 are inserted as buffers so as not to load C50.
Feedback voltage for IC15 is taken from the emitter of TR44 to eliminate the voltage drop across TR41A, TR43 and TR44. D34 prevents the output of IC15 from going into negative saturation and so turn TR41 on when not wanted. TR42A also functions as a diode.
A measuring operation may be divided into three periods:

(1) Zero setting, approx. 1 sec.
(2) Sampling, lasting 5 sec for sigma measurements and approx. 30 sec. for DIN PEAK measurements.
(3) Retaining the result of the measurement until the next triggering.

When the START button is operated, the trigger signal enters R143 in the form of a positive voltage pulse which triggers the monostable multivibrator IC19. This delivers the zero set pulse of approx. 1 sec, during which period FET switches TR35, TR45, TR41, TR42 and TR38 go on, thereby zero-setting the circuits.
The negative flank of the first pulse triggers the next monostable multivibrator IC20, which delivers the sampling pulse. This results in the following changes from before: TR45, TR35 and TR41 go off, and the circuit is ready to measure the maximum voltage arriving from the sigma or DIN meter circuit.
On the negative flank of the sampling pulse the circuit goes into the »hold« state, causing TR42 and TR38 to go off. The charge on C50 can now no longer be changed, and the meter locking caused by TR38 ceases.
Chaning the time constant from 5 sec to 30 sec is carried out by means of TR49, which is on only during sigma measurements. In DIN PEAK measurements, during which TR36 and TR39 are on, the meter time constant is simulated by the network composed of R125 and C49 which is necessary to preserve correct dynamic conditions.

Frequency analyser. The frequency analyser is composed of two 2nd-order bandpass filters of the state-variable type. Because these filters are identical except that their cente frequency is 7% off-tune, a description of the one section will suffice.
Range switching is carried out by means of FET switches TR62 ... TR66 and TR68 ... TR72 in such a manner that they are on pairwise. For example, in the range from 100 Hz to 316 Hz it is TR62 and TR68 which are on.
Continuous variation of the frequency will be possible by altering the values of all resistors in series with the FET switches which have been cut into the circuit. This introduces certain difficulties in practice for which reason a different solution was chosen.
The resistors instead of being varied are cut in and out at a frequency of approx. 8 kHz, and by varying the cut-in and cut-out times the same effect is obtained as would have resulted from altering the resistors, and the result is a change in frequency. Cut-in and cut-out are carried out by means of TR61 and TR67, controlled by TR87.
An astable multivibrator, IC33, generates the switch signal. It triggers a monostable multivibrator the pulse width of which is controllable by means of a DC voltage.
By charging C82 with a constant current a linear change of the mark-to-space ratio as a function of control voltage is obtained. P12 and P13 are used to adjust the voltage so that a change from 0 to 10 V at R239 produces a frequency change of 3.16 times (10 dB).

Overdrive limiter. Heavy overdriving causes the time constant generated by C33, C34 and R82 to keep the meter in saturation for a relatively long time. This is remedied by a circuit (TR90 and TR91) which senses on the meter output. At a level corresponding to 1.5 times at full scale, TR22A is switched on, causing the time constant to be reduced by a factor of approx. 500.

3.15 kHz oscillator. The oscillator employs IC21 as amplifying device and is of the Wien bridge type. TR54 peak-rectifies the output signal, and the smoothed voltage across C62 controls the gate of TR55 which serves as a variable resistor. The gain will adjust itself so that the amplitude of the output voltage becomes equal to the sum of the voltage drop across D53 plus the base-emitter voltage across TR54.

Power supply. The plus supply uses an integrated regulator, IC22, with a built-in reference voltage and current limiter.
The output voltage from the series transistor TR56 is inverted in IC23 and furnishes, at the output of series transistor TR57, the negative supply. The current limiter for the latter is TR58, which removes control voltage from TR57 when the voltage drop across R181 is approx. 0.6 V.

ADJUSTMENTS

The Wow/Flutter Meter WM1 is designed for operation for long periods of time without readjustments and maintenance. Only in the case of component faults it will normally be necessary to check and adjust the instrument. In that case the following procedure should be observed.
Only those adjustments are described which can be carried out with normally available instruments. The remaining adjustments require special test equipment for which reason the instrument should be sent to the factory if such adjustments are necessary.
The adjustments described require the following instruments:

1. Digital voltmeter, AC/DC, accuracy better than 0.1%.
2. Audio generator, 1 kHz ... 10 kHz.
3. Frequency counter, 1 kHz ... 10 kHz, accuracy better than 5×10^{-6}.

Adjustment of the Internal Oscillator and the Drift Meter Circuit

1. Check the mechanical zero (»0«) on the drift meter (3).
2. Operate the following pushbuttons:

Drift range (1):	0.3%
Meter circuit (7):	DIN
Filter characteristic (17):	W+F and LIN
Wow/flutter range (16):	1%
Frequency analyser (10):	OFF

3. Allow the instrument to warm up for not less than half an hour with its cabinet closed.
4. Remove the top cover.
5. Check the +17 V potential in the power supply and if necessary adjust with potentiometer P10 on circuit board A (see Fig. 9). Check ÷17 V potential.
6. Connect a frequency counter to the 3.15 kHz output (11), and with potentiometer P9 on circuit board A adjust the oscillator frequency to exact value of 3.15 kHz.
7. Short-circuit the centre pin of the drift potentiometer (4) to chassis potential and adjust the deflection of the drift meter (3) to 0 with potentiometer P1 on circuit board B.

8. Remove short-circuit. Set drift potentiometer (4) to 0. When switching between the 0.3% and 10% ranges (1) the drift meter (3) should show a constant reading of 0. This reading is adjusted in the 0.3% range with the FINE potentiometer (2) and in the 10% range with potentiometer P2 on circuit board B.
9. Set the drift range switch (1) to 0.3% position. Adjust drift meter (3) reading to 0 using drift potentiometer (4) and, if necessary, FINE potentiometer (2). Thereafter set the range switch (1) to 10% position.
10. Connect an audio generator to one of the inputs, say (12), and adjust frequency to exactly 3.465 (3.15 kHz + 10%), checking with a frequency counter.

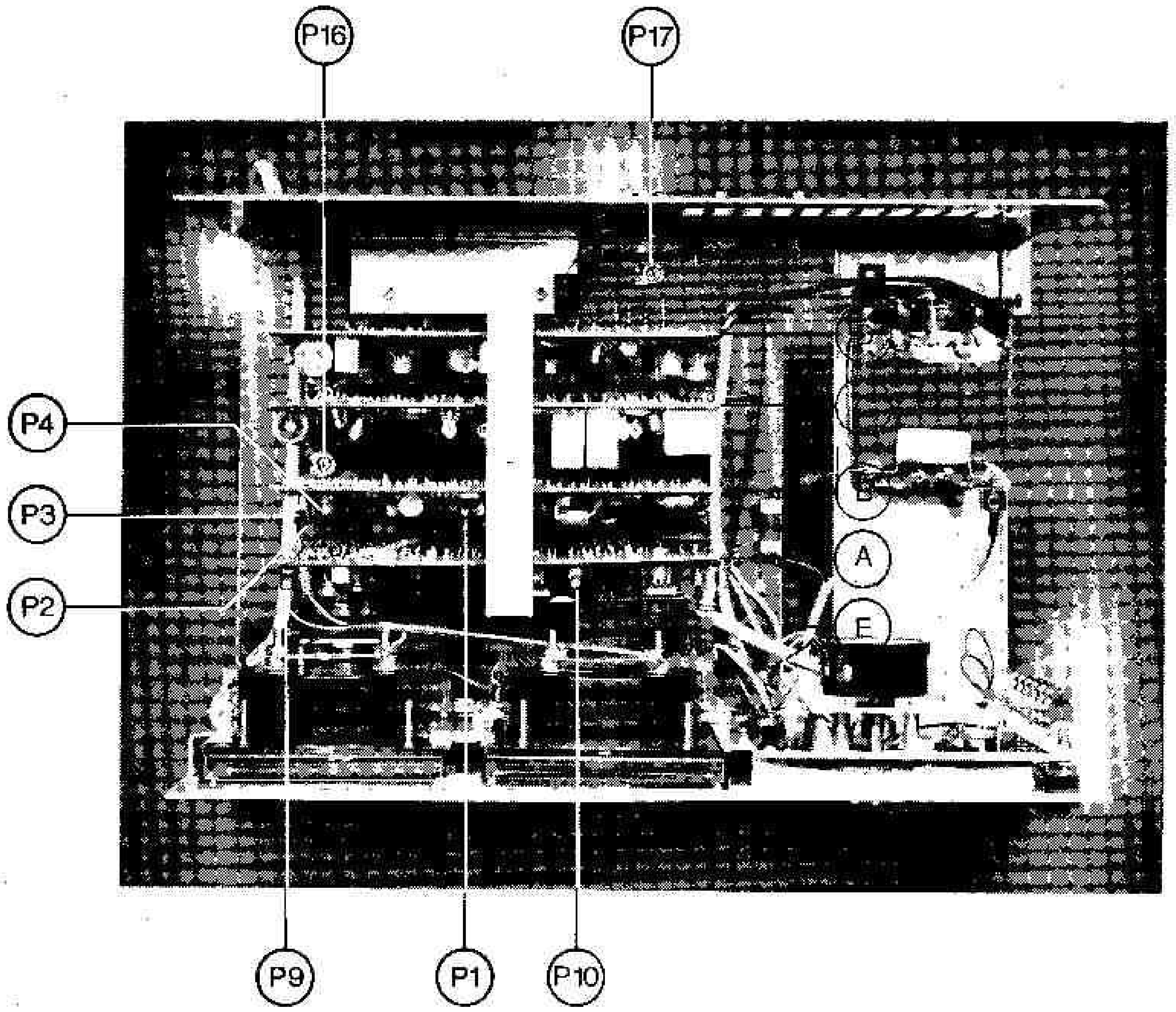


Fig. 9. Adjustment.

11. Connect a digital voltmeter to the drift analog output (18) and adjust the output voltage to 1 V DC with potentiometer P3 on circuit board B.
12. With potentiometer P16 on circuit board E (bottom board) adjust drift meter (3) to read +10%.

Adjustment of Frequency Analyser (9)

1. Connect a digital voltmeter to the centre pin of filter potentiometer (9). Voltage at this point should be capable of being varied from 0 to +10 V by turning the dial from 1 to 3.16.
2. Turn the dial against the left end stop. Then turn the dial slowly clockwise, checking if the voltage at the potentiometer centre pin only just begins to rise smoothly (from 0 V) at 1 on the dial scale. If it does not, adjust the knob with respect to the shaft.
3. Thereafter turn the dial clockwise to 3.16 on the outer scale. Voltage at the potentiometer centre pin should then be +10 V; correction, if necessary, may be made with the potentiometer P17 on the bottom board.

PARTS LIST

R1	5010045	Resistor	47 KΩ	5%	0.125 W
R2	5010049	Resistor	100 KΩ	5%	0.125 W
R3	5010059	Resistor	10 KΩ	5%	0.125 W
R4	5010144	Resistor	680 Ω	5%	0.125 W
R5	5010063	Resistor	150 KΩ	5%	0.125 W
R6	5010064	Resistor	2.2 KΩ	5%	0.125 W
R7	5010083	Resistor	270 KΩ	5%	0.125 W
R8	5010064	Resistor	2.2 KΩ	5%	0.125 W
R9	5010144	Resistor	680 Ω	5%	0.125 W
R10	5010059	Resistor	10 KΩ	5%	0.125 W
R11	5010045	Resistor	47 KΩ	5%	0.125 W
R12	5010069	Resistor	3.9 KΩ	5%	0.125 W
R13	5010040	Resistor	1 KΩ	5%	0.125 W
R14	5010083	Resistor	270 KΩ	5%	0.125 W
R15	5010075	Resistor	33 KΩ	5%	0.125 W
R16	5010141	Resistor	27 KΩ	5%	0.125 W
R17	5010141	Resistor	27 KΩ	5%	0.125 W
R18	5010062	Resistor	68 KΩ	5%	0.125 W
R19	5010075	Resistor	33 KΩ	5%	0.125 W
R20	5010040	Resistor	1 KΩ	5%	0.125 W
R21	5010075	Resistor	33 KΩ	5%	0.125 W
R22		Resistor	24.9 KΩ	1%	0.125 W
R23	5010141	Resistor	27 KΩ	5%	0.125 W
R24	5010141	Resistor	27 KΩ	5%	0.125 W
R25	5010040	Resistor	1 KΩ	5%	0.125 W
R26	5010059	Resistor	10 KΩ	5%	0.125 W
R27	5010091	Resistor	82 KΩ	5%	0.125 W
R28	5010066	Resistor	1.8 KΩ	5%	0.125 W
R29	5010075	Resistor	33 KΩ	5%	0.125 W
R30	5010045	Resistor	47 KΩ	5%	0.125 W
R31	5010064	Resistor	2.2 KΩ	5%	0.125 W
R32	5010064	Resistor	2.2 KΩ	5%	0.125 W
R33	5010091	Resistor	82 KΩ	5%	0.125 W
R34	5010076	Resistor	3.3 KΩ	5%	0.125 W
R35	5010411	Resistor	47 Ω	5%	0.125 W
R36		Resistor	1.2 MΩ	5%	0.125 W
R37		Resistor	562 KΩ	1%	0.125 W
R38		Resistor	100 KΩ	1%	0.125 W
R39		Resistor	10 KΩ	1%	0.125 W
R40		Resistor	1 KΩ	1%	0.125 W
R41	5010052	Resistor	6.8 KΩ	5%	0.125 W
R42	5010059	Resistor	10 KΩ	5%	0.125 W
R44	5010049	Resistor	100 KΩ	5%	0.125 W
R45	5010040	Resistor	1 KΩ	5%	0.125 W
R45A	5010045	Resistor	47 KΩ	5%	0.125 W
R46	5010065	Resistor	100 Ω	5%	0.125 W
R47	5010141	Resistor	27 KΩ	5%	0.125 W
R48	5010068	Resistor	820 Ω	5%	0.125 W
R49	5010048	Resistor	4.7 KΩ	5%	0.125 W
R50	5010058	Resistor	470 Ω	5%	0.125 W
R51	5010058	Resistor	470 Ω	5%	0.125 W
R52	5010064	Resistor	2.2 KΩ	5%	0.125 W
R53	5010067	Resistor	560 KΩ	5%	0.125 W
R53A	5010067	Resistor	3.3 KΩ	5%	0.125 W
R54	5010064	Resistor	2.2 KΩ	5%	0.125 W
R55	5010048	Resistor	4.7 KΩ	5%	0.125 W
R56		Resistor	13.7 KΩ	1%	0.125 W
R57		Resistor	402 KΩ	1%	0.125 W
R58		Resistor	124 KΩ	1%	0.125 W
R59	5010059	Resistor	10 KΩ	5%	0.125 W

R60	5010048	Resistor	4.7 KΩ	5%	0.125 W
R61		Resistor	2.87 KΩ	1%	0.125 W
R62		Resistor	18.7 KΩ	1%	0.125 W
R63		Resistor	280 KΩ	1%	0.125 W
R64	5010054	Resistor	1 MΩ	5%	0.125 W
R65		Resistor	18.7 KΩ	1%	0.125 W
R66	5010040	Resistor	1 KΩ	5%	0.125 W
R67		Resistor	18.7 KΩ	1%	0.125 W
R68		Resistor	18.7 KΩ	1%	0.125 W
R69		Resistor	7.15 KΩ	1%	0.125 W
R70		Resistor	9.76 KΩ	1%	0.125 W
R71		Resistor	18.7 KΩ	1%	0.125 W
R72		Resistor	18.7 KΩ	1%	0.125 W
R73		Resistor	10 KΩ	1%	0.125 W
R74		Resistor	3.83 KΩ	1%	0.125 W
R75		Resistor	3.16 KΩ	1%	0.125 W
R76		Resistor	1 KΩ	1%	0.125 W
R77		Resistor	316 Ω	1%	0.125 W
R78		Resistor	147 Ω	1%	0.125 W
R79	5010045	Resistor	47 KΩ	5%	0.125 W
R80		Resistor	4.99 KΩ	1%	0.125 W
R81		Resistor	60.4 KΩ	1%	0.125 W
R82	5010047	Resistor	120 KΩ	5%	0.125 W
R82A	5010049	Resistor	100 KΩ	5%	0.125 W
R83		Resistor	110 KΩ	1%	0.125 W
R84		Resistor	225 KΩ	1%	0.125 W
R85		Resistor	3.16 KΩ	1%	0.125 W
R86		Resistor	1 KΩ	1%	0.125 W
R87		Resistor	316 Ω	1%	0.125 W
R88		Resistor	100 Ω	1%	0.125 W
R89		Resistor	46.4 Ω	1%	0.125 W
R90		Resistor	402 KΩ	1%	0.125 W
R91		Resistor	402 KΩ	1%	0.125 W
R92		Resistor	130 KΩ	1%	0.125 W
R93		Resistor	267 KΩ	1%	0.125 W
R94		Resistor	294 KΩ	1%	0.125 W
R95		Resistor	5.23 KΩ	1%	0.125 W
R96		Resistor	100 KΩ	1%	0.125 W
R97		Resistor	158 KΩ	1%	0.125 W
R98		Resistor	158 KΩ	1%	0.125 W
R99		Resistor	6.19 KΩ	1%	0.125 W
R100		Resistor	3.65 KΩ	1%	0.125 W
R101		Resistor	3.65 KΩ	1%	0.125 W
R102		Resistor	6.98 KΩ	1%	0.125 W
R103		Resistor	158 KΩ	1%	0.125 W
R104		Resistor	158 KΩ	1%	0.125 W
R105		Resistor	6.19 KΩ	1%	0.125 W
R106		Resistor	3.65 KΩ	1%	0.125 W
R107		Resistor	3.65 KΩ	1%	0.125 W
R108		Resistor	6.98 KΩ	1%	0.125 W
R109	5010049	Resistor	100 KΩ	5%	0.125 W
R109A	5010054	Resistor	1 MΩ	5%	0.125 W
R110		Resistor	54.9 KΩ	1%	0.125 W
R111		Resistor	20 KΩ	1%	0.125 W
R112		Resistor	182 KΩ	1%	0.125 W
R113		Resistor	29.4 KΩ	1%	0.125 W
R114		Resistor	8.87 KΩ	1%	0.125 W
R115		Resistor	14.7 KΩ	1%	0.125 W
R116		Resistor	54.9 KΩ	1%	0.125 W
R117		Resistor	100 KΩ	1%	0.125 W
R118		Resistor	100 KΩ	1%	0.125 W
R119		Resistor	4.87 KΩ	1%	0.125 W

R120		Resistor	4.87 KΩ	1%	0.125 W
R121		Resistor	10 KΩ	1%	0.125 W
R122		Resistor	10 KΩ	1%	0.125 W
R123		Resistor	10 KΩ	1%	0.125 W
R124		Resistor	10 KΩ	1%	0.125 W
R125		Resistor	4.99 KΩ	1%	0.125 W
R126		Resistor	2.67 KΩ	1%	0.125 W
R126A		Resistor	20 KΩ	1%	0.125 W
R127	5010059	Resistor	10 KΩ	5%	0.125 W
R128	5010053	Resistor	15 KΩ	5%	0.125 W
R129	5010049	Resistor	100 KΩ	5%	0.125 W
R130	5010298	Resistor	2.7 KΩ	5%	0.125 W
R131	5010053	Resistor	15 KΩ	5%	0.125 W
R131A	5010049	Resistor	100 KΩ	5%	0.125 W
R132	5010059	Resistor	10 KΩ	5%	0.125 W
R133		Resistor	54.9 KΩ	1%	0.125 W
R134		Resistor	10 KΩ	1%	0.125 W
R135		Resistor	10 KΩ	1%	0.125 W
R136		Resistor	100 KΩ	1%	0.125 W
R137		Resistor	100 KΩ	1%	0.125 W
R138		Resistor	100 KΩ	1%	0.125 W
R139		Resistor	100 KΩ	1%	0.125 W
R140		Resistor	100 KΩ	1%	0.125 W
R141		Resistor	88.7 KΩ	1%	0.125 W
R142	5010059	Resistor	10 KΩ	1%	0.125 W
R142A	5010040	Resistor	1 KΩ	1%	0.125 W
R143	5010059	Resistor	10 KΩ	1%	0.125 W
R144	5010045	Resistor	47 KΩ	1%	0.125 W
R145	5010052	Resistor	6.8 KΩ	5%	0.125 W
R145A	5010049	Resistor	100 KΩ	5%	0.125 W
R146	5010052	Resistor	6.8 KΩ	5%	0.125 W
R147	5010075	Resistor	33 KΩ	5%	0.125 W
R148	5010052	Resistor	6.8 KΩ	5%	0.125 W
R149	5010052	Resistor	6.8 KΩ	5%	0.125 W
R150	5010053	Resistor	15 KΩ	5%	0.125 W
R151	5010073	Resistor	390 KΩ	5%	0.125 W
R152		Resistor	1.5 MΩ	5%	0.125 W
R153	5010052	Resistor	6.8 KΩ	5%	0.125 W
R154	5010053	Resistor	15 KΩ	5%	0.125 W
R155	5010059	Resistor	10 KΩ	5%	0.125 W
R156	5010047	Resistor	120 KΩ	5%	0.125 W
R157		Resistor	6.19 KΩ	1%	0.125 W
R158		Resistor	2 KΩ	1%	0.125 W
R159	5010052	Resistor	6.8 KΩ	5%	0.125 W
R160		Resistor	39.2 KΩ	1%	0.125 W
R161		Resistor	649 KΩ	1%	0.125 W
R162		Resistor	243 KΩ	0,25%	0.125 W
R163	5010068	Resistor	820 KΩ	5%	0.125 W
R164	5010040	Resistor	1 KΩ	5%	0.125 W
R165		Resistor	249 KΩ	0.25%	0.125 W
R166	5010247	Resistor	1.5 KΩ	5%	0.125 W
R168		Resistor	2 KΩ	1%	0.125 W
R169	5010411	Resistor	47 Ω	5%	0.125 W
R170	5010059	Resistor	10 KΩ	5%	0.125 W
R171	5010059	Resistor	10 KΩ	5%	0.125 W
R172	5010059	Resistor	10 KΩ	5%	0.125 W
R173	5010059	Resistor	10 KΩ	5%	0.125 W
R174		Resistor	5.62 KΩ	1%	0.125 W
R175		Resistor	1.2 KΩ	10%	1 W
R176		Resistor	6.04 KΩ	1%	0.125 W
R177		Resistor	6.04 KΩ	1%	0.125 W

R178	5010069	Resistor	3.9 KΩ	5%	0.125 W
R179		Resistor	10 KΩ	1%	0.125 W
R180		Resistor	6.04 KΩ	1%	0.125 W
R181		Resistor	2.2 Ω	10%	1 W
R182	5010059	Resistor	10 KΩ	5%	0.125 W
R183	5010049	Resistor	100 KΩ	5%	0.125 W
R184	5010059	Resistor	10 KΩ	5%	0.125 W
R185	5010059	Resistor	10 KΩ	5%	0.125 W
R186	5010049	Resistor	100 KΩ	5%	0.125 W
R187		Resistor	4.99 KΩ	1%	0.125 W
R188		Resistor	20 KΩ	1%	0.125 W
R189	5010041	Resistor	5.6 KΩ	5%	0.125 W
R190		Resistor	20 KΩ	1%	0.125 W
R191		Resistor	4.99 KΩ	0,25%	0.125 W
R192		Resistor	15.8 KΩ	0.25%	0.125 W
R193		Resistor	49.9 KΩ	0.25%	0.125 W
R194		Resistor	158 KΩ	0.25%	0.125 W
R195		Resistor	499 KΩ	0.25%	0.125 W
R196	5010059	Resistor	10 KΩ	5%	0.125 W
R197	5010049	Resistor	100 KΩ	5%	0.125 W
R198	5010041	Resistor	5.6 KΩ	5%	0.125 W
R200	5010049	Resistor	100 KΩ	5%	0.125 W
R201		Resistor	4.64 KΩ	0.25%	0.125 W
R202		Resistor	14.7 KΩ	0.25%	0.125 W
R203		Resistor	46.4 KΩ	0.25%	0.125 W
R204		Resistor	147 KΩ	0.25%	0.125 W
R205		Resistor	464 KΩ	0.25%	0.125 W
R206	5010059	Resistor	10 KΩ	5%	0.125 W
R207		Resistor	137 KΩ	1%	0.125 W
R208		Resistor	100 KΩ	1%	0.125 W
R209		Resistor	37.4 KΩ	1%	0.125 W
R210		Resistor	20 KΩ	1%	0.125 W
R211		Resistor	20 KΩ	1%	0.125 W
R212		Resistor	1.62 KΩ	1%	0.125 W
R213	5010041	Resistor	5.6 KΩ	5%	0.125 W
R214		Resistor	4.99 KΩ	1%	0.125 W
R215	5010059	Resistor	10 KΩ	5%	0.125 W
R216		Resistor	4.64 KΩ	0.25%	0.125 W
R217		Resistor	14.7 KΩ	0.25%	0.125 W
R218		Resistor	46.4 KΩ	0.25%	0.125 W
R219		Resistor	147 KΩ	0.25%	0.125 W
R220		Resistor	20 KΩ	1%	0.125 W
R221		Resistor	20 KΩ	1%	0.125 W
R222	5010049	Resistor	100 KΩ	5%	0.125 W
R223	5010041	Resistor	5.6 KΩ	5%	0.125 W
R225	5010049	Resistor	100 KΩ	5%	0.125 W
R226	5010059	Resistor	10 KΩ	5%	0.125 W
R227		Resistor	4.32 KΩ	0.25%	0.125 W
R228		Resistor	13.7 KΩ	0.25%	0.125 W
R229		Resistor	43.2 KΩ	0.25%	0.125 W
R230		Resistor	137 KΩ	0.25%	0.125 W
R231		Resistor	432 KΩ	5%	0.125 W
R232		Resistor	8.45 KΩ	1%	0.125 W
R233		Resistor	5.49 KΩ	1%	0.125 W
R234	5010048	Resistor	4.7 KΩ	5%	0.125 W
R235	5010059	Resistor	10 KΩ	5%	0.125 W
R236	5010040	Resistor	1 KΩ	5%	0.125 W
R237		Resistor	14 KΩ	1%	0.125 W
R238		Resistor	2 KΩ	2%	0.125 W
R239	5010059	Resistor	10 KΩ	5%	0.125 W
R240		Resistor	4.99 KΩ	1%	0.125 W

R241		Resistor 2.1 KΩ	1%	0.125 W	
R242		Resistor 3.09 KΩ	1%	0.125 W	
R243		Resistor 27 KΩ	1%	0.125 W	
R250		Resistor 1.62 KΩ	1%	0.125 W	
R251	5010059	Resistor 10 KΩ	5%	0.125 W	
R252	5010045	Resistor 47 KΩ	5%	0.125 W	
R253	5010059	Resistor 10 KΩ	5%	0.125 W	
R254	5010153	Resistor 1.2 KΩ	5%	0.125 W	
R256		Resistor 10 KΩ	1%	0.125 W	
R257		Resistor 1.78 KΩ	1%	0.125 W	
R258		Resistor 37.4 KΩ	1%	0.125 W	
R259	5010065	Resistor 100 Ω	5%	0.125 W	
R260		Resistor 13.3 KΩ	1%	0.125 W	
R261		Resistor 93.1 KΩ	1%	0.125 W	
R262		Resistor 25.5 KΩ	1%	0.125 W	
R263		Resistor 10 KΩ	1%	0.125 W	
R264		Resistor 18.2 KΩ	1%	0.125 W	
R265		Resistor 10 KΩ	1%	0.125 W	
R266	5010053	Resistor 15 KΩ	5%	0.125 W	
R267	5010049	Resistor 100 KΩ	5%	0.125 W	
R268	5010049	Resistor 100 KΩ	5%	0.125 W	
R269	5010117	Resistor 330 KΩ	5%	0.125 W	
R270		Resistor 8.45 KΩ	1%	0.125 W	
R271		Resistor 8.66 KΩ	1%	0.125 W	
R272	5001022	Resistor 390 Ω	5%	0,5 W	
R273	5010049	Resistor -100 KΩ	5%	0.125 W	
R274	5001007	Resistor 39 Ω	10%	0,5 W	
R275	5001007	Resistor 39 Ω	10%	0,5 W	
R276		Resistor 13,3 KΩ	1%	0.125 W	
R277	5010049	Resistor 100 KΩ	5%	0.125 W	
R278		Resistor 422 KΩ	1%	0.125 W	
P1		Potentiometer, TR	10 KΩ-lin	0,5W	
P2		Potentiometer, TR	10 KΩ-lin	0,5 W	
P3		Potentiometer, TR	10 KΩ-lin	0,5 W	
P4		Potentiometer, TR	50 KΩ-lin	0,5 W	
P5		Potentiometer, TR	1 KΩ-lin	0,1 W	
P6		Potentiometer, TR	1 KΩ-lin	0,1 W	
P7		Potentiometer, TR	1 KΩ-lin	0,1 W	
P8		Potentiometer, TR	50 KΩ-lin	0,1 W	
P9		Potentiometer, TR	20 KΩ-lin	0,5 W	
P10		Potentiometer, TR	10 KΩ-lin	0,5 W	
P11		Potentiometer, TR	50 KΩ-lin	0,5 W	
P12		Potentiometer, TR	2 KΩ-lin	0,5 W	
P13		Potentiometer, TR	1 KΩ-lin	0,5 W	
P15	5370000	Potentiometer, TR	250 Ω-lin	0,1 W	
P16	5370000	Potentiometer, TR	250 Ω-lin	0,1 W	
P17	5370168	Potentiometer, TR	5 KΩ-lin	0.1 W	
P18		Potentiometer, TR	25 KΩ-lin	3 W	
P19		Potentiometer, TR	25 KΩ-lin	3 W	
P20		Potentiometer, TR	470 Ω-lin	0.25 W	
C1	4133011	Capacitor, MK	10 nF	10%	250 V
C2	4100029	Capacitor, PS	2.2 nF	5%	63 V
C3	4133012	Capacitor, MK	150 nF	20%	250 V
C4	4101007	Capacitor, PS	220 pF	5%	63 V
C5	4200108	Capacitor, Elko Tant	4.7 µF		25 V
C6	4200101	Capacitor, Elko Tant	10 µF		16 V
C6A	4201041	Capacitor, Elko Tant	6.8 µF		40 V
C7	4101007	Capacitor, PS	220 pF	5%	63 V

C8	4133012	Capacitor, MK	150 nF	20%	250 V
C9	4000077	Capacitor, K.Plaq	47 pF	2%	63 V
C10	4100058	Capacitor, PS	3.3 nF	2.5%	63 V
C11	4100058	Capacitor, PS	3.3 nF	2.5%	63 V
C12	4100058	Capacitor, PS	3.3 nF	2.5%	63 V
C13	4100029	Capacitor, PS	2.2 nF	5%	63 V
C14	4100029	Capacitor, PS	2.2 nF	5%	63 V
C15	4101018	Capacitor, PS	470 pF	5%	63 V
C16	4133004	Capacitor, MK	22 nF	20%	250 V
C17	4200108	Capacitor, Elko Tant	4.7 µF		25 V
C18	4130100	Capacitor, MK	68 nF	10%	250 V
C18A	4130132	Capacitor, MK	100 nF	10%	250 V
C19	4201057	Capacitor, Elko Tant	1 µF		35 V
C20	4010003	Capacitor, K.HK.	220 pF	20%	400 V
C21	4010003	Capacitor, K.HK.	220 pF	20%	400 V
C22	4100031	Capacitor, PS	4.7 nF	1%	63 V
C23	4010060	Capacitor, K.HK.	22 nF		40 V
C24	4010067	Capacitor, K.Plaq	1.5 nF	10%	63 V
C25	4201058	Capacitor, Elko Tant	0.47 µF		35 V
C26	4100048	Capacitor, PS	27 nF	1%	63 V
C27	4100048	Capacitor, PS	27 nF	1%	63 V
C28	4100048	Capacitor, PS	27 nF	1%	63 V
C29	4100048	Capacitor, PS	27 nF	1%	63 V
C30	4100048	Capacitor, PS	27 nF	1%	63 V
C31	4130136	Capacitor, MK	1 µF	20%	100 V
C32	4200108	Capacitor, Elko Tant	4.7 µF		25 V
C32A	4201041	Capacitor, Elko	6.8 µF		40 V
C32B	4200100	Capacitor, Elko	22 µF		40 V
C33	4200230	Capacitor, Elko Tant	15 µF		16 V
C34	4200230	Capacitor, Elko Tant	15 µF		16 V
C35	4230132	Capacitor, MK	100 nF	10%	250 V
C36	4130132	Capacitor, MK	100 nF	10%	250 V
C37		Capacitor, MK	1 µF	5%	100 V
C38	4230132	Capacitor, MK	100 nF	10%	250 V
C38A	4130132	Capacitor, MK	100 nF	10%	250 V
C39	4130132	Capacitor, MK	100 nF	10%	250 V
C40	4130132	Capacitor, MK	100 nF	10%	250 V
C41	4200133	Capacitor, Elko	100 µF		10 V
C42	4200098	Capacitor, Elko	100 µF		6 V
C43		Capacitor, Elko	47 µF		16 V
C44		Capacitor, Elko	47 µF		16 V
C45		Capacitor, MK	4.7 µF	5%	100 V
C46	4201058	Capacitor, Elko Tant	0.47 µF		35 V
C47		Capacitor, MK	4.7 µF	5%	100 V
C48	4200111	Capacitor, Elko	1000 µF		10 V
C48A	4200230	Capacitor, Elko Tant	15 µF		16 V
C49		Capacitor, Elko Tant	22 µF		16 V
C49A	4011022	Capacitor, K.Plaq	4.7 nF		40 V
C50	4134010	Capacitor, MK	470 nF	10%	400 v
C51	4133011	Capacitor, MK	10 nF	10%	250 V
C52	4200230	Capacitor, Elko Tant	15 µF		16 V
C52A	4201041	Capacitor, Elko	6.8 µF		40 V
C53	4133011	Capacitor, MK	10 nF	10%	250 V
C54	4200230	Capacitor, Elko Tant	15 µF		16 V
C54A	4201041	Capacitor, Elko	6.8 µF		40 V
C55	4000085	Capacitor, K.Plaq	100 pF	2%	63 V
C56	4000085	Capacitor, K.Plaq	100 pF	2%	63 V
C57	4000085	Capacitor, K.Plaq	100 pF	2%	63 V
C58	4000085	Capacitor, K.Plaq	100 pF	2%	63 V
C59	4000078	Capacitor, K.Plaq	68 pF	2%	63 V
C60	4000078	Capacitor, K.Plaq	68 pF	2%	63 V

C61	4200101	Capacitor, Elko Tant	10 µF		16 V
C62	4201058	Capacitor, Elko Tant	0.47 µF		35 V
C62A	4200016	Capacitor, Elko	22 µF		25 V
C62B	4201041	Capacitor, Elko	6.8 µF		40 V
C63	4200101	Capacitor, Elko Tant	10 µF		16 V
C64	4201074	Capacitor, Elko	47 µF		40 V
C65	4010041	Capacitor, K.Plaq	10 nF		40 V
C66	4200108	Capacitor, Elko Tant	4.7 µF		25 V
C67	4200174	Capacitor, Elko	470 µF		25 V
C68	4200332	Capacitor, Elko	2200 µF		25 V
C69	4201074	Capacitor, Elko	47 µF		40 V
C70		Capacitor, PS	320 nF	1%	63 V
C73		Capacitor, PS	2.2 nF	1%	63 V
C74	4200101	Capacitor, Elko Tant	10 µF		16 V
C75	4200101	Capacitor, Elko Tant	10 µF		16 V
C76	4130132	Capacitor, MK	100 nF	10%	250 V
C77		Capacitor, PS	320 nF	1%	63 V
C78		Capacitor, PS	2.2 nF	1%	63 V
C81	4010067	Capacitor, K.Plaq	1.5 nF	10%	63 V
C82	4100031	Capacitor, PS	4.7 nF	1%	63 V
C83	4100031	Capacitor, PS	4.7 nF	1%	63 V
C84	4200099	Capacitor, Elko	100 µF		16 V
C85	4200099	Capacitor, Elko	100 µF		16 V
C86	4200100	Capacitor, Elko	22 µF		40 V
C87	4200100	Capacitor, Elko	22 µF		40 V
C88	4200100	Capacitor, Elko	22 µF		40 V
C89	4010060	Capacitor, K.HK.	22 nF		40 V
C90	4134010	Capacitor, MK	470 nF	10%	400 V
C91	4011025	Capacitor, K.Plaq	3.3 nF	10%	100 V
C92	4011025	Capacitor, K.Plaq	3.3 nF	10%	100 V
C95		Capacitor, Elko	100 µF		16 V

D1...			
D6	8300058	Diode, Si	1N4148
D6A	8300128	Diode, Zener	ZPD 5.6
D7...			
D28	8300058	Diode, Si	1N4148
D29	8300028	Diode, Zener	ZPD 9.1
D30...			
D33	8300058	Diode, Si	1N4148
D34	8300028	Diode, Zener	ZPD 9.1
D35...			
D39	8300058	Diode, Si	1N4148
D40	8300209	Diose, Ge	AA144
D41	8300209	Diode, Ge	AA144
D42	8300058	Diode, Si	1N4148
D43	8300058	Diode, Si	1N4148
D43A	8300058	Diode, Si	1N4148
D44...			
D46	8300058	Diode, Si	1N4148
D48	8300058	Diode, Si	1N4148
D49...			
D51	8300128	Diode, Zener	ZDP 5.6
D52	8300058	Diode, Si	1N4148
D53	8300222	Diode, Zener	ZPD 2.7
D54	8300023	Diode, Si	1N4002
D55	8300028	Diode, Zener	ZDP 9.1
D56	8300023	Diode, Si	1N4002
	8300155	Rectifier, Si	B40C800
D57...			
D80	8300058	Diode, Si	1N4148

D81	8300169	Diode, Zener	ZPD 5.1
D82	8300058	Diode, Si	1N4148
D90...			
D98	8300058	Diode, Si	1N4148
D99	8300128	Diode, Zener	ZPD 5.6
D100	8300058	Diode, Si	1N4148
D101	8300058	Diode, Si	1N4148
D102	8300058	Diode, Si	1N4148
D103	8300058	Diode, Si	1N4148
D104	8300195	Diode, LED	TIL209

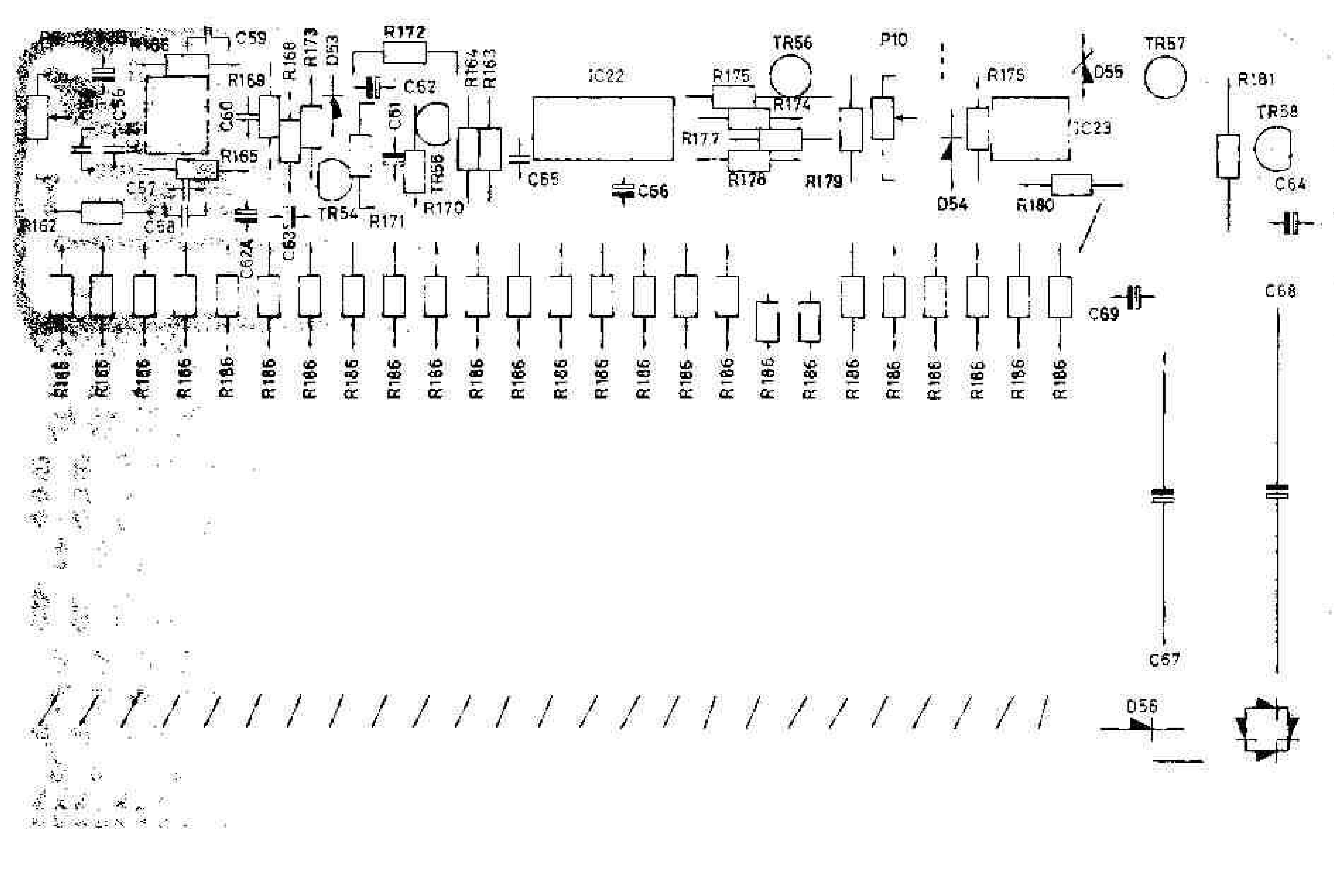
TR...			
TR12	8320377	Transistor, NPN	BC547C
TR13		Transistor, FET	2N5462
TR14	8320076	Transistor, PNP	MPS6517
TR15	8320377	Transistor, NPN	BC547C
TR15A	8320295	Transistor, NPN	BC337
TR16	8320075	Transistor, NPN	MPS6515
TR17	8320075	Transistor, NPN	MPS6515
TR18...			
TR22	8320119	Transistor, FET	TIS88A
TR22A	8320119	Transistor, FET	TIS88A
TR23...			
TR33	8320119	Transistor, FET	TIS88A
TR34	8340025	Transistor, PNP	SPS5431
TR35...			
TR38		Transistor, FET	TIS74
TR39...			
TR40	8320119	Transistor, FET	TIS88A
TR41	8320119	Transistor, FET	TIS88A
TR41A	8320119	Transistor, FET	TIS88A
TR42	8320119	Transistor, FET	TIS88A
TR42A	8320119	Transistor, FET	TIS88A
TR43	8320119	Transistor, FET	TIS88A
TR44	8320137	Transistor, NPN	BC182A
TR45	8320119	Transistor, FET	TIS88A
TR46	8320075	Transistor, NPN	MPS6515
TR47	8320076	Transistor, PNP	MPS6517
TR48	8320076	Transistor, PNP	MPS6517
TR49	8320119	Transistor, FET	TIS88A
TR50	8320137	Transistor, NPN	BC182B
TR51...			
TR53		Transistor, FET	TIS74
TR54	8340025	Transistor, PNP	SPS5431
TR55		Transistor, FET	BF244C
TR56	8320258	Transistor, NPN	TIP31
TR57	8320257	Transistor, PNP	TIP32
TR58	8320076	Transistor, PNP	MPS6517
TR61	8320413	Transistor, FET	U1897E
TR62	8320413	Transistor, FET	U1897E
TR63...			
TR66	8320412	Transistor, FET	U1899E
TR67	8320413	Transistor, FET	U1897E
TR68	8320413	Transistor, FET	U1897E
TR69...			
TR72	8320412	Transistor, FET	U1899E
TR73	8320413	Transistor, FET	U1897E
TR74	8320413	Transistor, FET	U1897E
TR75...			
TR78	8320412	Transistor, FET	U1899E

TR79	8320413	Transistor, FET	U1897E
TR80	8320413	Transistor, FET	U1897E
TR81...			
TR84	8320412	Transistor, FET	U1899E
TR85	8320076	Transistor, PNP	MPS6517
TR86	8320076	Transistor, PNP	MPS6517
TR87	8320323	Transistor, PNP	MPSA05
TR90	8320076	Transistor, PNP	MPS6517
TR91	8320075	Transistor, NPN	MPS6515
TR92	8320119	Transistor, FET	TIS88A

IC1		Quad 2 Input Nor Gate	SN 74LS02
IC2		Dual 4 Input Nand Schmitt Trigger	SN 74LS13
IC3	8340144	Timer	LM 555
IC4	8340039	Operational Amplifier	LM307
IC5	8340039	Operational Amplifier	LM 307
IC6	8340142	Dual Operational Amplifier	LM 1458
IC7	8340141	Operational Amplifier	LM 741
IC8	8340039	Operational Amplifier	LM 307
IC9	8340039	Operational Amplifier	LM 307
IC10	8340039	Operational Amplifier	LM 307
IC11	8340142	Dual Operational Amplifier	LM 1458
IC12	8340039	Operational Amplifier	LM 307
IC13	8340142	Dual Operational Amplifier	LM 1458
IC14	8340142	Dual Operational Amplifier	LM 1458
IC15	8340039	Operational Amplifier	LM 307
IC16	8340039	Operational Amplifier	LM 307
IC17	8340142	Dual Operational Amplifier	LM 1458
IC18	8340142	Dual Operational Amplifier	LM 1458
IC19	8340067	Timer	LM 555
IC20	8340067	Timer	LM 555
IC21	8340143	Operational Amplifier	LM 709
IC22	8340145	Voltage Regulator	LM 723
IC23	8340039	Operational Amplifier, FET	LM 307
IC24		Operational Amplifier, FET	CA 3140
IC25		Operational Amplifier, FET	CA 3140
IC26		Operational Amplifier, FET	CA 3140
IC27	8340039	Operational Amplifier, FET	LM 307
IC28		Operational Amplifier, FET	CA 3140
IC29		Operational Amplifier, FET	CA 3140
IC30		Operational Amplifier, FET	CA 3140
IC31	8340067	Timer	LM 555
IC32	8340048	Dual Operational Amplifier	LM 1458
IC33	8340067	Timer	LM 555
IC35	8340039	Operational Amplifier	LM 307

	Moving-coil meter, DRIFT	± 0.5 mA
	Moving-coil meter, FLUTTER	1 mA
8013178	Power transformer	2 × 19 V/0.3 A
6271086	Power cable	3 × 0.75 mm^2
7400149	Switch filters	
7400150	Switch Meter circuit	
7400150	Switch Wow range	
7400151	Switch Drift range	
7400153	Switch Frequency analyser	
7200039	Fuseholder	
6600031	Fuse	80 mA slow
7210182	Terminal screw, red	3026003
7210181	Terminal screw, black	3026003
7210184	BNC socket	50 Ω
7212007	DIN socket, 5 pole	

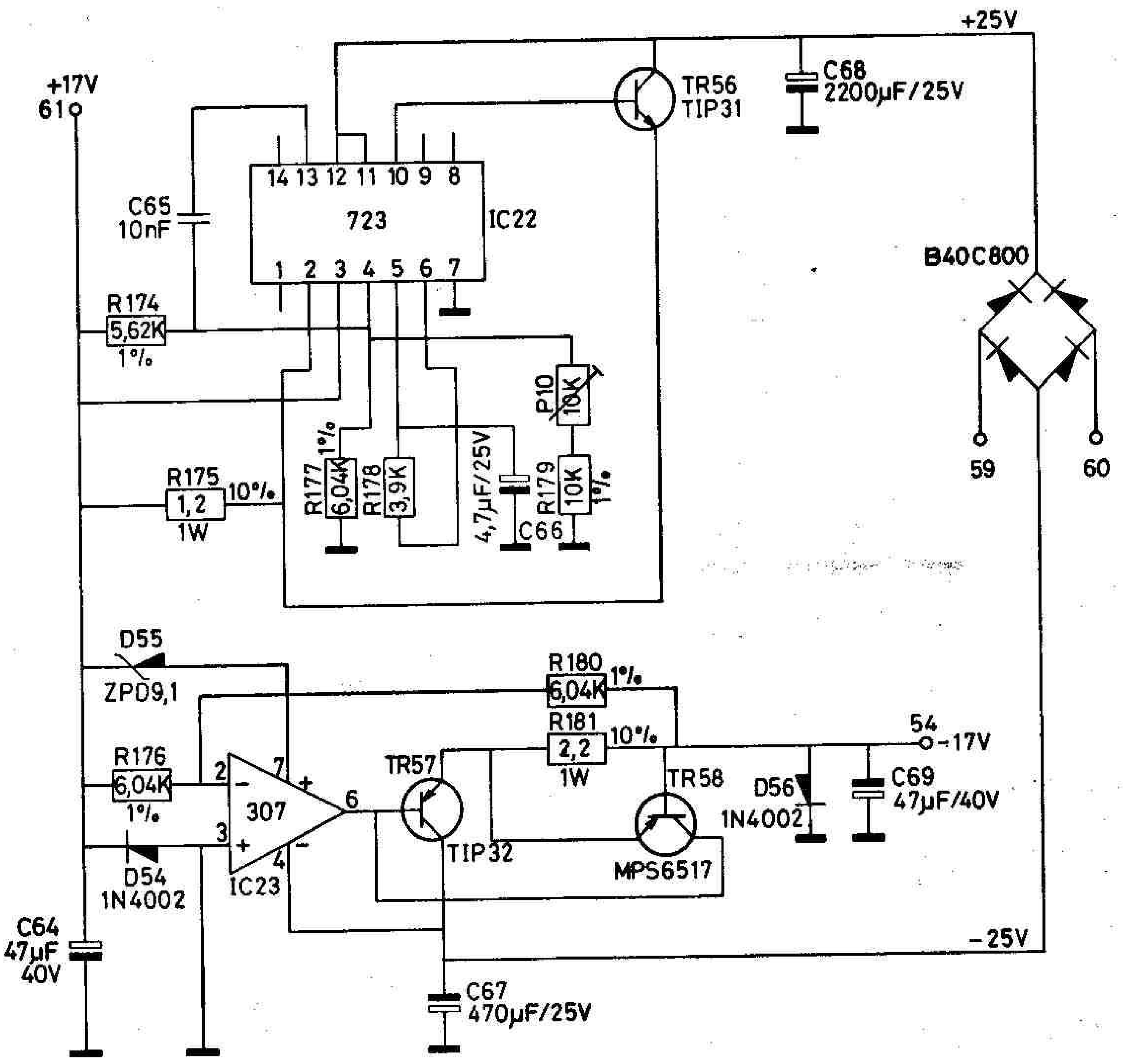
	Knob FINE	020-2320/040-1020
	Knob Drift-Offset	020-4420/040-4020/042-4400
	Knob Frekv. analysator	020-6420/040-6020
0585027	Rubber foot	
	Manual	WM1



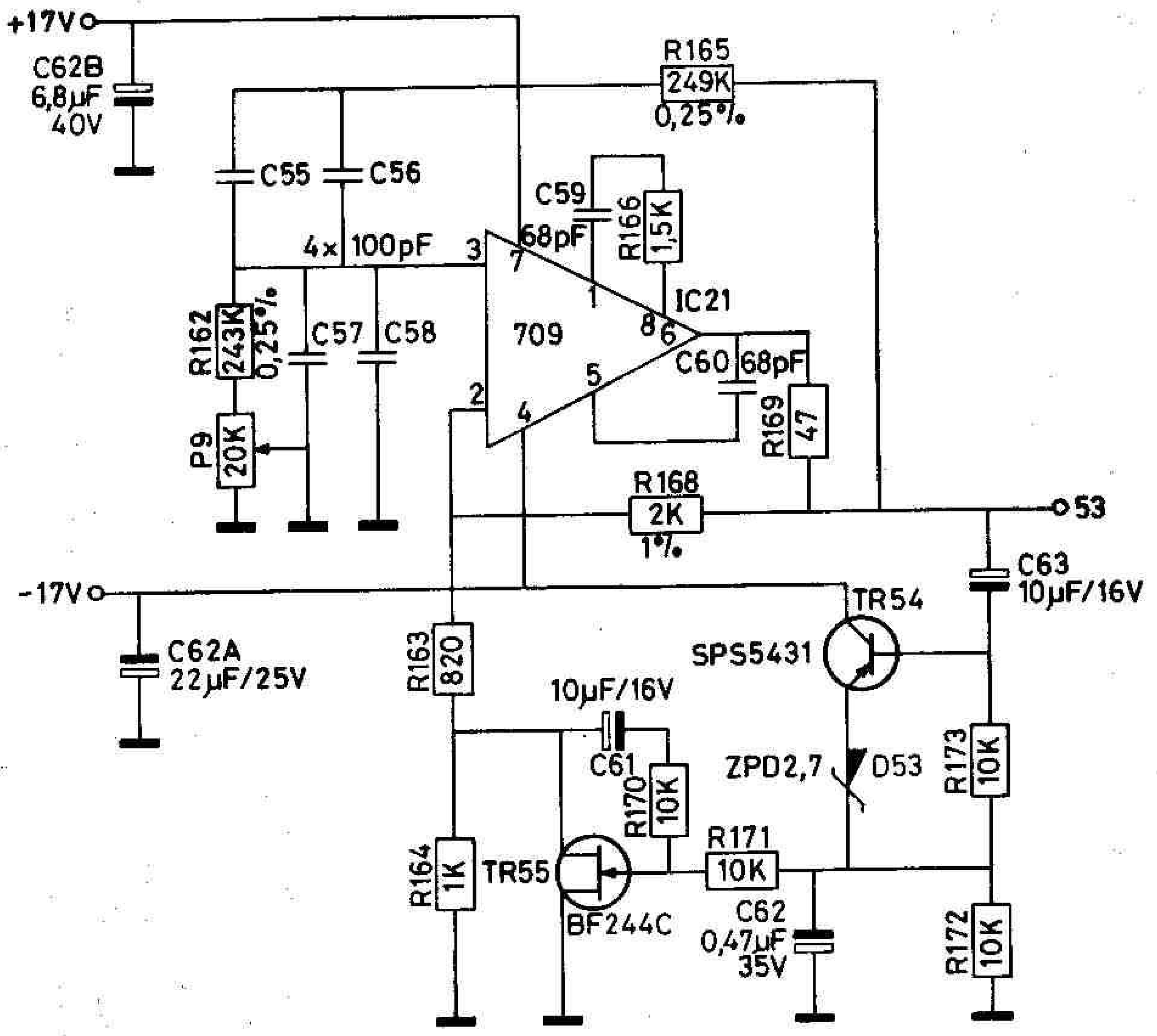
Parts layout for circuit board A.
Power supply, oscillator etc. (TR54 ... TR60, IC21 ...IC23).

P9
C62B
R166
C59
R172
R168
R173
D53
R164
R163
TR56
P10
TR57
C55
C56
IC21
R169
C60
C62
C61
IC22
R175
R174
R176
D55
R181
TR58
R165
R177
IC23
C57
TR55
C65
R178
R179
D54
R180
C64
R162
C58
TR54
R171
R170
C66
C62A
C63
C69
C68
R186
C67
D56

Power Supply



3,15KHz Oscillator



25 x FET-Switch Driver.

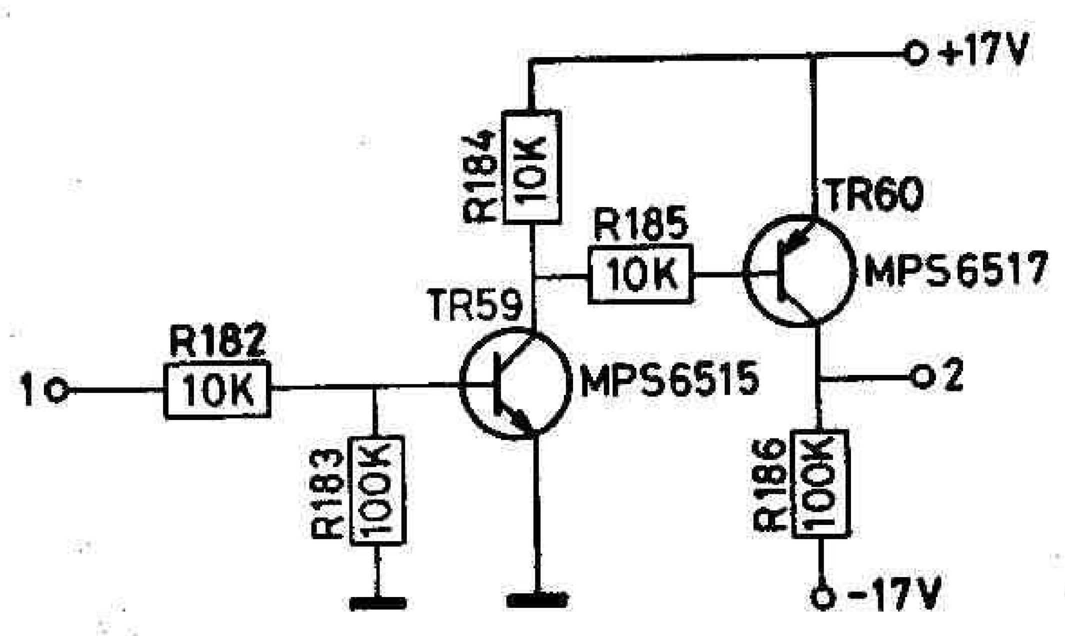
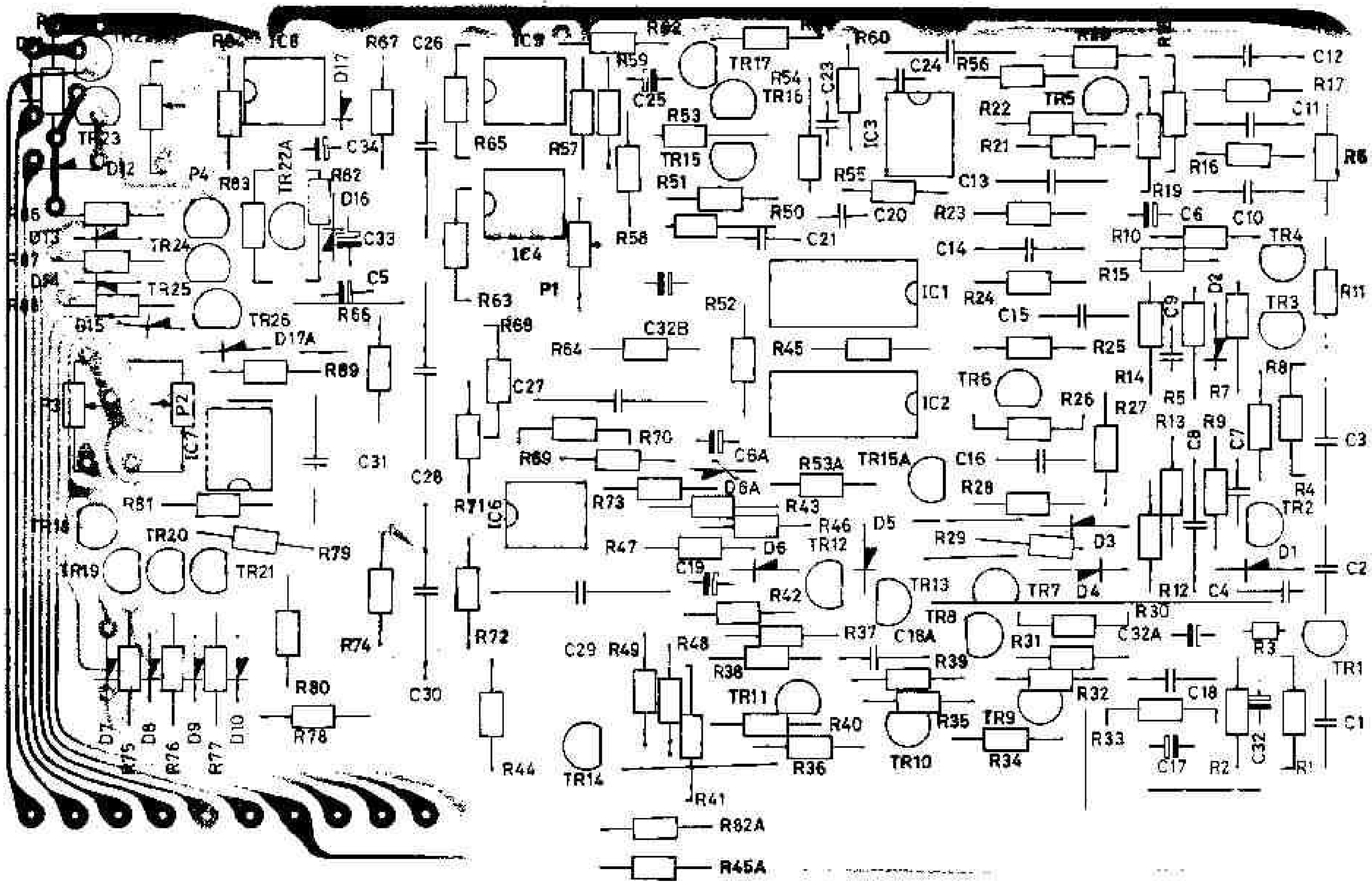


Diagram for circuit board A.
Power supply, oscillator etc. (TR54...TR60, IC21...IC23).

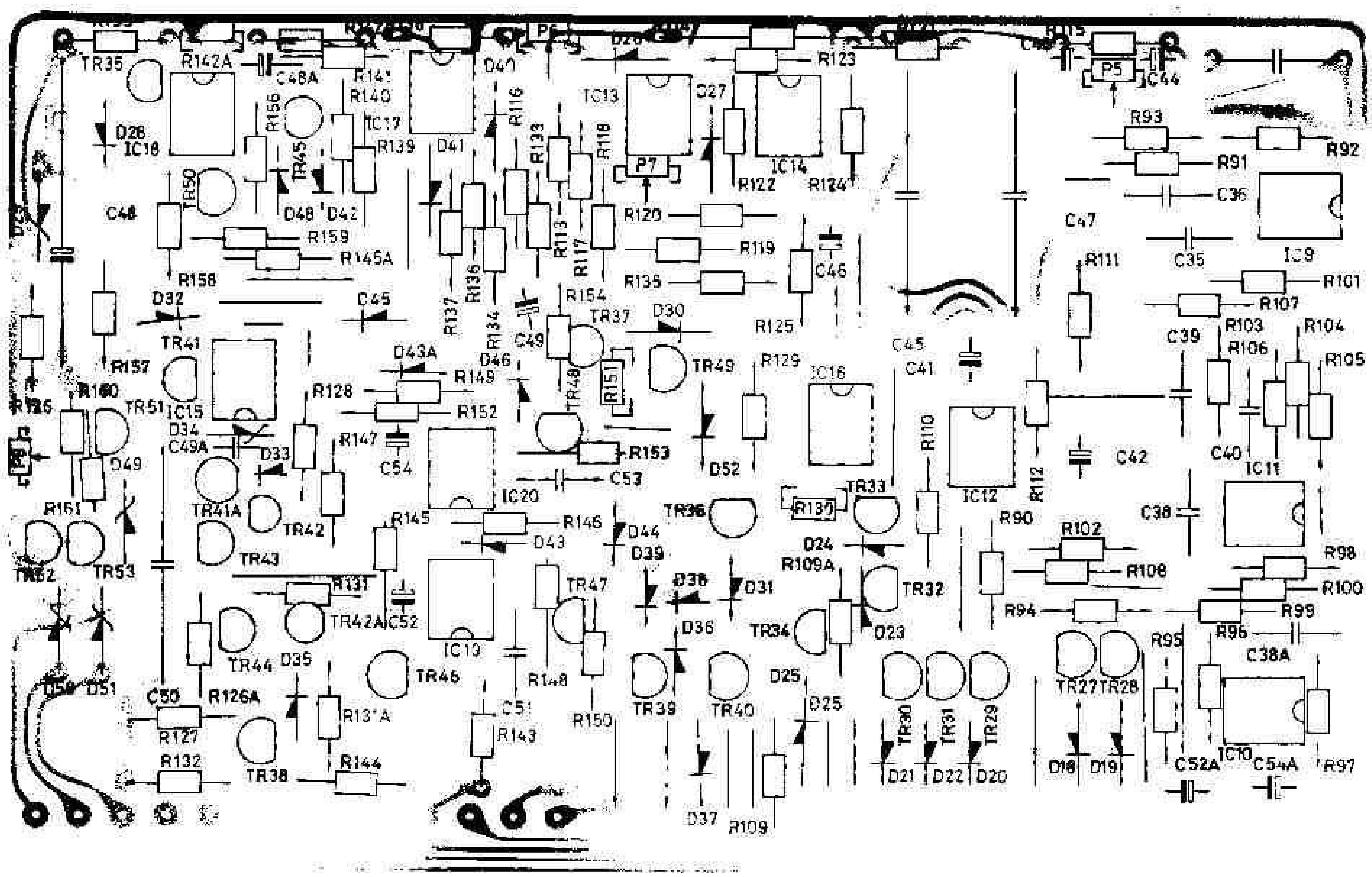


Parts layout for circuit board B.
Input stage, detector, attenuator etc.
(TR1...TR26, IC1...IC8).


R85
D11
TR22
R84
IC8
D17
R67
C26
IC5
R62
R61
R60
C22
R20
R18
C12
R59
TR17
R54
C23
C24
R56
R17
C25
TR16
TR5
C11
TR23
C34
R65
R57
R53
IC3
R22
D12
TR22A
R82
TR15
R21
R16
R6
P4
R83
D16
R51
R55
C13
R19
R86
R50
C20
R23
C6
C10
D13
C33
C21
R10
TR4
R87
TR24
R58
C14
IC4
D14
TR25
C5
P1
IC1
R15
R11
R88
R66
R63
R24
D2
D15
TR26
R52
C15
C9
TR3
D17A
R68
C32B
R64
R45
R25
R89
C27
TR6
R14
R8
P3
R5
R7
P2
IC2
R26
R27
IC7
R70
R13
R9
C8
C7
C3
R69
C6A
R53A
TR15A
C16
C31
C28
D6A
R4
R81
R71
IC6
R73
R43
R28
TR2
TR18
R46
D5
TR20
R79
R47
D6
TR12
R29
D3
D1
TR19
TR21
C19
TR13
TR7
D4
R12
C4
C2
R42
R30
TR8
R37
C18A
C32A
R3
R74
R72
C29
R49
R48
R31
R38
R39
TR1
R80
C30
TR11
R32
C18
R40
R35
TR9
C1
D7
D8
D9
D10
R78
R75
R76
R77
R44
TR14
R36
TR10
R34
R33
C17
R2
C32
R1
R41
R82A
R45A

Diagram for circuit board B.
Input stage, detector, attenuator etc.
(TR1…TR26, IC1…IC8).

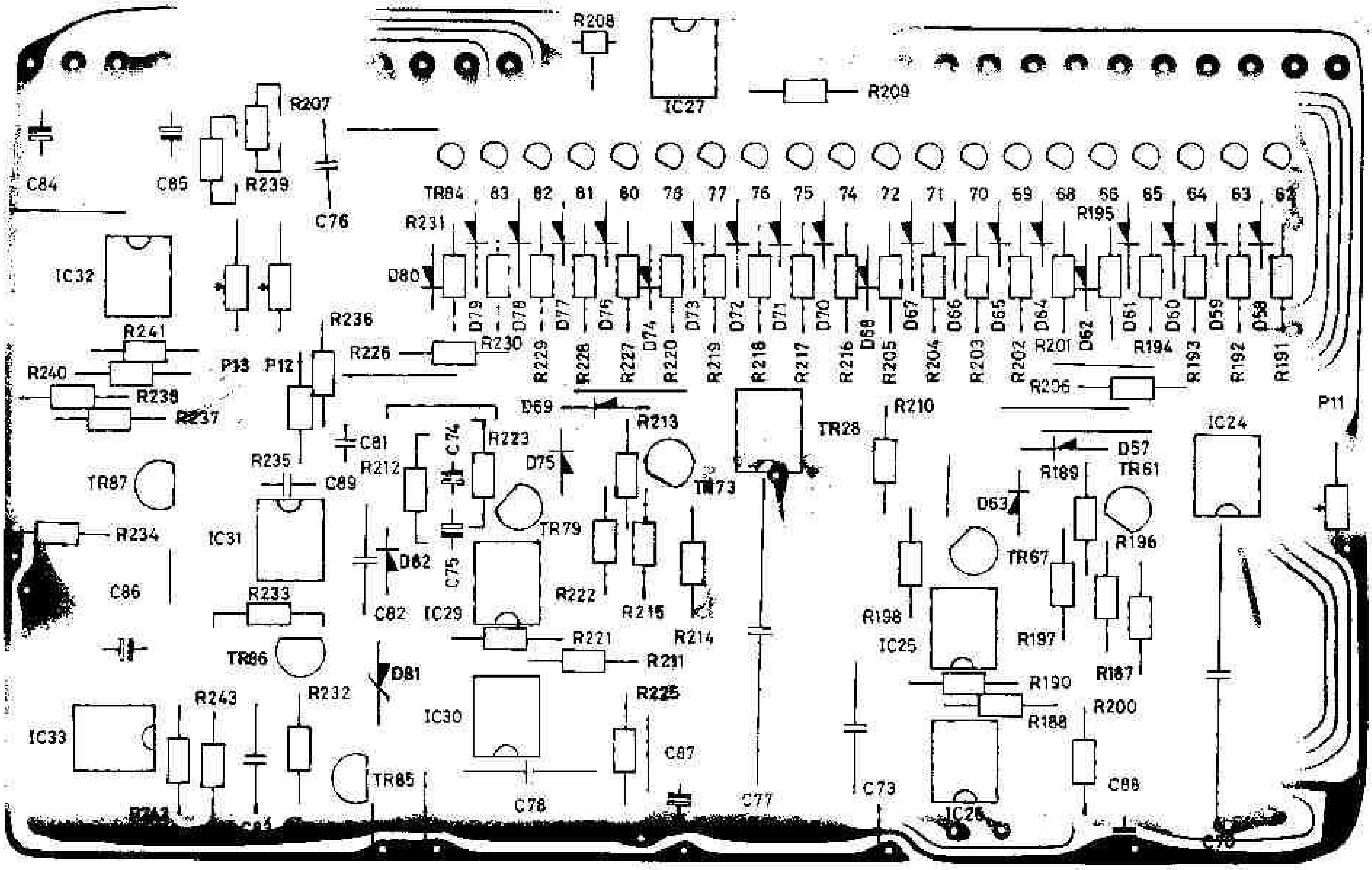
◌ Located outside circuit board.



Parts layout for circuit board C.
Filters, meter circuit etc.
(TR27...TR53, IC9...IC20).


R155
R142A
R142
R138
P6
R114
D26
R121
R115
C43
C44
P5
TR35
C48A
R141
R140
D40
IC13
D27
R123
R116
IC17
R156
TR45
R139
D41
R133
R118
IC14
C37
R93
R92
R91
D28
IC18
TR50
D48
D42
P7
R122
R124
R120
C36
C48
D29
R159
R145A
R113
R117
R119
C47
C35
IC9
R136
R137
R134
R135
C46
R111
R101
R158
D32
D45
R154
TR37
D30
R107
R125
R103
R104
TR41
R157
D43A
D46
C49
R129
C45
C41
R106
C39
R105
R160
R126
TR51
IC15
R128
R149
R152
TR48
R151
TR49
IC16
D34
C49A
P9
D49
D33
R147
C54
R153
D52
R110
IC12
R112
C42
C40
IC11
R161
TR41A
TR42
IC20
C53
TR36
R130
TR33
R90
R102
C38
R145
R146
D44
D24
TR52
TR53
TR43
D43
D39
R109A
R108
R98
R100
R131
TR47
D38
D31
TR32
R94
R99
TR42A
C52
D36
TR34
D23
R96
IC19
R95
C38A
D50
D51
TR44
D35
TR46
R148
D25
TR27
TR28
C50
R126A
R131A
C51
R150
TR39
TR40
TR30
TR31
TR29
R127
R143
IC10
C52A
C54A
R132
R144
TR38
D21
D22
D20
D18
D19
R97
D37
R109

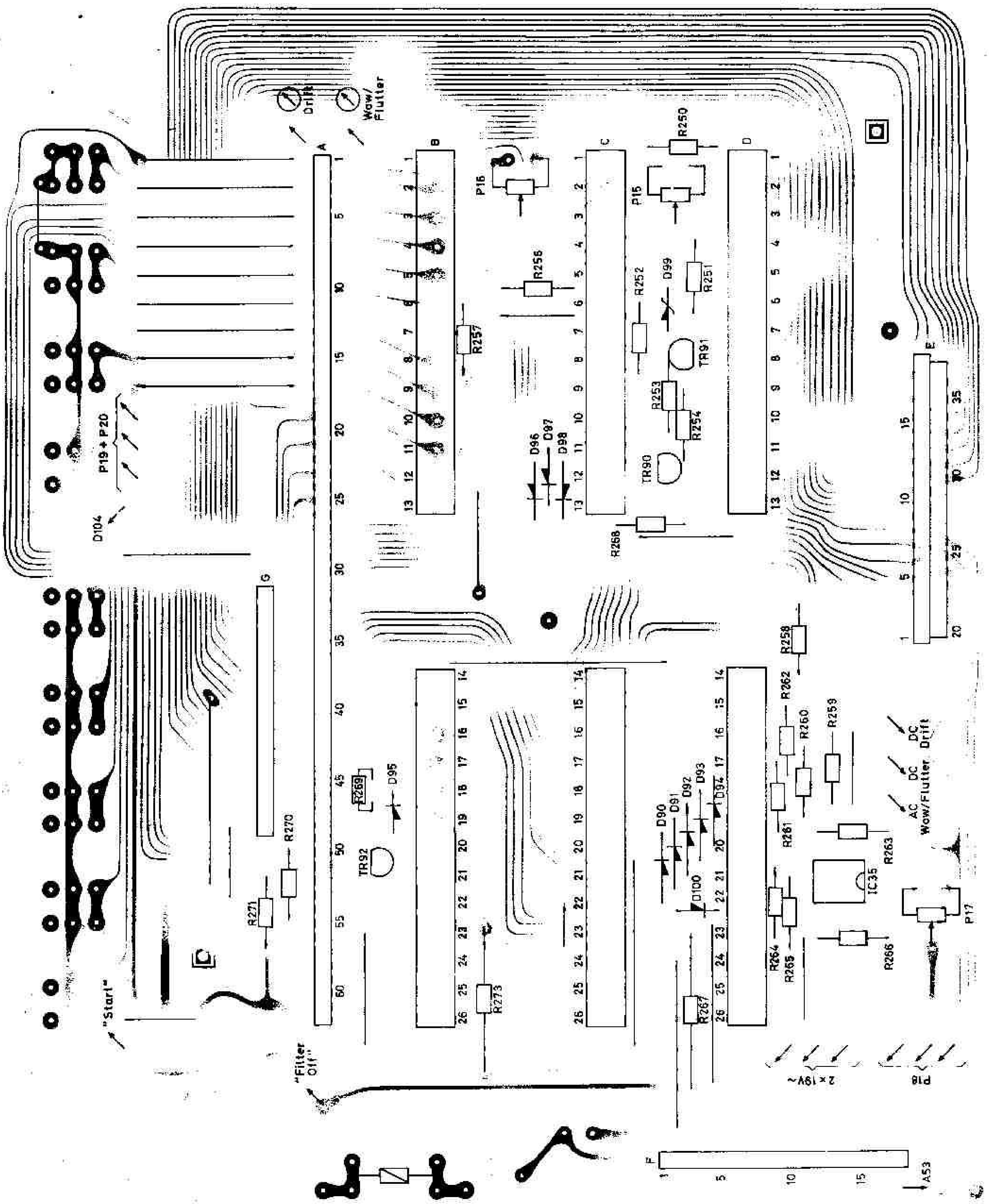
Diagram for circuit board C. Filters, meter circuit etc. (TR27…TR53, IC9…IC20).



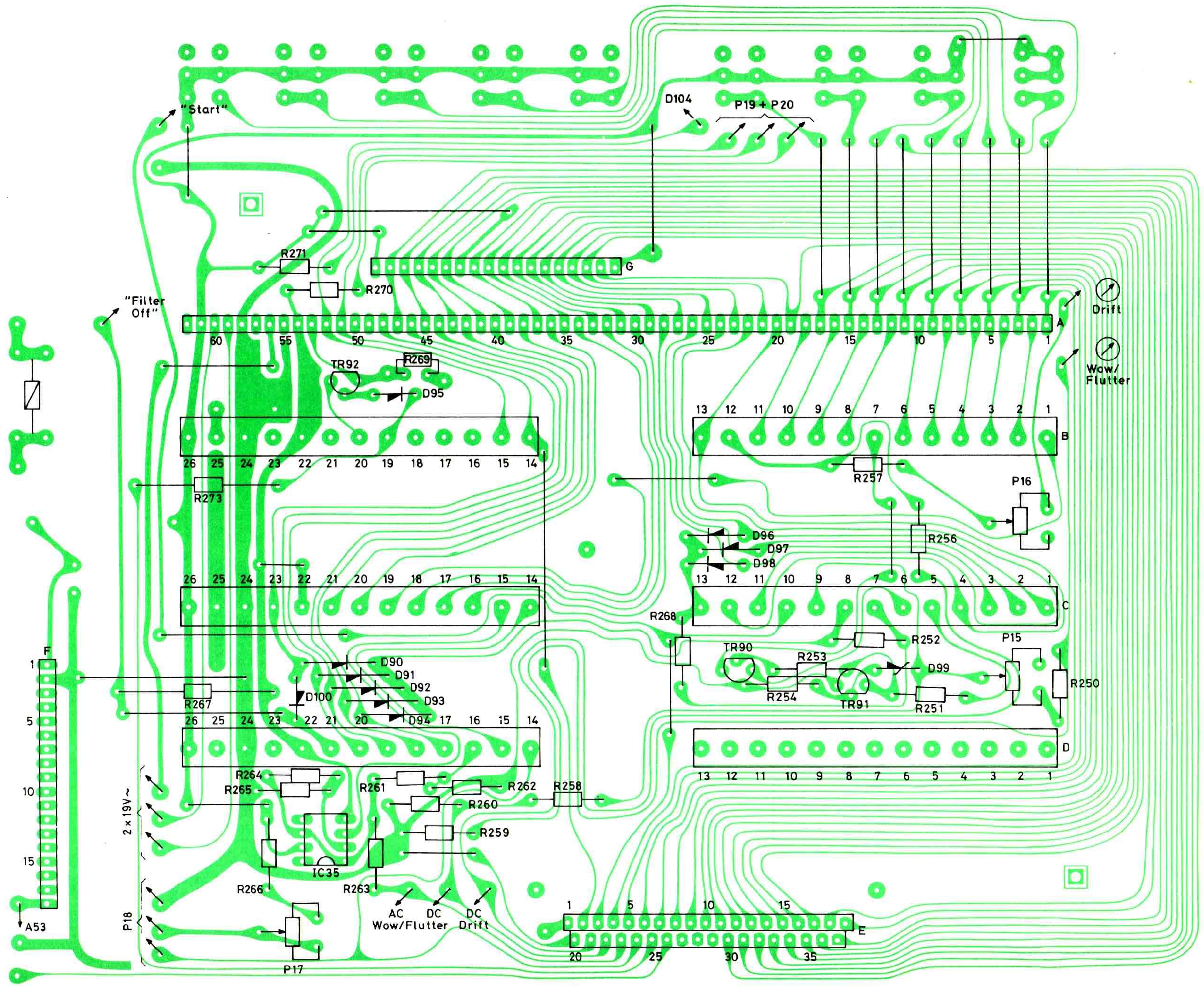
Parts layout for circuit board D.
Frequency analyser (TR61...TR87,
IC24...IC33).

C70
C88
IC26
C73
C77
C78
C87
TR85
C83
R242
IC33
R188
R200
R190
R187
R197
IC25
R198
R225
IC30
R211
R214
R221
IC29
D81
R232
TR86
C82
R233
C86
R215
R222
C75
D82
IC31
R234
TR67
R196
D63
TR79
TR87
TR61
R189
TR73
D75
C89
R212
R235
IC24
D57
TR28
R223
C74
C81
R210
R213
D69
R237
R238
P11
R206
R240
R191
R192
R193
R194
R201
R202
R203
R204
R205
R216
R217
R218
R219
R220
R227
R228
R229
R230
R226
P12
P13
R241
R236
D58
D59
D60
D61
D62
D64
D65
D66
D67
D68
D70
D71
D72
D73
D74
D76
D77
D78
D79
D80
IC32
R195
R231
C76
62
63
64
65
66
68
69
70
71
72
74
75
76
77
78
80
81
82
83
TR84
R239
C85
C84
R207
IC27
R209
R208

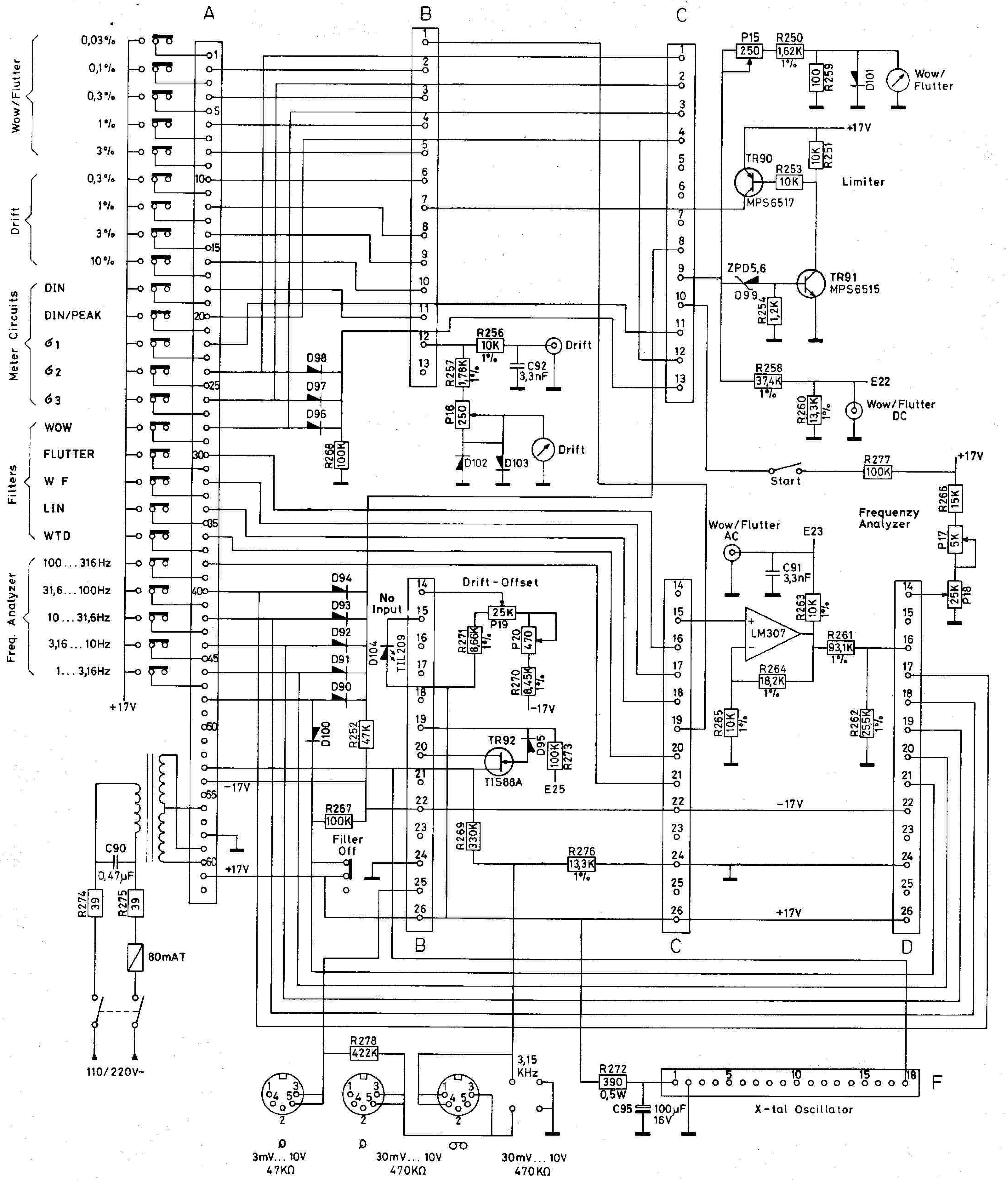
Diagram for circuit board D.
Frequency analyser (TR61…TR87, IC24…IC33).



Parts layout for circuit board E.
Bottom board. (TR90…TR92, IC35).



"Start"
D104
P19 + P20
Drift
Wow/
Flutter
"Filter
Off"
R271
R270
G
A
TR92
R269
D95
B
C
D
E
F
R273
R257
P16
R256
D96
D97
D98
R268
R252
P15
R250
TR90
R253
D99
R254
TR91
R251
D90
D91
D92
D93
D94
D100
R267
R264
R265
R261
R262
R258
R260
R259
2 x 19V~
IC35
R266
R263
AC
Wow/Flutter
DC
DC
Drift
P18
P17
A53



Dioder: 1N4148

Diagram for circuit board E.
Bottom board. (TR90...TR92, IC35).