

BKF6d
DISTORTION
METER



OPERATING INSTRUCTIONS

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Distortion Meter

Type BKF6

Section A. Introduction

The Distortion Meter, type BKF6, is a line-operated precision instrument permitting correct measurements of the percentage of distortion on signals from 20 cps to 20 kc, in accordance with the CCIF-Standards which define distortion as the ratio of the root-mean-square (rms) value of the harmonics alone to that of the total signal.

The measured distortion is directly indicated in percentage on the built-in rms-reading meter, which has full-scale deflection for distortions from 0.3% to 100% in a 1-3-10 sequence, with first scale division at 0.01%.

With the selective network left out, the

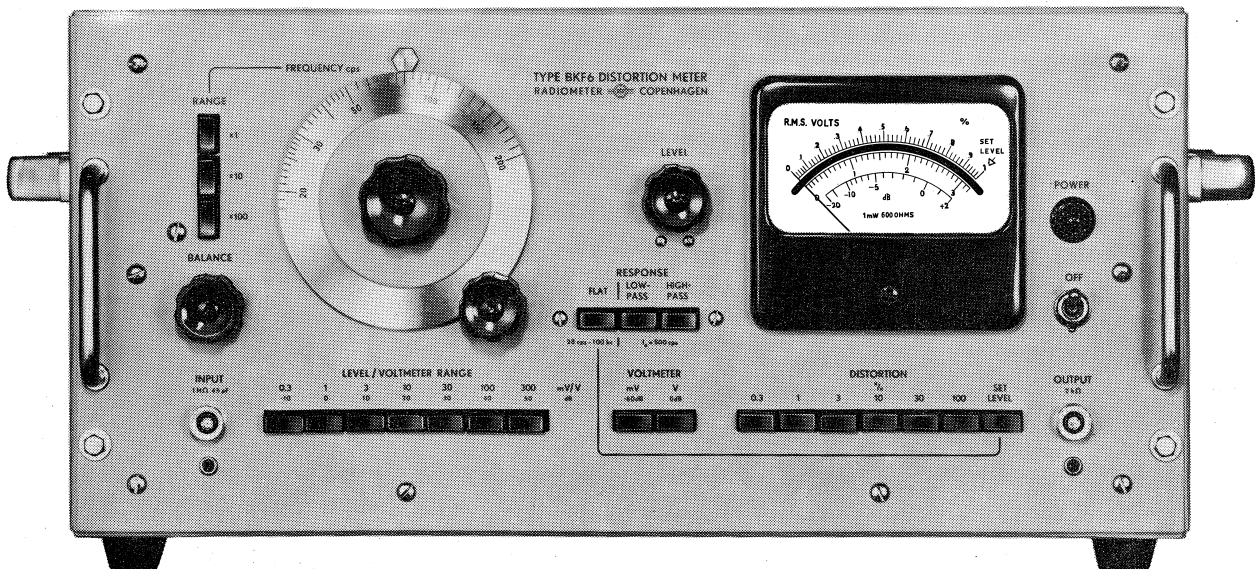


Fig.1 The Distortion Meter, type BKF6.

Distortion Meter can be used as a sensitive VTVM with a frequency range from 20 cps to 200 kc, and full-scale deflection for input voltages from 0.3 mV to 300 V, in a 1-3-10 sequence. Furthermore, it can operate as a calibrated amplifier with a gain adjustable in 10 dB steps from -30 to +90 dB, and with a very low residual distortion of approximately 1% at 30 V and with a maximum output voltage of 50 V.

The Distortion Meter, type BKF6, is push-button controlled, thus providing fast and clear operation.

Distortion factor measurements are often necessary in laboratory and electronic shop work. For measurements on tone generators, amplifiers, etc., the Distortion Meter, type BKF6, is an eminent instrument which makes possible fast and convenient measurements of the total harmonic distortion.

Section B. Specifications

DISTORTION METER

Frequency Range:

Fundamental Frequency:

20 cps to 200 kc in 3 decade ranges.

Distortion Frequency:

20 cps to 200 kc.

Frequency Accuracy:

2%

Frequency Attenuation:

Fundamental reduced by more than 80 dB.
Second harmonic attenuated less than 0.3 dB.

Distortion Ranges:

0.3% to 100% f.s. in a 1-3-10 sequence.

Meter:

Senses rms.
Meter scale linear.
First scale division at 0.01%.

Taut-band suspension.

Accuracy:

$\pm 3\%$ of f.s. + 0.01% distortion.
If high-pass or low-pass filter is used, consult filter curves for possible correction.

Residual Distortion:

Less than 0.01%

Sensitivity:

110 mV to 300 V f.s. adjustable by a 10 dB step-attenuator and a fine control covering 14 dB.

High Pass and Low Pass

Filters:

The filters are double RC filters with cut-off frequencies of 250 cps and a 12 dB/oct. slope.

Input Impedance:

Constant 1 M Ω shunted by 45 pF, unbalanced.

Output:

10 V at full meter deflection. Output impedance 2 k Ω in series with 4 μ F.

VOLTMETER

Frequency Response:

20 cps to 100 kc within 0.3 dB, up to 200 kc within 1 dB.

Sensitivity:

0.3 mV to 300 V rms (-72dB to +52dB) f.s. in a 1-3-10 sequence.

Accuracy:

Better than 5% of f.s. with a crest-factor 2.8 (square wave on-off ratio 1:9)

Input Impedance:

1 M Ω shunted by 45 pF.

Noise:

5 to 15 μ V depending on source impedance and attenuator setting.

Hum at Output Jack

Less than 5 μ V referred to input at max. sensitivity.

AMPLIFIER

Gain:

-30 dB to +90 dB in 10 dB steps.

Frequency Response:

20 cps to 100 kc within 0.3 dB, up to 200 kc within 1 dB.

Output Voltage:

10 V at full deflection, 30 V with about 1% distortion, 50 V max.

Hum: Approx. 50 mV.

Output Current:

3 mA max.

Output Impedance:

2 k Ω in series with 4 μ F.

TERMINALS

Input and Output Sockets:

UHF coaxial sockets, type SO239.

POWER SUPPLY

110- 115- 127- 200- 220- 240 V, 50-60 cps.

Consumption 35 watts.

TUBES

4 E80CF special quality tubes.

OVER-ALL DIMENSIONS

HEIGHT	WIDTH	DEPTH
25 cm	49 cm	21 cm
10 inches	19 1/4 inches	8 1/5 inches

WEIGHT

14 1/2 kilos (32 lbs.)

ACCESSORIES SUPPLIED

1 Type 12G19-1.5, Power Cord.

ACCESSORIES AVAILABLE

Type BAT11 and BAT12 Balancing Transformers for direct mounting on input socket.

Type AD1 Adapter accommodating 14 mm coax. plug.

Type AD2 Adapter accommodating 13 mm coax. plug.

1 Type 3B3 Coaxial Cable (60 pF capacity) terminated in two UHF Type PL259 Plugs.

Section C. Accessories

The type BAT 1:1 transformers change the one-side grounded input of an instrument to a balanced input.

Two models are available:

Type BAT11 is an audio-frequency type for use from 25 cps to 50 kc.

Type BAT12 is a carrier frequency type for use from 10 kc to 500 kc.

The illustration shows the type BAT12. The type BAT11 is similar in appearance, although it has a smaller core and a correspondingly lower weight.

The transformers are furnished with the type PL-259 UHF plugs. Therefore, they can be plugged directly into the inputs of the Distortion Meter, type BKF6.

The Balancing Transformers are designed with special attention to the frequency response, the electrostatic shielding, and the input impedance.

The input terminals accommodate ordinary 4 mm banana plugs.

TYPE BAT11

Voltage Ratio:

1 : 1

Frequency Response:

25 cps to 50 kc within ± 0.5 dB.

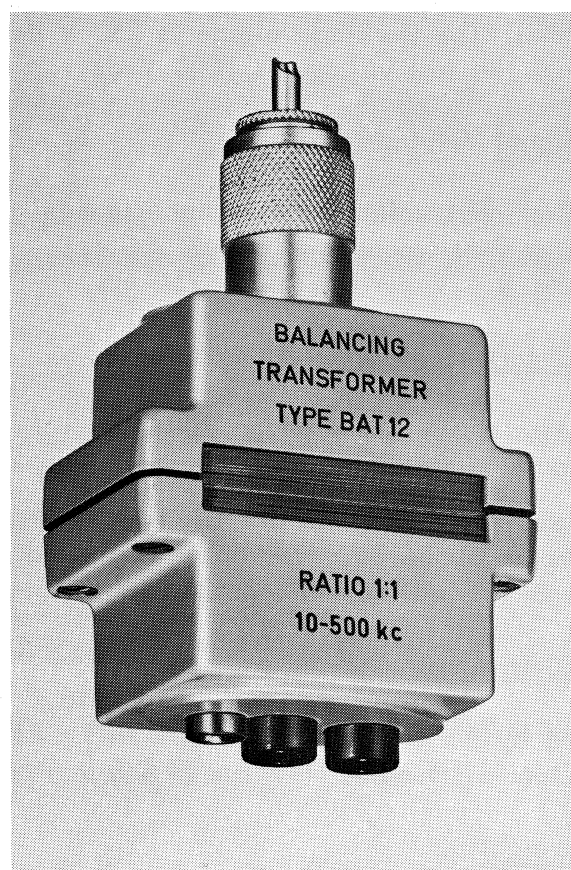


Fig.2. The Balancing Transformer , type BAT12.

Input Impedance:

Higher than $10\text{ k}\Omega$ throughout the frequency range, provided that the secondary load is less than 20 pF .

Symmetry:

Common-mode signal rejection:

90 dB at 500 cps
 70 dB at 5 kc
 45 dB at 50 kc

Magnetic Pick-Up:

When the primary is connected to a source with 300Ω impedance, a typical case, the magnetic pick-up is very low.

Insulation:

The dc leakage between the primary and the shield is less than 5×10^{-10} mhos. The working voltage is 250 V dc, and the test voltage is 1000 V dc.

Signal Voltage:

The input voltage should not exceed 100 V at frequencies above 250 cps and 0.4 V per cps below 250 cps.

Distortion:

With a 5 V input and a 300Ω primary source impedance, the distortion is:

less than 0.2% 2nd and 0.2% 3rd harmonic above 100 cps, about 0.6% 2nd and 1% 3rd harmonic at 30 cps.

Dimensions:

54 by 45 mm (2 3/16 by 1 3/4 in.)
 Over-all length: 117 mm (4 5/8 in.)

Weight:

500 grams net (1 lb. 2 oz.).

TYPE BAT12

Voltage Ratio:

1 : 1

Frequency Response:

10 kc to 500 kc within ± 0.5 dB.

Input Impedance:

Higher than $3 \text{ k}\Omega$ throughout the frequency range, provided that the secondary load is less than 20 pF.

Shielding:

The mutual capacitance between the windings is less than 1 pF.

Symmetry:

Common-mode signal rejection:

65 dB at 50 kc
 60 dB at 100 kc
 50 dB at 500 kc

Magnetic Pick-up:

When the primary is connected to a source with 300Ω impedance, a typical case, the magnetic pick-up is very low.

Insulation:

The dc leakage between the primary and the shield is less than 5×10^{-10} mhos. The working voltage is 250 V dc, and the test voltage is 1000 V dc.

Signal Voltage:

The input voltage should not exceed 100 V.

Dimensions:

58 by 36 mm (2 1/4 by 1 7/16 in.).
 Over-all length: 102 mm (4 in.).

Weight:

225 grams net (8 oz.).

Section D. General Description

GENERAL

The principle of operation is indicated in the block diagram shown in Fig.3.

The input amplifier stage, preceded by a 6×10 dB attenuator, is very carefully designed to ensure that the residual distortion of the Distortion Meter is kept down to a minimum.

The selective section of the Distortion Meter is a Wien Bridge fed from a 1:2 driver stage. The bridge reduces the signal level of the frequency to which it is adjusted (fundamental frequency) by more than 80 dB. Negative feedback is introduced from the amplifier stage following the Wien Bridge to the input amplifier stage in order to obtain a flat response for all the harmonics.

The harmonics and hum components are via the VOLTMETER-DISTORTION at-

tenuator passed on to the output amplifier and further to the rms rectifier when the RESPONSE switch is set to FLAT. If the HIGH PASS or LOW PASS positions are used, only the harmonics or the hum components are measured.

CONTROLS, TERMINALS, and METER

As shown in Fig.4 the Distortion Meter, type BKF6, is equipped with the following controls, terminals and meter:

POWER SWITCH (OFF) (1), and PILOT LAMP (POWER) (2)

Power switch and pilot lamp are located on the right hand side of the front panel.

FREQUENCY DIAL (3) and RANGE SWITCH (4)

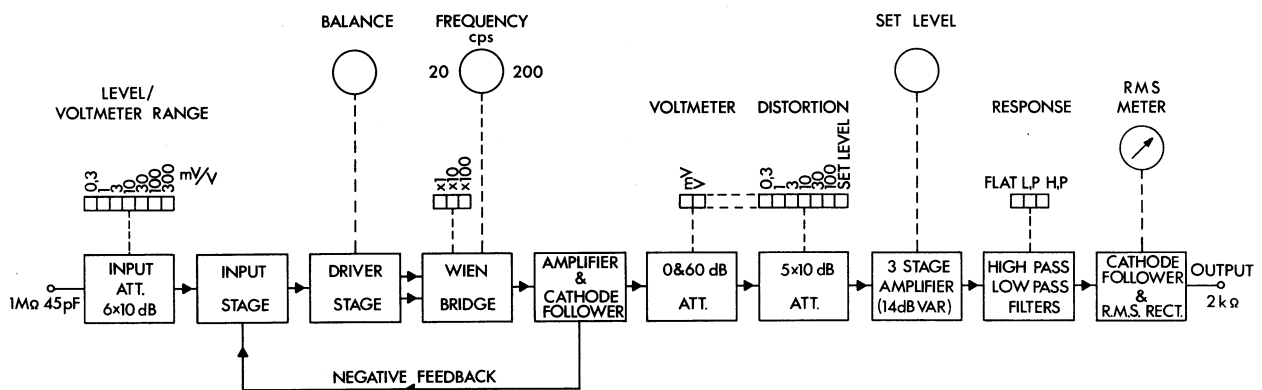


Fig. 3. Block diagram of the Distortion Meter, type BKF6.

The FREQUENCY dial is located on the left hand part of the front panel and is engraved from 20 to 200. It is operated by means of two knobs:

The center knob for coarse adjustment and the knob on the periphery of the frequency dial for fine adjustment.

The driving mechanism of the latter can be disengaged, by pressing downwards on the knob, to allow for fast rotation of the frequency dial. The frequency range is shifted by means of the three frequency RANGE push-buttons which are located to the left of the frequency dial and which introduce multiplying factors of $\times 1$, $\times 10$, and $\times 100$, whereby the total frequency range of 20 - 20.000 cps is covered.

BALANCE Potentiometer (5):

The BALANCE potentiometer is located below the RANGE buttons. The potentiometer balances the driver stage of the Wien Bridge.

LEVEL/VOLTMETER RANGE Switch (6) and VOLTMETER Switch (7):

The LEVEL/VOLTMETER RANGE Switch is a series of push-buttons located below the frequency dial. In connection with the VOLTMETER Switch placed next to it, the desired voltage range is selected. The designation of the button activated indicates the input voltage necessary for full meter scale deflection when the Distortion Meter is used as a voltmeter.

RESPONSE Selector (8):

The RESPONSE Selector consists of three buttons, switching in or out the HIGH and LOW PASS filters, or disengaging them, according to the desired response. This series of push-buttons is located immediately above the two VOLTMETER buttons.

DISTORTION and SET LEVEL (9):

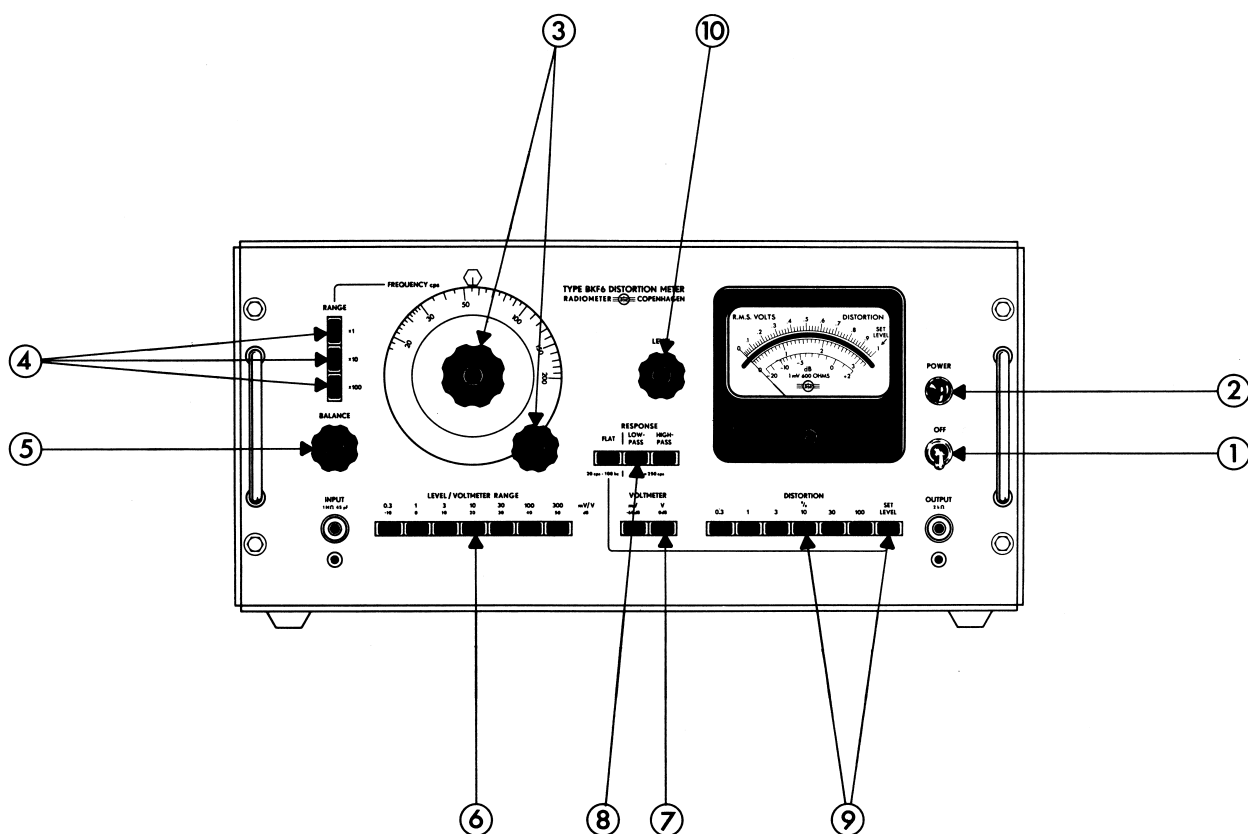


Fig. 4. Front plate of the Distortion Meter, type BKF6.

The row of push-buttons DISTORTION is located below the indicating meter. The buttons are used to select the desired distortion percentage range. The buttons switch the potentiometer LEVEL ⑩ into circuit with the button SET LEVEL pressed. The potentiometer is used for fine adjustment of the meter indication prior to the distortion measurement.

TERMINALS:

Both the input and output terminals accommodate banana plugs and UHF plugs. Adapters allow for the use of a 13 mm or 14 mm coaxial plug.

METER:

The meter is equipped with a mirror-backed scale and a knife-edged pointer providing for accurate reading free from parallax. It has three scales. The two upper scales are used when measuring distortion or voltage, the reading being directly given as a percentage, in rms millivolts, or in volts, respectively. The lower scale is used for level measurements and is graduated in decibels, (0 dB = 0.775 V). The mechanical zero screw is located on the meter itself.

LINE VOLTAGE JACK, FUSE and VOLTAGE INDICATOR:

All three are located on the rear of the instrument. Use a 160 mA slow-blow fuse for line voltages between 200 and 240 volts and a 320 mA for 110 - 127 volts operation. The Distortion Meter, type BKF6, is set to a line voltage of 220 volts when leaving the factory and is furnished with the corresponding fuse.

Reading another line voltage is made possible by loosening the center screw and rotating the disc.

NOTE:

REMEMBER to resolder one supply lead to a different tag on the supply transformer when switching to another line voltage, and to exchange the fuse when switching from 200-240 to 110-127 volts operation and conversely. See page 23.

Section E. Operating Instructions

PREPARING THE DISTORTION METER, Type BKF6:

Check that the instrument is switched to the correct line voltage as indicated by the plate on the rear of the cabinet. Connect the instrument to the line voltage and switch on. After a few minutes warm-up time, the Distortion Meter is ready for use.

USED AS A DISTORTION METER:

- 1) Connect the object to be measured to the input terminals of the Distortion Meter, type BKF6.
- 2) Select the desired frequency range.
- 3) Select the desired level range.
- 4) Push the RESPONSE button FLAT.
- 5) Push the SET LEVEL button and adjust the LEVEL knob until the meter reading coincides with the mark SET LEVEL on the upper scale of the meter.
- 6) Select the different distortion ranges one after another, starting with 100%, and adjust to minimum deflection for each range by means of the frequency knob, the balance knob being used for fine adjustment in the lower ranges. The smallest value obtained is the percentage of distortion of the object under test.

- 7) Press the RESPONSE button HIGH PASS in order to limit the influence of hum, if the rms level of the harmonics is wanted. If the fundamental frequency (the frequency to which the FREQUENCY dial is tuned) is lower than 500 cps, please consult the response curves of Fig.5 for correction.
- 8) Press the RESPONSE button LOW PASS in order to limit the influence of the harmonics, if the rms level of the hum components is wanted. This measure-

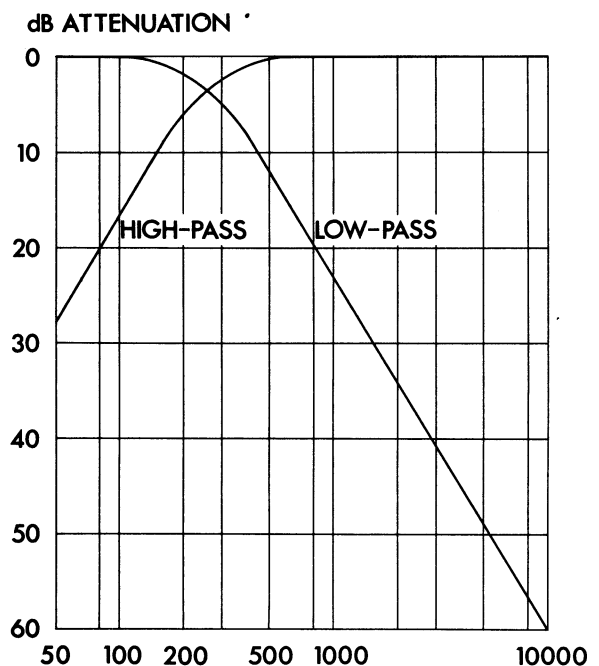


Fig.5. Response Curves of the built-in low-pass and high-pass filters.

ment is only relevant for fundamental frequencies above 1 kc. For fundamental frequencies below 5 kc, please consult the response curves of Fig.5 for correction.

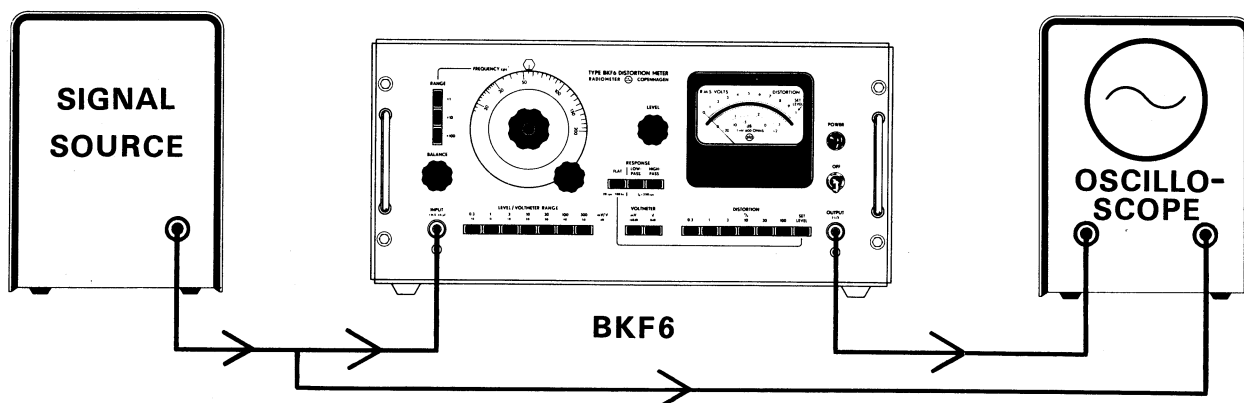
NOTE:

Examinations of the predominant harmonic frequency is most conveniently carried out by connecting the X and Y inputs of an oscilloscope across the Distortion Meter input and output ter-

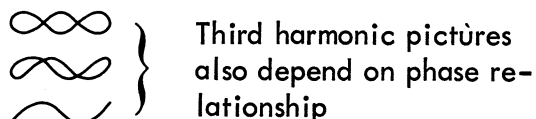
minals and observing the resulting Lissajous figure. (See Fig.6).

USED AS A VTVM:

- 1) Connect the object under test to the input of the Distortion Meter.
- 2) Press RESPONSE FLAT.
- 3) Select the desired voltage range. The voltage is read directly on the meter in rms volts or millivolts.



Proper alignment of the DISTORTION METER, type BKF6, gives on the oscilloscope the pictures shown when only second or third harmonics are present.



Improper BALANCE tilts the picture:



Improper FREQUENCY setting "opens" the picture:



The pictures are in general more complicated because several harmonics and hums are present.

Fig. 6. The Distortion Meter, type BKF6, connected to an oscilloscope to examine the predominant harmonic. The Lissajous figures obtained for the second and third harmonics as predominant harmonics, respectively, are also shown.

- 4) Release the three RANGE buttons at input frequencies higher than 50 kc.

USED AS AN AMPLIFIER:

- 1) Connect the signal source to the input of the Distortion Meter.
- 2) Release the three RANGE buttons.
- 3) Select RESPONSE FLAT.
- 4) Select mV or V and the voltage range.
- 5) The output voltage can be read off the meter, since full-scale deflection corresponds to an output voltage of 10 V rms.
- 6) The gain as a function of the input voltage setting is as follows:

VOLTMETER RANGE	GAIN
0.3 mV	90 dB
1 mV	80 dB
3 mV	70 dB
10 mV	60 dB
30 mV	50 dB
100 mV	40 dB
300 mV	30 dB

1	V	20 dB
3	V	10 dB
10	V	0 dB
30	V	-10 dB
100	V	-20 dB
300	V	-30 dB

- 7) The output may be increased to approx. 14 dB above the value giving full meter scale deflection.

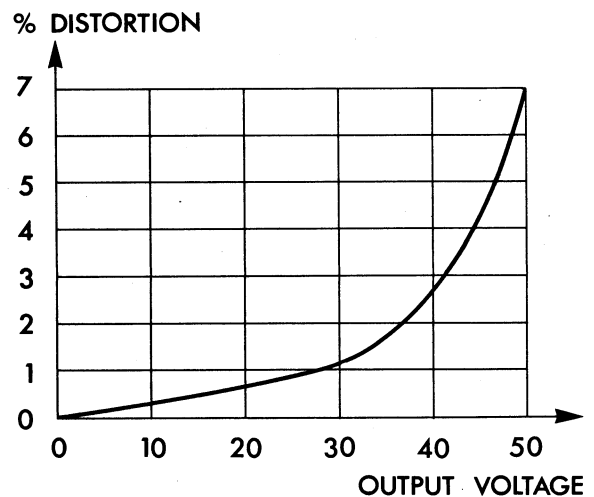


Fig.7. Curve showing the typical distortion of the output signal as a function of the output voltage.

Section F. Circuit Description

The input signal is attenuated by individual voltage dividers for each setting so as to keep constant both the input resistance and the capacity (please refer to the circuit diagram at the end of this instruction manual). When used as a distortion meter, the fundamental frequency is found only on the first two tubes, V1A and V1B. In order to minimize the formation of harmonics in these tubes, the working point of V1A is adjusted so that the second harmonic generated in V1A will compensate for that generated in V1B. The residual distortion of the Distortion Meter is thus made less than 0.01% for distortion measurements at 0.3 V input and less than 0.003% for 0.1 V input.

The selective section of the Distortion Meter, type BKF6, is a Wien-Bridge which reduces the signal level of the tuning frequency by more than 80 dB. The circuit of the Wien-Bridge is shown in Fig.8.

The anode resistor and the cathode resistor of tube V1B form the non-selective branch of the bridge.

The selective branch consists of a tandem variable capacitor (FREQUENCY) and three switchable pairs of resistors (RANGE).

The diagonal voltage generated by tube V1B is divided by 3 by the selective branch at the tuning frequency ($f = \frac{1}{2\pi RC}$)

If the BALANCE control is so set that the left branch of the bridge also divides the generator diagonal voltage by 3, then the other (output) diagonal voltage is zero. The fundamental frequency can thus be rejected from the signal fed to tube V2A.

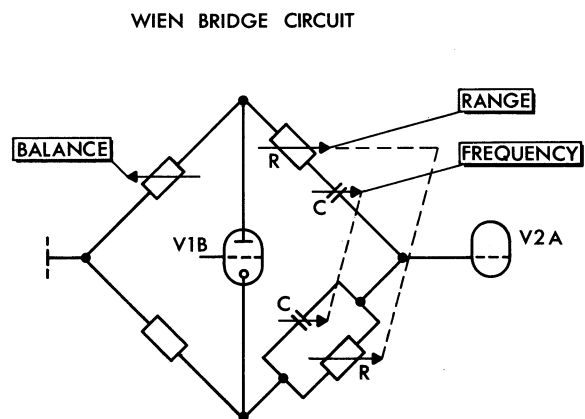


Fig.8. The Wien-Bridge of the Distortion Meter, type BKF6.

The disturbing influence of the grid capacity of the tube V2A on the Wien-Bridge is minimized by supplying the current, drawn by the grid of V2A, from the anode of V2b via a capacitive attenuator, which can be adjusted by means of a trimmer (C212).

The response at low frequencies depends to some extent on the capacity of electrolytic capacitors with an unavoidable

spread in their value. The response at high frequencies is adjusted by the trimmer C207.

The three-stage amplifier, V3A, V3B, V4A, has a gain of 70 dB when the mV or V push-button is pressed; otherwise the gain depends on the setting of the LEVEL control, that gives a variation of approximately 14 dB.

Strong negative feedback provides for a response within 0.3 dB between 20 cps and 100 kc and within 1 dB to approx. 300 kc. The response falls abruptly under 20 cps in order to prevent disturbance from line voltage surges that create jumps in the dc voltage from the power supply. These jumps are amplified in the selective amplifier and can give rise to meter fluctuations if they are not attenuated.

The response at low frequencies is adjusted with the variable resistor R421.

The response at high frequencies is made optimal by decoupling the cathode resistor of V3B and the main feedback resistor (R413) somewhat at high frequencies.

The flat frequency response can be changed by switching in a high-pass or low-pass filter, both having their 3 dB points at 250 cps. With only the high-pass filter operative, the distortion arising from harmonics is measured, whilst the hum is left out. On the other hand the low-pass filter is able to exclude the harmonics and measure the hum alone. In both cases Fig.5 should be consulted to determine the possible errors from insufficient attenuation.

The low-pass and high-pass filters are 2-stage R-C filters coupled to the succeeding cathode follower in such a way that a "sharp knee" is obtained on the filter curve.

From a cathode-follower driving the rms voltmeter circuit, the output voltage is fed to a coaxial output socket. The output voltage is 10 V at full scale deflection with a maximum value of 50 V.

The rms-sensing meter circuit can handle an input voltage with a crest factor (peak value divided by rms value) of 2.8 at full deflection.

Section G. Maintenance

GENERAL

The Distortion Meter, type BKF6, is designed to withstand rough treatment, but careful handling and proper operation assure a long life and high reliability.

Necessary repairs should be carried out only by skilled personnel equipped with the proper material to ensure that the repairs are correctly made.

REMOVING THE CABINET

Withdraw the power plug from the power outlet before removing the cabinet. The cabinet is attached to the front panel by means of four screws, located on the left and right edges of the front panel, immediately above and below the withdrawing handles.

TUBE REPLACEMENT

If tubes are replaced in an attempt to find a fault in the instrument, it is advisable, in order to simplify the adjustment necessary for tubes No.1 and No.2, to replace only one tube at a time and to insert the old tube again if it is found not to be defective. The tubes are special-quality tubes with a life of at least 10000 hours when the instrument is operated at the nominal line voltage. Only tube No.4 is operated close to the max. rating.

Replacement of tube V1

always calls for a readjustment of the potentiometer MIN. DISTORTION (R202) in order to ensure a second harmonic level lower than -80 dB (typically -90dB) with 300 mV at the grid of V1A and a 10 dB lower level at an input of 100 mV. The third harmonics are typically 10 dB lower than the second harmonics.

Proceed as follows: (See Fig. 9)

- a) Feed a 1 kc signal of 300 mV with less than -110 dB harmonics to the INPUT terminal.
- b) Press SET LEVEL and adjust to full deflection.
- c) Measure the (10 V) 1 kc signal at the OUTPUT terminal with a Wave Analyzer (e.g. RADIOMETER FRA3 or FRA2).
- d) Tune the BKF6 to minimum deflection.
- e) Measure the second harmonic at the OUTPUT with the analyzer and adjust it to a minimum by means of R202 MIN. DISTORTION.

Remember to reduce the reading of the analyzer by 50 dB since the amplification of the BKF6 is increased by 50 dB when the 0.3% DISTORTION button is pressed.

The harmonic level obtained depends on

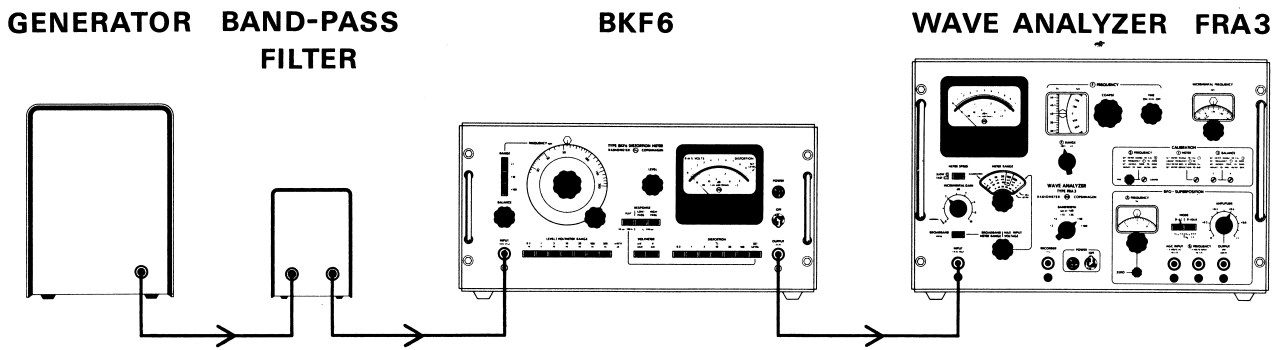


Fig.9. Measuring setups for the readjustment necessary after having replaced tube No.1.

the tube specimen, but very few tubes give a higher distortion level than -85 dB. In that case they have to be rejected from socket No.1.

Replacement of tube No.2

will generally be possible without making any adjustment of the attached trimmers C207 and C212.

C207 determines the frequency response at frequencies higher than 100 kc.

C212 determines the current feed-back to the grid of V2A in order to reduce the loading of the Wien-Bridge.

The correct setting of C212 is checked as follows:

- a) Press SET LEVEL.
- b) Press RANGE x10.
- c) Feed a 10 kc signal to the INPUT and adjust to approximately full-scale deflection.
- d) Turn the FREQUENCY dial through its total range and adjust C212 so that the variation is at a minimum (less than 1%)
- e) Press RANGE x100 and repeat procedure. Make a compromise if the trimmer needs readjusting.

Replacement of tube No.3 and tube No.4 is directly possible with faultless new specimens.

CHECKING THE dc VOLTAGES

Short-circuit the INPUT terminal to chassis and press the button LEVEL/VOLTMETER RANGE -0.3 and the button VOLTMETER-V in order to minimize the risk of getting wrong readings due to overdrive from hum pickup.

Connect the chassis to ground.

Set the line voltage input to its nominal value.

Make sure that the dc outputs of the two power supplies are 25 volts and 350 volts, respectively. If not, adjust R700 and R701 before checking the dc voltages at the various test points. The voltages are shown in the diagram, and deviations of some 10% will generally be of no importance.

RIPPLE VOLTAGES

stated in the diagram are mainly due to the second harmonic of the line frequency. Deviations of some 30% or even more from the stated value will generally be of no importance.

CHECKING THE SIGNAL VOLTAGES

The signal levels stated in the diagram are measured with an input voltage of 316 mV-1kc at the grid of tube V1A, with a meter deflection that is full-scale and with the RESPONSE button FLAT depressed.

Release all three RANGE buttons in order to obtain a low impedance at the grid of tube V2A and thus no noticeable hum pickup.

Minor deviations in signal levels from the values stated are of no importance because the correct sensitivity is set by the variable resistor ADJ: VOLTMETER (R425) in the anode lead of tube V4A.

ADJUSTMENT OF BALANCE COARSE

Replacing one of the resistors, R209, R210, R211 or R212, will probably necessitate a readjustment of the BALANCE COARSE resistor in order to ensure that the front panel BALANCE control is within its range throughout the total frequency range.

Proceed as follows:

- 1) Release the three RANGE push-buttons.
- 2) Set BALANCE in mid-position.
- 3) Press the button SET LEVEL.
- 4) Set the input level of a 1 kc signal so that the level at the cathode of V1B is somewhere between 100 mV and 500 mV, giving half-scale deflection on an external voltmeter with an input impedance of 10 MΩ (e.g. Radiometer RV34 or RV35).
- 5) Connect the external voltmeter to the anode of V1B and adjust the BALANCE COARSE resistor so that the signal is twice the signal at the cathode with an accuracy better than 1%.
- 6) Make sure that the front panel BALANCE control uses the middle part of its function angle when measuring distortion at both ends of the three frequency ranges and also at a mid-frequency. Otherwise adjust the BALANCE COARSE resistor correspondingly.

CHECKING THE FREQUENCY RESPONSE

See Fig.10.

If the frequency response of the instrument is not within the limits guaranteed,

it is advisable to check the response with the button VOLTMETER RANGE 0.3 and the button VOLTMETER pressed, so that the input attenuator is switched off in order to establish whether the fault is due to the attenuator or to the amplifiers.

A check of the response of the input amplifier is easily made if a voltmeter is connected to the cathode of tube V2B. The input capacity of this voltmeter must be lower than 5 pF (e.g. Radiometer Vacuum Tube Voltmeter RV35 with probe) in order not to disturb the response at high frequencies.

It is advisable to press the button VOLTMETER-V in order to avoid that the grid of tube V3A loads the cathode of V2B irregularly when overdriven by the approx. 3.6 volts present with 0.316 volt at the grid of tube V1A.

The three RANGE buttons have to be released in order to obtain the best response at high frequencies. The deviations from the straight response are only a few percent down to 5 cps, if the variable resistor R207 is properly adjusted. (Use a dc scope below 20 cps).

The response at high frequencies depends on the setting of the trimmer C207 in the R-C network in the anode lead of tube V2A.

The response is generally straight up to 200 kc and within a few percent up to 500 kc. The rapid fall-off starts at about 800 kc.

The response of the output amplifier (V3 +V4) contributes to the resulting response with an amount that is independent of the two VOLTMETER push-button settings at low frequencies; but at frequencies higher than 300 kc, the response of the input amplifier depends somewhat on which of the VOLTMETER buttons is pressed, because the load at the cathode of V2B changes a little.

The total response of the two amplifiers in cascade is straight within 1% down to 20 cps, if the input amplifier is in

order and if the variable resistor R421 is properly adjusted. The drop in response rises to approx. 12 dB per octave at lower frequencies in order to reduce the meter fluctuations, developed by line voltage ranges, to a non-disturbing level.

The total response is within 2% up to 200 kc, and generally within a few per cent up to 400 kc or even higher, if the small drop in response of the output amplifier at frequencies higher than some hundred kilocycles is compensated for by readjusting the trimmer C207 of the input amplifier.

The response at high frequencies is somewhat dependent on the capacitive coupling between the two amplifiers. The coupling is brought down to a non-disturbing level, when the instrument is mounted in its case. In order to obtain the correct frequency response when trimming the instrument outside its case, it is necessary to shield the bottom and the printed board of the vertically placed input amplifier.

ADJUSTING THE INPUT ATTENUATOR

See Fig.10.

The constant input capacitance and correct frequency response depend on the proper adjustment of the trimmers of the attenuator sections.

The correct attenuation at low frequencies

depends solely on the resistors switched in.

The resistors are high-stability resistors (metal film) with an accuracy of 0.5%

The check is accomplished by feeding 1 kc and 100 kc signals to the INPUT socket with exactly known ($\pm 0.1\%$) voltages of 0.3 mV - 1 mV - 3 mV - 10 mV - 30 mV - 100 mV and 300 mV.

The 1 kc signal gives a check on the resistors. The 100 kc signal makes possible the correct setting of the trimming capacitors, C103 - C106 - C109 - C112 - C115 and C118, by adjusting them so that the response from 1 kc to 100 kc is the same as on the 0.3 mV range.

On the 1 mV range a drop in sensitivity of approx. 0.5% at 15 kc is unavoidable. The drop at 5 kc and 50 kc is scarcely detectable.

The input capacity is made constant by adjusting the trimmers C101, C104, C108, C111, C114 and C117 so that the capacity present with no attenuation (0,3 mV/V button pressed) is also had with attenuation.

The trimming is carried out by mounting a 1 to 10 M Ω resistor in parallel with a trimming capacitor (both shielded) in front of the BKF6. Use a TEKTRONIX probe for an oscilloscope, if available.

The trimmer of the probe is so adjusted on the 0.3 mV range that the response

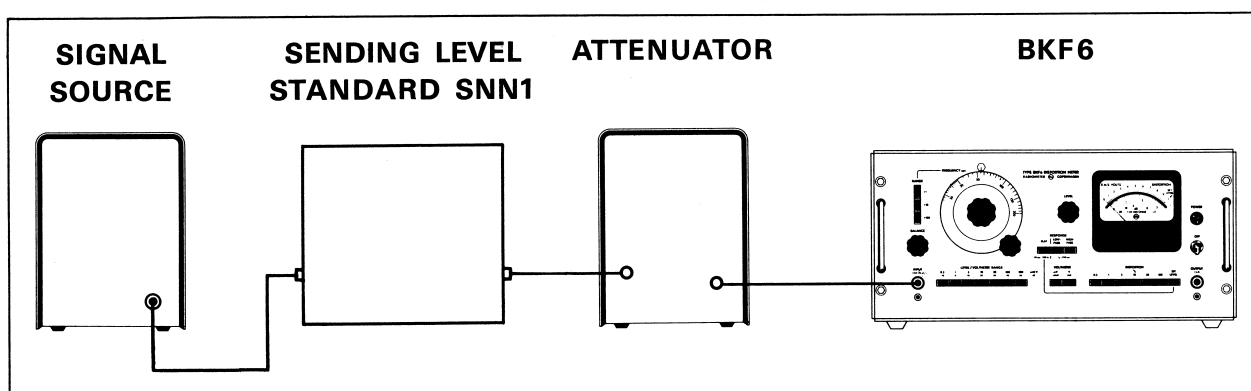


Fig.10. Measuring setup for the adjustment of the frequency response and the attenuator.

of the range is not changed by the probe. The aforementioned trimmer (varying the input capacity) can now be properly adjusted by adjusting the 100kc sensitivity equal to the 1 kc sensitivity on each range, if this is the case on the 0.3 mV range. Otherwise the response present on the 0.3 mV range must be obtained.

TRIMMING THE WIEN BRIDGE

Before making any attempt to trim the Wien-Bridge, check that the (internal) BALANCE COARSE control is properly set (see page 19) in order not to strain the range of the front plate BALANCE control.

Also make sure that the FREQUENCY dial stops at the short line engraved beyond the 18 cps line when the rotor of the variable capacitor stops against the stator. Unscrew the stopping screw behind the dial a few turns in order to make this check. Any misalignment has to be corrected by temporarily loosening the coupling on the shaft while making the alignment. (Remember to re-adjust the stopping screw)

The trimming is accomplished by using the input frequencies: 20-200-2000 and 20000 cps, which have an accuracy of 0.1% and a distortion less than 2%.

With the frequency dial set to 20, the trimming resistors of each range (R301 & R304 - R305 & R308 and R309 & R312) are so adjusted that the distortion of the input signal is measured. (Important: BALANCE set to mid-position). See Fig.11.

With the FREQUENCY dial set to 200 cps, the trimming capacitors C300 & C301, C302 & C303 and C304 & C305 of the three ranges x1, x10 and x100 are adjusted.

The adjustment of the resistors and capacitors on each range has to be made several times if a serious case of inaccuracy is to be cured, owing to the fact, that the adjustment of the capacitors also has a slight influence on the tuning with the dial set to 20 cps, (tuning capacitor near its max. value).

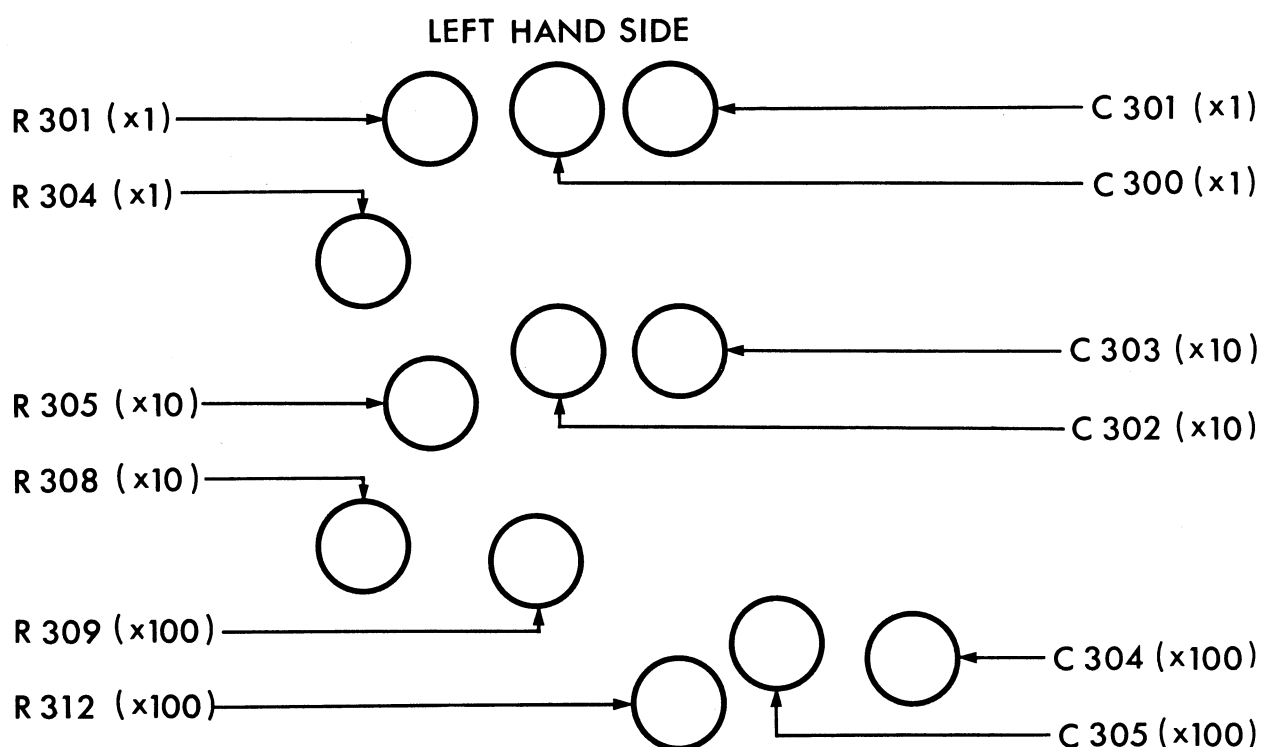


Fig.11. Adjustment of the Wien-Bridge.

**SWITCHING TO ANOTHER LINE VOLT-
AGE**

1. Remove the cabinet, see page 17.
2. Remove the blue cable from tap No. 6 (220 V) on the power transformer placed in the upper back, right-hand corner of the instrument.

3. Resolder the blue cable to the appropriate solder lug of the transformer:

Lug No.	Line Voltage
2	110 V
3	115 V
4	127 V
5	200 V
6	220 V
7	240 V

Section H. Parts List

In the following parts list a group code prefix number is used. To facilitate the use of this code, the different types of parts and their corresponding group code prefixes are listed below:

Standard resistors	100- to 139-
Precision resistors	140- to 152-
Non-linear resistors	160-
UHF resistors	170- to 172-
Carbon potentiometers	180- to 185-
Wire-wound potentiometers	190- to 195-
Mica capacitors	200- to 208-
Ceramic capacitors	210- to 214-
Paper capacitors	220- to 222-
Metal-paper capacitors	224- to 229-
Plastic capacitors	240- to 245-
Electrolytic capacitors	260- to 267-
Variable capacitors	280- to 286-
Special tubes	310-
Rectifiers	340- to 341-
Diodes	350-
Transistors	360-
Integrated circuits	364-
Lamps, batteries, fuses	400- to 486-
Switches	500- to 580-
Coils, coil material and transformers	700- to 785-

As we are continually improving our instruments, it is important, when ordering spare parts, that you include the following information:

- The code number and description of the part
- The circuit reference from the wiring diagram
- The complete type designation of your instrument
- The serial number of your instrument.

Please note that the position of any part can easily be found by referring to the last column of the parts list. This indicates on which figure the part can be located.

CAPACITORS

Designation	Type	Value	Code No.	Shown in Fig.
C100	polyester	0.27 μ F 10% 400 V	240-627	12
C101	trimmer	25 pF	285-011	12
C102	polystyrene	25 pF 5% 500 V	243-082	12
C103	trimmer	25 pF	285-011	12
C104	trimmer	25 pF	285-011	12
C105	polystyrene	4 pF + 1 pF 500 V	243-024	12
C106	trimmer	25 pF	285-011	12
C108	trimmer	25 pF	285-011	12
C109	trimmer	6 pF	285-010	12
C110	polystyrene	200 pF 5% 125 V	243-001	12
C111	trimmer	25 pF	285-011	12
C112	trimmer	6 pF	285-010	12
C113	polystyrene	600 pF 5% 125 V	243-027	12
C114	trimmer	25 pF	285-011	12
C115	trimmer	6 pF	285-010	12
C116	polystyrene	2000 pF 5% 125 V	243-028	12
C117	trimmer	25 pF	285-011	12
C118	trimmer	6 pF	285-010	12
C119	polystyrene	6000 pF 5% 125 V	243-029	12
C200	polyester	0.1 μ F 10% 400 V	240-610	13
C201	electrolytic	4 μ F 250 V	260-018	13
C202	electrolytic	4 μ F 250 V	260-018	13
C203	polyester	1 μ F 10% 400 V	241-006	13
C204	ceramic	150 pF 5%	211-315	13
C205	electrolytic	4 μ F 250 V	260-018	13
C206	electrolytic	47 μ F 250/275 V	261-040	13
C207	trimmer	11 pF	285-509	13
C210	electrolytic	4 μ F 250 V	260-018	13
C211	electrolytic	470 μ F 50/60 V	261-010	13
C212	trimmer	11 pF	285-509	13
C213	ceramic	3.9 pF \pm 0.5 pF	210-139	13
C215	electrolytic	4 μ F 250 V	260-018	13
C216	ceramic	10 pF	211-210	13

Designation	Type	Value	Code No.	Shown in Fig.
C217	trimmer	11 pF	285-509	13
C218	ceramic	6.8 pF 10%	211-168	14
C219	ceramic	100 pF 5%	211-310	14
C300	trimmer	25 pF	285-011	14
C301	trimmer	25 pF	285-011	14
C302	trimmer	25 pF	285-011	14
C303	trimmer	25 pF	285-011	14
C304	trimmer	25 pF	285-011	14
C305	trimmer	25 pF	285-011	14
C306	variable capacitor	2 x 500 pF	280-025	
C307	ceramic	matched	211-	
C308	ceramic	matched	211-	
C309	ceramic	matched	211-	
C400	polyester factory adjusted	0.1 μ F 10% 160 V	241-001	15
C401	polyester	12 nF 10% 400 V	240-512	15
C402	electrolytic	4 μ F 250 V	260-018	15
C403	polyester	1.8 nF 10% 400 V	240-418	15
C404	electrolytic	2 x 100 μ F 350/400 V	261-034	15
C405	polyester	2.2 nF 10% 400 V	240-422	15
C406	electrolytic	4 μ F 250 V	260-018	15
C407	ceramic	22 pF 5%	210-222	15
C500	electrolytic	1 μ F 500/550 V	260-020	16
C501	polystyrene	4 nF 2.5% 125 V	243-043	16
C502	polyester	600 pF 5%	243-027	16
C503	polystyrene	4 nF 2.5% 125 V	243-043	16
C504	polystyrene	500 pF 5%	243-008	16
C505	polyester	22 nF 10% 400 V	240-522	16
C506	polyester	2 μ F 10% 125 V	241-005	16
C507	polyester	2 μ F 10% 125 V	241-005	16
C508	polyester	2 μ F 10% 125 V	241-005	16
C700	electrolytic	2,000 μ F 50/60 V	261-035	
C701	electrolytic	2,000 μ F 50/60 V	261-035	
C702	electrolytic	47 μ F 50/60 V	260-016	

Designation	Type	Value	Code No.	Shown in Fig.
C703	electrolytic	2 x 20 μ F 450/500 V	861-018	
C704	electrolytic	2 x 100 μ F 350/400 V	261-034	
C705	electrolytic	2 x 100 μ F 350/400 V	261-034	

RESISTORS

Designation	Type	Value	Code No.	Shown in Fig.
R1	carbon film	1 k Ω 5% 0.5 W	100-410	
R2	carbon potm., lin.	500 Ω	180-127	
R100	metal film	684 k Ω 0.5% 1/4 W	140-276	12
R101	metal film	463 Ω 0.5% 1/4 W	140-282	12
R102	metal film	900 k Ω 0.5% 1/4 W	140-277	12
R103	metal film	111 k Ω 0.5% 1/4 W	140-283	12
R104	metal film	968 k Ω 0.5% 1/4 W	140-278	12
R105	metal film	32.6 k Ω 0.5% 1/4 W	140-284	12
R106	metal film	990 k Ω 0.5% 1/4 W	140-279	12
R107	metal film	10.1 k Ω 0.5% 1/4 W	140-285	12
R108	metal film	994 k Ω 0.5% 1/4 W	140-280	12
R109	metal film	3.16 k Ω 0.5% 1/4 W	140-170	12
R110	metal film	1 M Ω 0.5% 1/4 W	140-281	12
R111	metal film	1 k Ω 0.5% 1/4 W	140-115	12
R200	metal film	1 M Ω 5% 1/4 W	140-281	13
R201	carbon film	470 Ω 5% 0.5 W	100-647	13
R202	carbon potm., lin.	25 k Ω	181-003	13
R203	carbon film	27 k Ω 5% 0.5 W	100-527	13
R204	carbon film	15 k Ω 5% 0.5 W	100-515	13
R205	carbon film	3.9 k Ω 5% 0.5 W	100-439	13
R206	carbon film	39 k Ω 5% 0.5 W	100-539	13
R207	carbon film	1 M Ω 5% 0.5 W	100-710	13
R208	carbon film	1 k Ω 5% 0.5 W	100-410	13
R209	carbon potm., lin.	1 k Ω	181-000	13
R210	metal film	23 k Ω 1% 0.5 W	140-222	13

Designation	Type	Value	Code No.	Shown in Fig.
R211	metal film	1.8 k Ω 1% 0.5 W	140-085	13
R212	metal film	10 k Ω 0.5% 0.5 W	140-007	13
R213	carbon film	33 k Ω 5% 0.5 W	100-533	13
R214	carbon film	100 k Ω 5% 0.5 W	100-610	13
R215	carbon film	1.2 k Ω 5% 0.5 W	100-412	13
R216	carbon film	27 k Ω 5% 0.5 W	100-527	13
R217	carbon film	390 k Ω 5% 0.5 W	100-639	13
R218	carbon film	1 k Ω 5% 0.5 W	100-410	13
R219	carbon film	100 k Ω 5% 0.5 W	100-610	13
R220	carbon film	6.8 k Ω 5% 0.5 W	100-468	13
R221	carbon film	15 k Ω 5% 1 W	101-515	13
R222	carbon film	1 k Ω 5% 0.5 W	100-410	13
R223	carbon film	1 k Ω 5% 0.5 W	100-410	13
R224	carbon film	5.6 k Ω 5% 0.5 W	100-456	13
R225	carbon film	15 k Ω 5% 0.5 W	100-515	13
R300	carbon film	10 M Ω 5% 0.5 W	100-810	14
R301	carbon potm.	2 M Ω	181-008	14
R302	carbon film	16 M Ω 0.5 W 2% 0.5 W	143-028	14
R303	carbon film	16 M Ω 0.5 W 2% 0.5 W	143-028	14
R304	carbon potm., lin.	2 M Ω	181-008	14
R305	carbon potm., lin.	200 k Ω	181-009	14
R306	metal film	1.6 M Ω 1% 1 W	140-166	14
R307	metal film	1.6 M Ω 1% 1 W	140-166	14
R308	carbon potm., lin.	200 k Ω	181-009	14
R309	carbon potm., lin.	25 k Ω	181-003	14
R310	metal film	160 k Ω 1% 0.5 W	140-094	14
R311	metal film	160 k Ω 1% 0.5 W	140-094	14
R312	carbon potm., lin.	25 k Ω	181-003	14
R400	metal film	10 k Ω 0.5% 1/4 W	140-117	15
R401	metal film	3.16 k Ω 0.5% 1/4 W	140-170	15
R402	metal film	1 k Ω 0.5% 1/4 W	140-115	15
R403	metal film	316 Ω 0.5% 1/4 W	140-114	15
R404	metal film	100 Ω 0.5% 1/4 W	140-169	15

Designation	Type	Value	Code No.	Shown in Fig.
R405	metal film	31.6 Ω 5% 1/4 W	140-110	15
R406	metal film	14.62 Ω 0.5% 1/4 W	140-109	15
R407	carbon film	1 k Ω 5% 0.5 W	100-410	15
R408	carbon potm., lin.	100 Ω "LEVEL"	180-100	15
R409	carbon film	10 Ω 5% 0.5 W	100-210	15
R410	carbon film	100 k Ω 5% 0.5 W	100-610	15
R411	carbon film	1 k Ω 5% 0.5 W	100-410	15
R412	carbon film	12 Ω 5% 0.5 W	100-212	
R413	wire-wound	2.5 Ω 1% 0.1 W		
R414	carbon film	2.2 M Ω 5% 0.5 W	100-722	15
R415	carbon film	1 k Ω 5% 0.5 W	100-410	15
R416	carbon film	390 k Ω 5% 0.5 W	100-639	15
R417	carbon film	100 k Ω 5% 0.5 W	100-610	15
R418	carbon film	1 k Ω 5% 0.5 W	100-410	15
R419	carbon film	10 k Ω 5% 0.5 W	100-510	15
R420	carbon film	1 k Ω 5% 0.5 W	106-410	15
R421	carbon potm., lin.	500 k Ω	181-006	15
R422	carbon film	33 k Ω 5% 0.5 W	100-533	15
R423	carbon film	12 k Ω 5% 1 W	101-512	15
R424	carbon film	120 Ω 5% 0.5 W	100-312	15
R425	carbon potm., lin.	2 k Ω	181-010	15
R426	carbon film	10 k Ω 5% 1 W	101-510	15
R427	carbon film	10 k Ω 5% 1 W	101-510	15
R428	carbon film	5.6 M Ω 0.5 W	100-756	15
R429	carbon film	1 k Ω 5% 0.5 W	100-410	15
R430	carbon film	1.8 k Ω 5% 0.5 W	100-418	15
R431	carbon film	18 k Ω 5% 2 W	109-011	15
R432	carbon film	10 Ω 5% 0.5 W	100-210	15
R433	carbon film	820 k Ω 5% 0.5 W	100-682	15
R434	carbon film	10 Ω 5% 0.5 W	100-210	15
R435	carbon film factory adjusted	47 k Ω 5% 0.5 W	100-547	15
R500	carbon film	180 k Ω 5% 0.5 W	100-618	16

Designation	Type	Value	Code No.	Shown in Fig.
R501	carbon film	150 k Ω 5% 0.5 W	100-615	16
R502	carbon film	1.2 M Ω 5% 0.5 W	100-712	16
R503	carbon film	150 k Ω 5% 0.5 W	100-615	16
R504	carbon film	1.2 M Ω 5% 0.5 W	100-712	16
R505	carbon film	1.8 k Ω 5% 0.5 W	100-418	16
R506	carbon film	1 M Ω 5% 0.5 W	100-710	16
R508	carbon film	47 k Ω 5% 0.5 W	100-547	16
R509	carbon film	15 k Ω 5% 0.5 W	100-515	16
R510	carbon film	5.6 k Ω 5% 0.5 W	100-456	16
R511	carbon film	18 k Ω 5% 0.5 W	100-518	16
R700	wire-wound	30 Ω 6 W 5%	132-002	
R701	wire-wound	400 Ω 6 W 5%	132-005	
R702	carbon film	560 Ω 5% 1 W	101-356	
R703	carbon film	82 k Ω 5% 0.5 W	100-582	
R704	carbon film	560 k Ω 5% 0.5 W	100-656	
R705	carbon film	1.5 k Ω 5% 0.5 W	100-415	
R706	carbon film	1.5 k Ω 5% 0.5 W	100-415	
R707	carbon film	8.2 k Ω 5% 1 W	101-482	
R708	carbon film	27 k Ω 5% 0.5 W	100-527	

DIODES and RECTIFIERS

Designation	Type	Code No.	Shown in Fig.
CR500	diode OA85	350-010	16
CR501	diode OA85	350-010	16
CR502	diode OA85	350-010	16
CR503	diode OA85	350-010	16
CR504	diode OA79	350-007	16
CR505	diode OA79	350-007	16
CR700	rectifier B30C400	340-004	
CR701	rectifier B390C90	340-012	

FUSES

Designation	Type	Code No.
F1	fuse, 220 V, 200 mA, or fuse, 115 V, 400 mA	450-013 450-016

LAMPS

Designation	Type	Code No.
I1	neon lamp, 220 V	400-501

METER

Designation	Type	Code No.
M1	meter with scale, 200 μ A	482-125

SWITCHES

Designation	Type	Code No.
S1	main switch	500-102
S100	switch "LEVEL VOLTMETER RANGE"	550-926
S300	switch "RANGE"	550-923
S400	switch "DISTORTION"	550-924
S500	switch "RESPONSE"	550-925

TRANSFORMER

Designation	Type	Code No.
T1	power transformer	770-568

TUBES

Designation	Type	Code No.	Shown in Fig.
V1	tube E80CF	300-006	13
V2	tube E80CF	300-006	13
V3	tube E80CF	300-006	15
V4	tube E80CF	300-006	15

TERMINALS

Designation	Type	Code No.
J1	coaxial bushing UHF	800-009
J2	phone jack	803-241
J3	coaxial bushing UHF	800-009
J4	phone jack	803-241
J5	main plug	802-103

MISCELLANEOUS

Type	Code No.
O-ring, OR 3.68 x 1.78	835-311
knob N30	850-230
knob N40	850-240
rubber foot	855-002

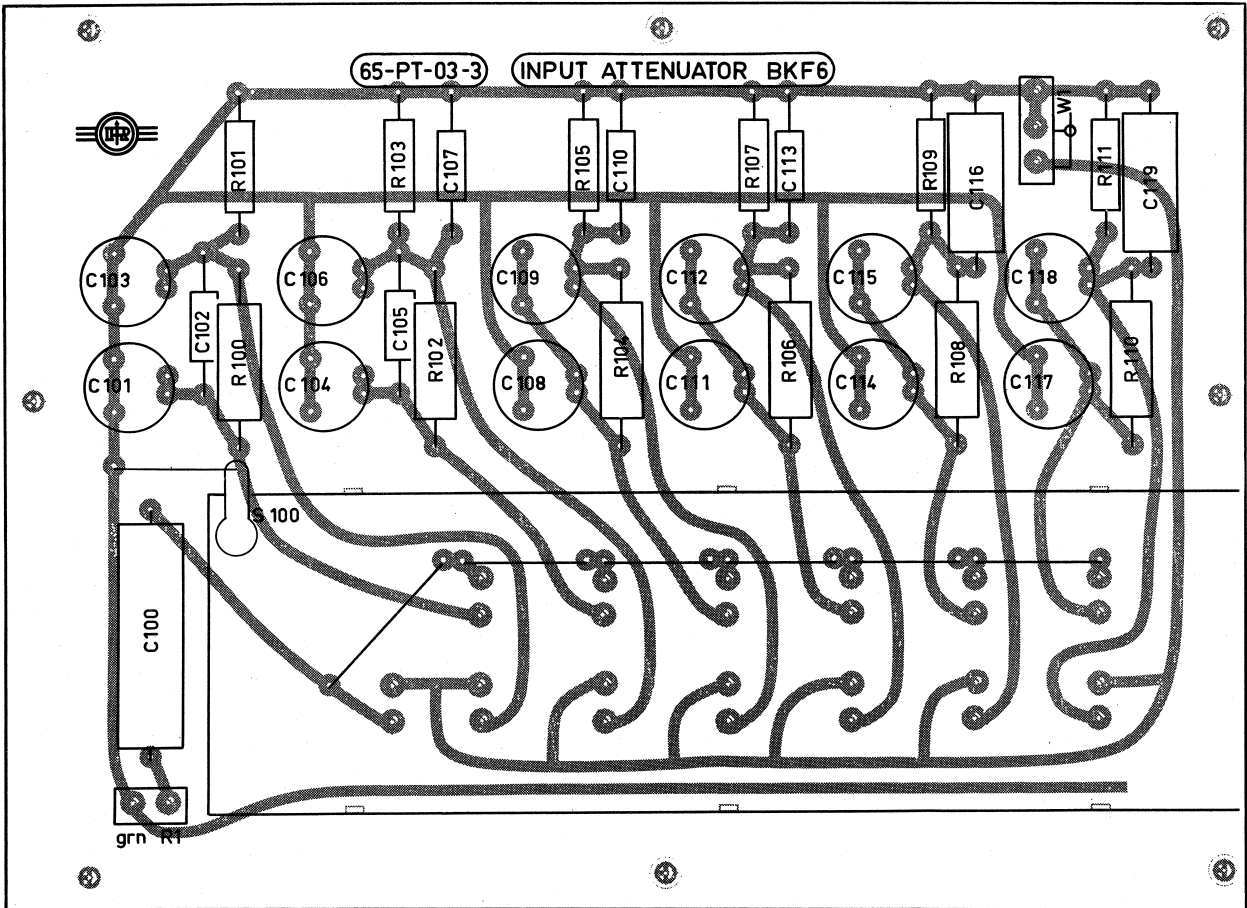


Fig.12. INPUT ATTENUATOR Printed Circuit Board.

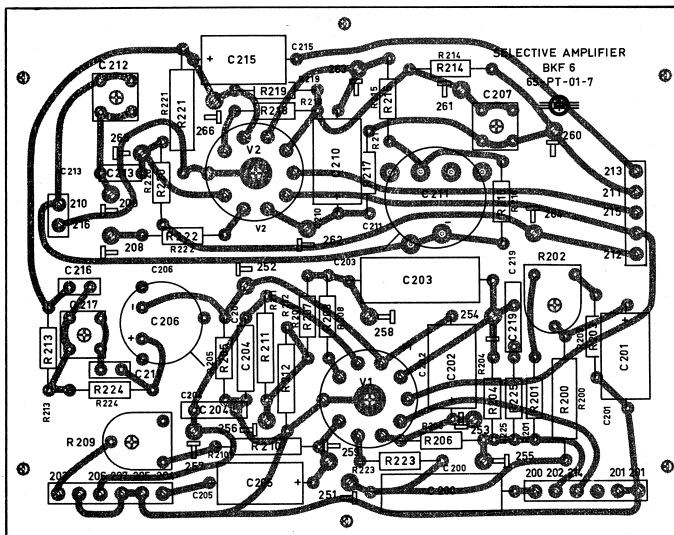


Fig.13. SELECTIVE AMPLIFIER Printed Circuit Board.

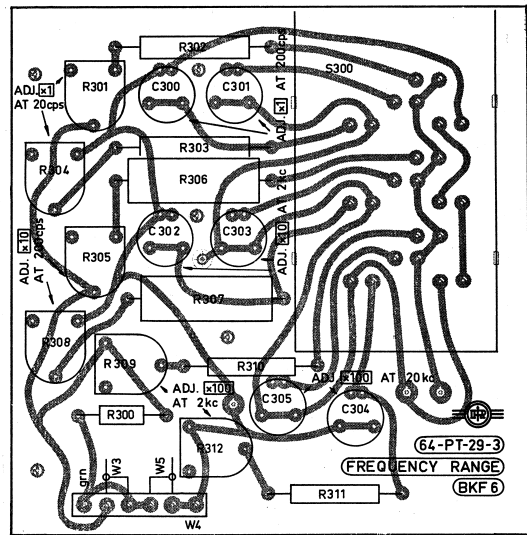


Fig.14. FREQUENCY RANGE Printed Circuit Board.

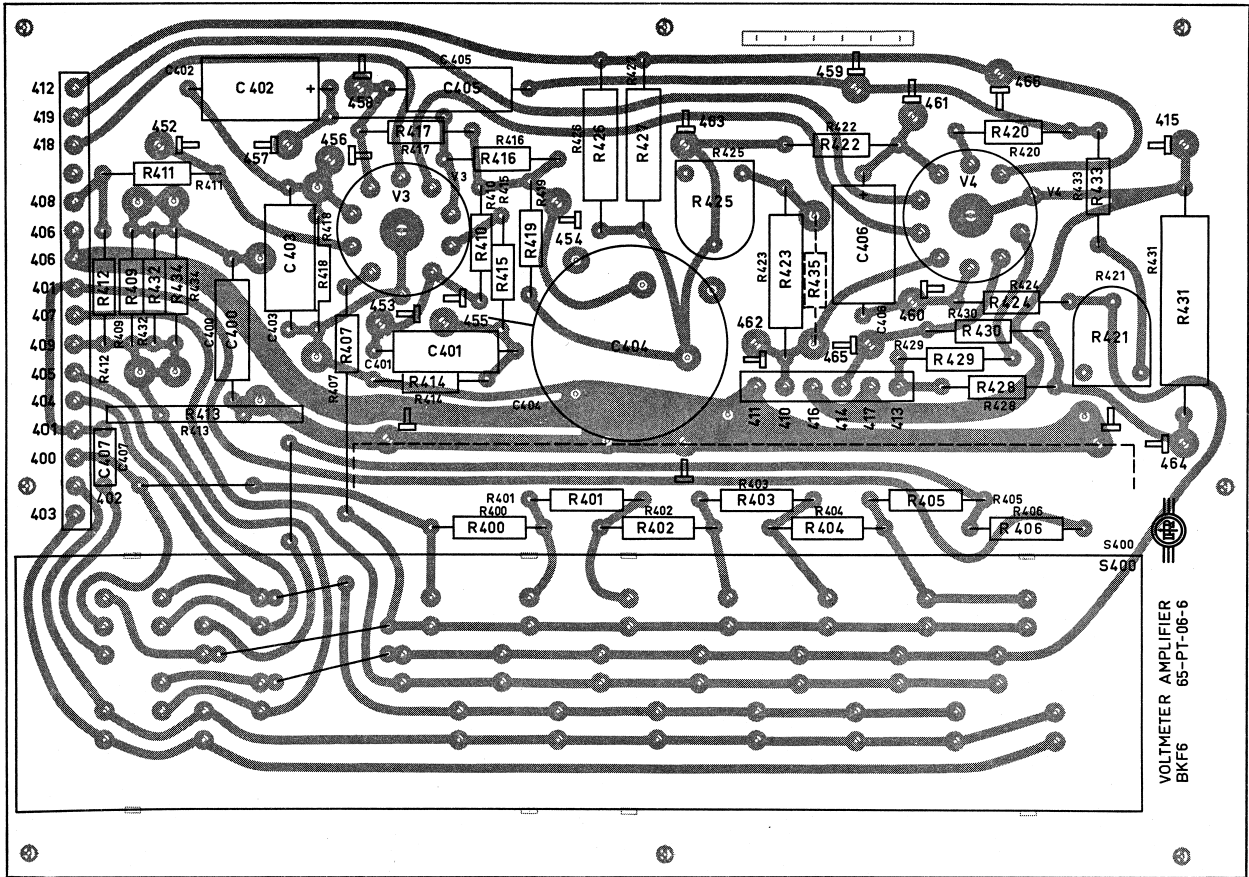


Fig.15. VOLTMETER AMPLIFIER Printed Circuit Board.

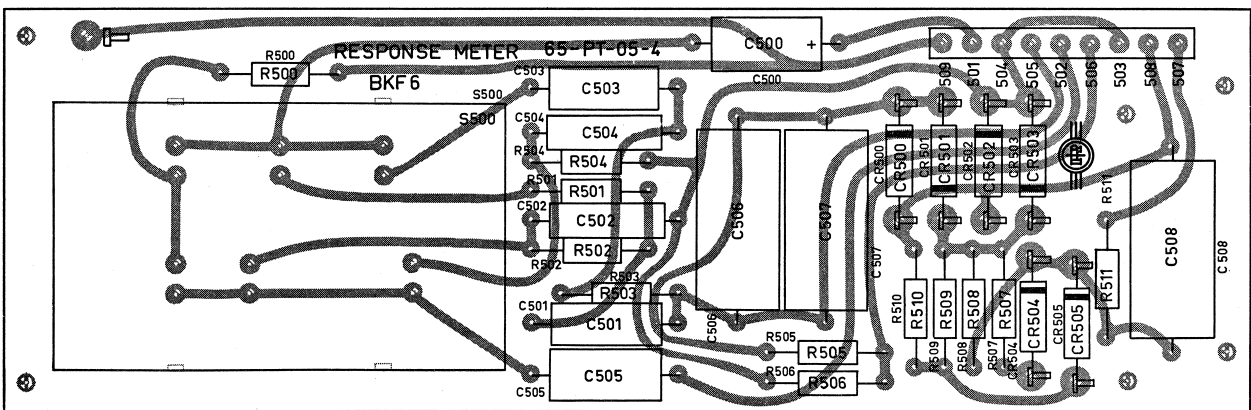
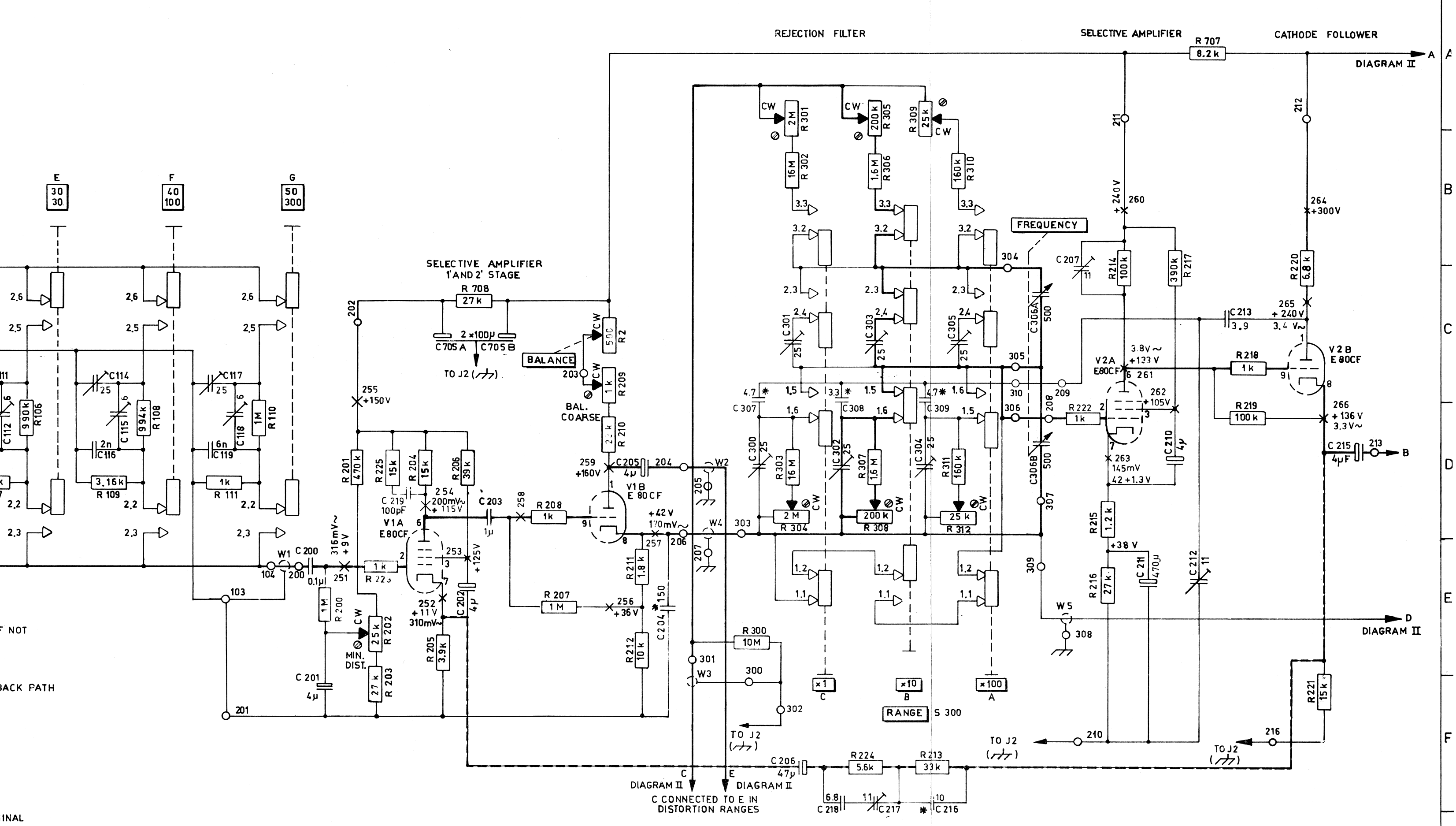


Fig.16. RESPONSE METER Printed Circuit Board.



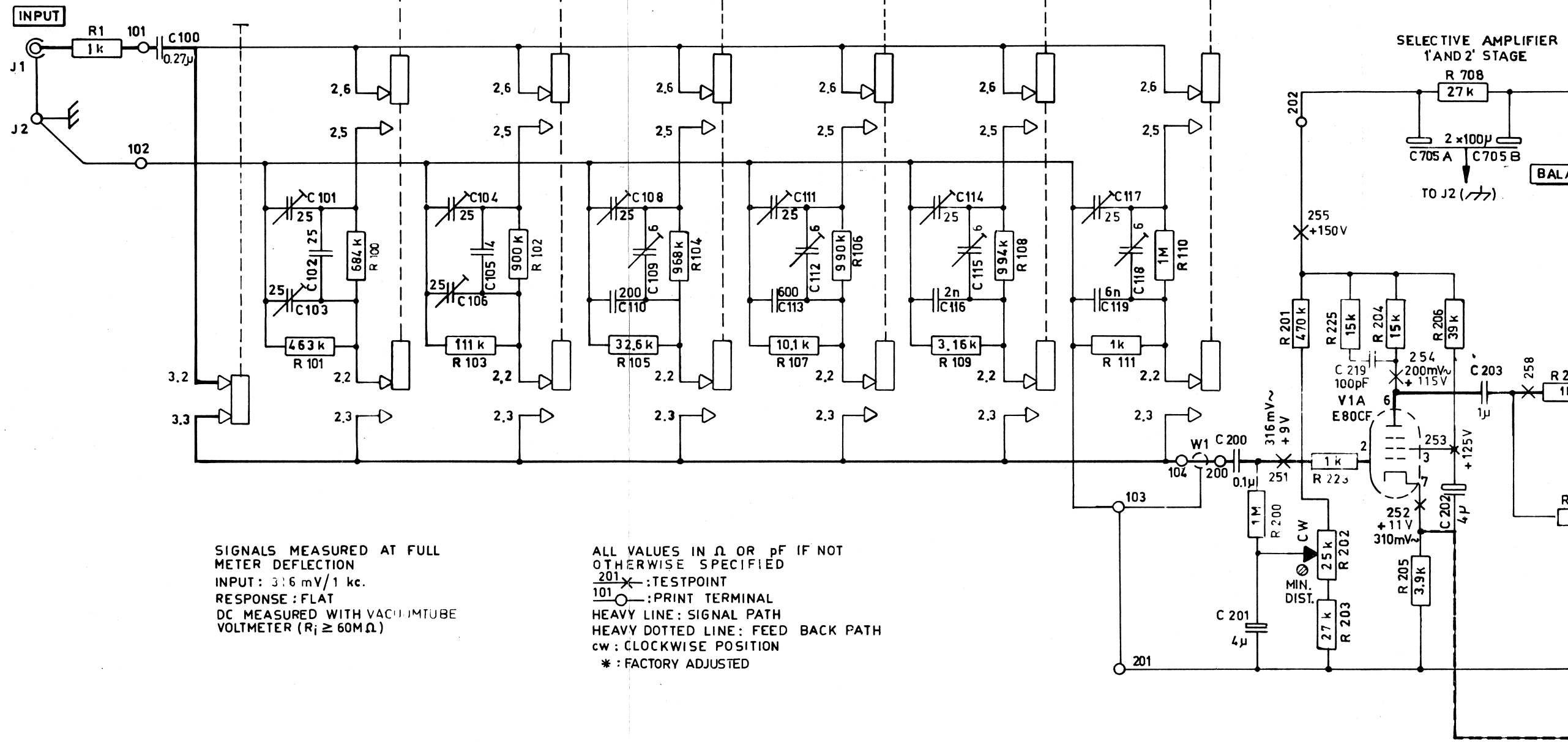
NOT JACK PATH

INAL

RADIOMETER COPENHAGEN		RADIOMETER COPENHAGEN 72 EMDRUPVEJ NV		Målestok Tegn. MG 7.1.67 Konf. 7 Norm.
This drawing must not be passed on to any person not authorized by us to receive it, nor be copied or otherwise made use of by such person without our authority.		DISTORTION METER DIAGRAM I: INPUT ATTENUATOR SELECTIVE AMPL. REJECTION FILTER TYPE BKF 6d From no. 115426 to no.		Erstatting 1164-A1 Erstattes af
1	20637	12-2-68	PAB	
Ri.Nr.	Erstat.Nr.	Dato	St. af	Not. Norm.

LEVEL / VOLTMETER RANGE S 100

	A	B	C	D	E	F	G
dB	-10	0	10	20	30	40	50
mV/V	0.3	1	3	10	30	100	300



SIGNALS MEASURED AT FULL METER DEFLECTION
 INPUT: 3.16 mV/1 kc.
 RESPONSE: FLAT
 DC MEASURED WITH VACUUM TUBE VOLTMETER ($R_i \geq 60M\Omega$)

ALL VALUES IN Ω OR pF IF NOT OTHERWISE SPECIFIED
 201 * : TESTPOINT
 101 ○ : PRINT TERMINAL
 HEAVY LINE: SIGNAL PATH
 HEAVY DOTTED LINE: FEED BACK PATH
 cw : CLOCKWISE POSITION
 * : FACTORY ADJUSTED

