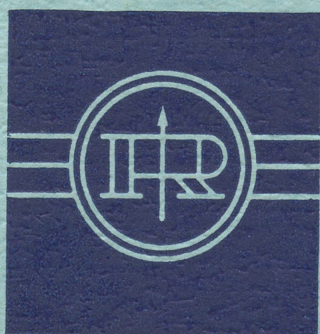


INSTRUCTION MANUAL

Pilot Level Meter
Type BFM 330



RADIOMETER

**ELECTRONIC MEASURING INSTRUMENTS
FOR SCIENTIFIC AND INDUSTRIAL USE**

**Instruction Manual
for**

**Pilot Level Meter
Type BFM 330**

1. edition

Table of Contents

	page
SECTION A - INTRODUCTION	A1
SECTION B - SPECIFICATIONS	B1
SECTION C - GENERAL DESCRIPTION	C1
1. General	C1
2. Controls and Terminals	C2
3. Dummy-Sockets for Terminations	C3
SECTION D - OPERATING INSTRUCTIONS	D1
1. Connecting and Burning-In the Instrument	D1
2. Adjusting the Instrument	D1
3. Measuring the 84.080 kHz (84.140 kHz) Pilot Level	D1
4. Measuring the 411.920 kHz (411.860 kHz) Pilot Level	D2
5. Connecting an External Meter or Recorder	D2
SECTION E - TECHNICAL DESCRIPTION	E1
1. General	E1
2. Input Circuit	E1
3. Attenuator	E2
4. 84.080 kHz (84.140 kHz) Channel	E2
5. 411.920 kHz (411.860 kHz) Channel	E3
6. Local Oscillator	E3
7. Adjusting Generator	E3
8. Power Supply	E4
SECTION F - MAINTENANCE	F1
1. General	F1
2. Removing the Instrument from the Cabinet	F1
3. Replacing the Tubes	F1
4. Aligning the Tuned Circuits	F2
5. Adjusting the Local Oscillator	F3
6. Adjusting the Adjusting Generator	F4
7. Operating Voltages	F5
8. Adjustment of the Crystal Filter	F5
SECTION G - PARTS LIST	G1
SECTION H - COMPONENT IDENTIFICATIONS	H1

Pilot Level Meter Type BFM 330

Section A. Introduction

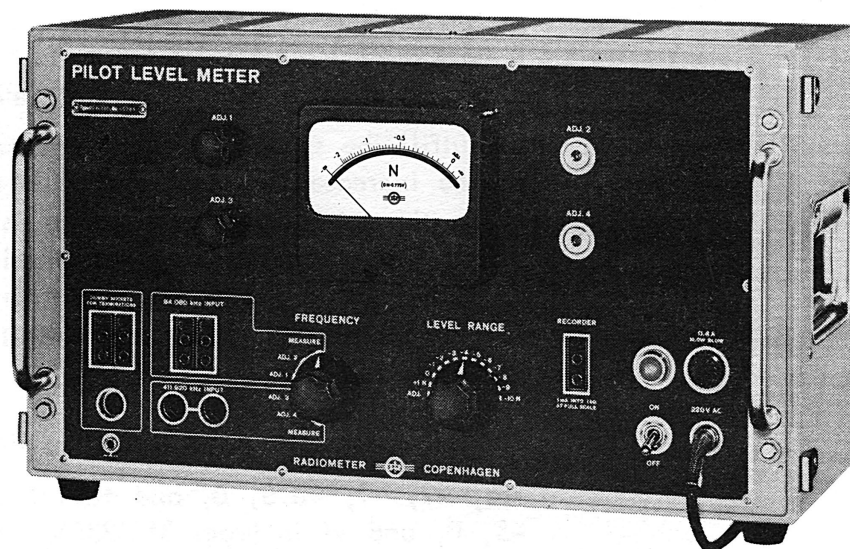


Fig.A1. The Pilot Level Meter, type BFM330

The Pilot Level Meter, type BFM330, is a line-operated precision instrument used to adjust and monitor the levels of the pilots which are transmitted in the groups (60 to 108 kHz) and in the supergroups (312 to 552 kHz) of coaxial cable carrier telephone systems. Measurements can be made on systems in use without disturbing the traffic. On the other hand, the measurements are not affected by the traffic. When connected to the group or supergroup, the instrument measures the absolute voltage level of the group pilot

84.080 kHz or the supergroup pilot 411.920 kHz (84.140 kHz and 411.860 kHz for type BFM330S1), both of which are prescribed by the CCITT. The adjustment of each of the two measuring frequencies can be checked with an internal adjusting generator.

The instrument is portable and has a built-in power supply for a line voltage of 220 volts, 40-60 Hz. It has a special recorder output to which a recorder can be connected when the level of a group or a supergroup pilot is to be recorded.

Section B. Specifications

MEASURING FREQUENCY	84.080 kHz and 411.920 kHz (84.140 kHz and 411.680 kHz for type BFM330S1)
LEVEL RANGE	<p>Meter deflects to 0 for -10, -9,, 0, +1 N, 0 N = 0.775V. (-90, -80,, 0, +10 dB, 0 dB = 0.775 V for types BFM330S3 and BFM330S2S3)</p> <p>To fulfill the specifications, the sensitivity may not be increased by more than 2 N (17 dB) above the setting that corresponds to the nominal pilot level at the measuring point. It is taken for granted that the nominal pilot level is 2.3 N (20 dB) below the nominal measuring level at the point in question.</p>
METER SCALE	<p>The meter scale has the following figures: $-\infty$, -2, -1, -0.5, 0, and +0.1 ($-\infty$, -20, -10, -5, 0, and +1 in types BFM330S3 and BFM330S2S3)</p> <p>The scale is subdivided as follows:</p> <p>Between -2 and -1 N (-20 and -10 dB): For every 0.1 N (1.0 dB)</p> <p>Between -1 and +0.1 N (-10 and +1 dB): For every 0.05 N (0.5 dB)</p> <p>The measuring unit is in the center of the meter scale.</p> <p>The reference level "0 N = 0.775 V" (0 dB = 0.775 V) is stated below the unit indication.</p> <p>The scale is an exponential scale. The meter deflection is proportional to the input voltage.</p> <p>The meter with appropriate rectifier measures the mean value, but the meter indicates the rms value of a sine wave.</p>

METER	The meter has pivot bearings.
Operational position:	Vertical
Damping of meter:	Approximately aperiodic.
Response time:	Approximately 0.5 second.
CALIBRATION OF ATTENUATOR	-10, -9,, 0, +1 N. (-90, -80,, 0, +10 dB)
MINIMUM LEGIBLE DEFLECTION	-12 N (-110 dB)
INPUT IMPEDANCE (measuring cable as specified below)	
<u>84.080 kHz (84.140 kHz):</u>	$Z_i \geq 6 \text{ k}\Omega$ within the frequency range 60-108 kHz.
<u>411.920 kHz (411.860 kHz):</u>	$Z_i \geq 4 \text{ k}\Omega$ within the frequency range 312-552 kHz.
INSERTION LOSS (measuring cable as specified below)	
<u>84.080 kHz (84.140 kHz):</u>	When connected to a circuit with the impedance $150 \Omega \angle 0^\circ$ on both sides, the insertion loss is less than 0.01 N (0.1 dB) within the frequency range 60-108 kHz. When connected to a circuit with the impedance $75 \Omega \angle 0^\circ$ on both sides, the insertion loss is less than 0.005 N (0.05 dB) within the frequency range 60-108 kHz.
<u>411.920 kHz (411.860 kHz):</u>	When connected to a circuit with the impedance $75 \Omega \angle 0^\circ$ on both sides, the insertion loss is less than 0.005 N (0.05 dB) within the frequency range 312-552 kHz.
INPUT	The instrument has two separate inputs.
<u>84.080 kHz (84.140 kHz):</u>	Balanced input. Arbitrary polarity of the signal and arbitrary grounding of one of the terminals do not affect the measurement.
<u>411.920 kHz (411.860 kHz):</u>	Unbalanced input. The linear crosstalk between the two inputs ($75 \Omega \angle 0^\circ$, $75 \Omega \angle 0^\circ$) is better than 10 N (86 dB) within the frequency range 60-552 kHz.
BALANCE TO GROUND (including measuring cable as specified below)	
<u>84.080 kHz (84.140 kHz):</u>	The balance to ground is better than 6.0 N (52 dB) within the frequency range 60-108 kHz. (see under "DEFINITIONS")

INSENSITIVITY TO LONGITUDINAL VOLTAGES (including measuring cable as specified below)

84.080 kHz (84.140 kHz):

The insensitivity to longitudinal voltages is better than 6.0 N (52 dB) within the frequency range 60-108 kHz.

(see under "DEFINITIONS")

SELECTIVITY

When the input of the instrument is supplied with a signal - the level being constant and the frequency deviating by Δf from the nominal frequency (84.080 kHz and 411.920 kHz (84.140 kHz and 411.860 kHz), respectively) - the meter indication, h , is within the following limits, where h_{nom} is the indication at the nominal frequency:

84.080 kHz (84.140 kHz):

$$|\Delta f| \leq 7 \text{ Hz:}$$

$$|h - h_{\text{nom}}| \leq 0.025 \text{ N (0.22 dB)}$$

$$|\Delta f| \geq 70 \text{ Hz:}$$

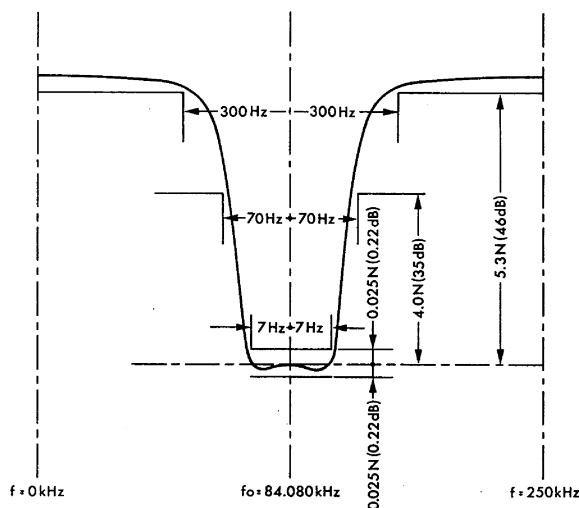
$$h \leq h_{\text{nom}} - 4.0 \text{ N (-35 dB)}$$

$$|\Delta f| \geq 300 \text{ Hz:}$$

$$h \leq h_{\text{nom}} - 5.3 \text{ N (-46 dB)}$$

The last two requirements are met within the frequency range 60-108 kHz.

Fig.B1. Selectivity Curve of the Pilot Level Meter, type BFM330.



411.920 kHz (411.860 kHz):

$$|\Delta f| \leq 7 \text{ Hz:}$$

$$|h - h_{\text{nom}}| \leq 0.025 \text{ N (0.22 dB)}$$

$$|\Delta f| \geq 70 \text{ Hz:}$$

$$h \leq h_{\text{nom}} - 4.0 \text{ N (-35 dB)}$$

$$|\Delta f| \geq 300 \text{ Hz:}$$

$$h \leq h_{\text{nom}} - 5.3 \text{ N (-46 dB)}$$

The last two requirements are met within the frequency range 312-552 kHz.

Guiding data for the pass band of the crystal filter appear in Fig.B1.

ATTENUATION OF THE IMAGE FREQUENCY (243.760 kHz)

When measuring the 411.920 kHz (411.860 kHz) pilot, the attenuation of the image frequency 243.760 kHz is higher than 6.0 N (52 dB).

NOISE LEVEL AND JITTER

With the input connection free and at any setting of the attenuator, the noise level is always below -14.0 N (-120 dB).

The jitter of the meter pointer is less than ± 0.005 N (± 0.05 dB).

ADJUSTMENT OF THE AMPLIFICATION

The amplification can be adjusted with a built-in adjusting generator without disconnecting the signal from the input.

ADJUSTING GENERATOR

Frequencies: 84.080 kHz and 411.920 kHz (84.140 kHz and 411.860 kHz).

Output level: -1.00 N (-10 dB)

TEST SIGNAL FROM ADJUSTING GENERATOR

Via an output connector in the bottom of the instrument, a test signal can be drawn from the adjusting generator.

Output voltage: 1 V open-circuit

Internal impedance: 3 k Ω

LOCAL OSCILLATOR

Frequency: 327.840 kHz

TEST SIGNAL FROM LOCAL OSCILLATOR

Via an output connector in the bottom of the instrument, a test signal can be drawn from the local oscillator.

Output voltage: 3 V open-circuit

Internal impedance: 1 k Ω

LEVEL STABILITY OF THE ADJUSTING GENERATOR

Before burning in: Deviation $\leq \pm 0.02$ N (± 0.2 dB)

After burning in: Deviation $\leq \pm 0.015$ N (± 0.15 dB)

FREQUENCY STABILITY OF THE ADJUSTING GENERATOR

The 84.080 kHz and 411.920 kHz (84.140 kHz and 411.860 kHz) crystals are mounted in a common thermostatically controlled oven.

Short-time stability
(after half an hour's burn-in time):

84.080 kHz (84.140 kHz): Deviation $\leq \pm 0.3$ Hz

411.920 kHz (411.860 kHz): Deviation $\leq \pm 1$ Hz

Long-time stability:

84.080 kHz (84.140 kHz): Deviation $\leq \pm 0.8$ Hz within 4 weeks

411.920 kHz (411.860 kHz): Deviation $\leq \pm 2.5$ Hz within 4 weeks

LEVEL STABILITY OF THE LOCAL OSCILLATOR

The level stability of the converted signal, due to possible variation of the output level of the local oscillator, is better than ± 0.002 N (± 0.02 dB).

FREQUENCY STABILITY OF THE LOCAL OSCILLATOR

The 327.840 kHz crystal is mounted in a thermostatically controlled oven.

Short-time stability
(after half an hour's burn-in time):

327.840 kHz: Deviation $\leq \pm 0.6$ Hz

Long-time stability:

327.840 kHz: Deviation $\leq \pm 2.0$ Hz within 4 weeks

MEASURING UNCERTAINTY

On the assumption that the instrument has been burned-in and that the ambient temperature is 20°C:

Attenuator: $\leq \pm 0.015$ N (± 0.13 dB)

Meter scale, range -1 to +0.1 N (-10 to +1 dB): $\leq \pm 0.010$ N (± 0.09 dB)

Adjusting generator: $\leq \pm 0.007$ N (± 0.07 dB)

Uncertainty because the response curve of the crystal filter is not flat in the band-pass range $|\Delta f| \leq 7$ Hz. The value stated

holds within the temperature range
+5 to +35°C:

$$\leq \pm 0.025 \text{ N } (\pm 0.22 \text{ dB})$$

Line voltage dependence
($\pm 10\%$ variations of line voltage):

$$\leq \pm 0.005 \text{ N } (\pm 0.05 \text{ dB})$$

Total measuring uncertainty with
coinciding signs:

$$\leq \pm 0.062 \text{ N } (\pm 0.56 \text{ dB})$$

Total measuring uncertainty with a
probability of 95% (see note 1):

$$\leq \pm 0.036 \text{ N } (\pm 0.33 \text{ dB})$$

On the assumption that the instru-
ment has been burned-in, adjusted
at 20°C, and that the ambient tem-
perature is within +5 and +35°C,
the following partial measuring un-
certainties are to be added:

Meter scale, at the 0 mark (ADJ):

$$\leq \pm 0.008 \text{ N } (\pm 0.08 \text{ dB})$$

Meter scale, range -1 to +0.1 N
(0 dB to +1 dB):

$$\leq \pm 0.005 \text{ N } (\pm 0.005 \text{ dB})$$

Total measuring uncertainty with
coinciding signs:

$$\leq \pm 0.075 \text{ N } (\pm 0.69 \text{ dB})$$

Total measuring uncertainty with a
probability of 95% (see note 1):

$$\leq \pm 0.038 \text{ N } (\pm 0.36 \text{ dB})$$

On the assumption that the instru-
ment has not been burned-in and
not re-adjusted, the following un-
certainty (typical value) must fur-
thermore be added:

$$\leq \pm 0.070 \text{ N } (\pm 0.61 \text{ dB})$$

Total measuring uncertainty with
coinciding signs:

$$\leq \pm 0.145 \text{ N } (\pm 1.30 \text{ dB})$$

Total measuring uncertainty with a
probability of 95% (see note 1):

$$\leq \pm 0.088 \text{ N } (\pm 0.82 \text{ dB})$$

Note 1: It is to be assumed that the partial
uncertainties are rectangularly distributed and
that the total measuring uncertainty is normally
distributed.

The standard deviation for a rectangular distribu-
tion is

$$\sqrt{\frac{a}{3}}$$

where $2a$ is the width of the rectangle.

The 95% fraction of the normal distribution cor-
responds to a deviation of $\pm 1.96 \cdot \sigma$ where σ is
the standard deviation in the normal distribution.

BURN-IN TIME (burning time required for reaching the stationary condition)

Approximately 3 hours.

It is possible to use the instrument after a burn-in time of half an hour, if frequent readjustments are made.

STABILITY OF THE INDICATION DURING BURNING-IN OF THE INSTRUMENT

After the instrument has been burned-in for half an hour, the indication (without adjustment) is approximately 0.01 N (0.1 dB) too high relative to the stationary indication. The indication is stationary after a burn-in time of approximately 3 hours, at an ambient temperature of 20°C.

SENSITIVITY TO EXTERNAL MAGNETIC FIELDS, MECHANICAL INFLUENCES, AND DISTURBING VOLTAGES SUPERIMPOSED ON THE LINE VOLTAGE

The sensitivity of the instrument to external magnetic fields, mechanical influences, and disturbing voltages superimposed on the line voltage is negligible.

DISTURBANCES TO THE OBJECT UNDER MEASURE CAUSED BY THE INSTRUMENT

Disturbances to the measured object caused by the local oscillator, the adjusting generator, switches, relays, etc., are negligible.

DISTURBANCES IN THE LINE VOLTAGE CAUSED BY THE INSTRUMENT

Disturbances in the line voltage caused by the local oscillator, the adjusting generator, switches, relays, etc., are negligible.

LINE VOLTAGE AND CONSUMPTION

<u>Line voltage:</u>	220 V $\pm 10\%$ 40-60 Hz (essentially sine wave)
<u>Consumption:</u>	85 VA

OUTPUT FOR RECORDER

Output dc current when the meter deflects to +0.1 N (+1.0 dB):

1 mA in 1 k Ω . The meter is not disconnected when a recorder is connected. The meter indication is correct when the internal resistance of the recorder is 1 k $\Omega \pm 100 \Omega$.

COMPONENTS

All the electronic components are of the professional type. All tubes except the voltage regu-

lator tube are long-life tubes. A shortening of their life must be expected if the line voltage cannot be kept within $220\text{ V} \pm 5\%$.

MOUNTING

The instrument is proof against damage in transportation and can easily be serviced. The chassis is mounted in a strong metal cabinet that has a cover and strong carrying handles.

DIMENSIONS (with cover)

Height: 310 mm (12 1/4 in.)

Width: 505 mm (20 in.)

Depth: 285 mm (11 1/4 in.)

WEIGHT 27 kg (60 lbs.)

ACCESSORIES SUPPLIED

150 Ω	Balanced	Termination, type SP 171
75 Ω	Balanced	Termination, type SP 172
75 Ω	Unbalanced	Termination, type SP 173

NECESSARY ACCESSORIES (Not supplied by Radiometer)

Balanced measuring cable 84.080 kHz (84.140 kHz)

Make: Dätwüler

Type: HF.S.4 (6-6) 14

Length: 2 meters

Total capacity: Between the two conductors: 35 pF $\pm 5\%$

Between one conductor and shield: 120 pF $\pm 5\%$

With two connectors type 9 Rel stp 6c (Siemens) and a length of approximately 2 meters.

Unbalanced measuring cable 411.920 kHz (411.860 kHz)

Make: Telcon

Type: AS 91 M

Length: 2 meters

Total capacity: 80 pF $\pm 5\%$

With two connectors type Rel stp 40q (Siemens) and a length of approximately 2 meters.

DEFINITIONS

Balance to ground

The balance to ground of the input is expressed by $\ln U_1/U_0$, where U_1 is the generator voltage fed to a measuring bridge, and U_0 is the voltage across the second bridge diagonal. The bridge consists of a balancing transformer and two exactly equal resistors of $75 \Omega \angle 0^\circ$. The voltmeter which measures the voltage U_0 is connected between the center tap of the balancing transformer and the grounded common point of the two resistors. The input connector of the instrument is connected across the balancing transformer and the chassis connected to the grounded point of the bridge. The balance to ground of the bridge proper should be at least 9 N ($\simeq 78$ dB).

Insensitivity to longitudinal voltages

The insensitivity of the instrument to longitudinal voltages is expressed by $\ln U_1/U_0$, where U_1 is a voltage which is impressed between the electrical mid-point of the input and the chassis of the instrument. U_0 indicates the reading. The mid-point of the input is produced by two exactly equal resistors of $75 \Omega \angle 0^\circ$.

Section C. General Description

GENERAL

The operating principle of the instrument can be seen in the simplified block diagram shown in Fig. C1.

84.080 kHz (84.140 kHz) Channel

The 84.080 kHz (84.140 kHz) signal is fed to the 84.080 kHz (84.140 kHz) INPUT connector and via the wafers S1a and S1b of the FREQUENCY switch to a balancing transformer. From here the signal is fed via the wafer S1c of the FREQUENCY switch to the LEVEL RANGE attenuator which attenuates the signal so much that the following amplifier can take it without being overloaded. The attenuated signal is fed to a preamplifier via the wafers S2a and S2b of the FREQUENCY switch. The preamplifier is followed by a crystal filter which provides for the necessary high selectivity of the instrument. Then the signal is fed to a final amplifier which incorporates a meter rectifier circuit. The rectified meter current is passed to the meter by the wafer S2c.

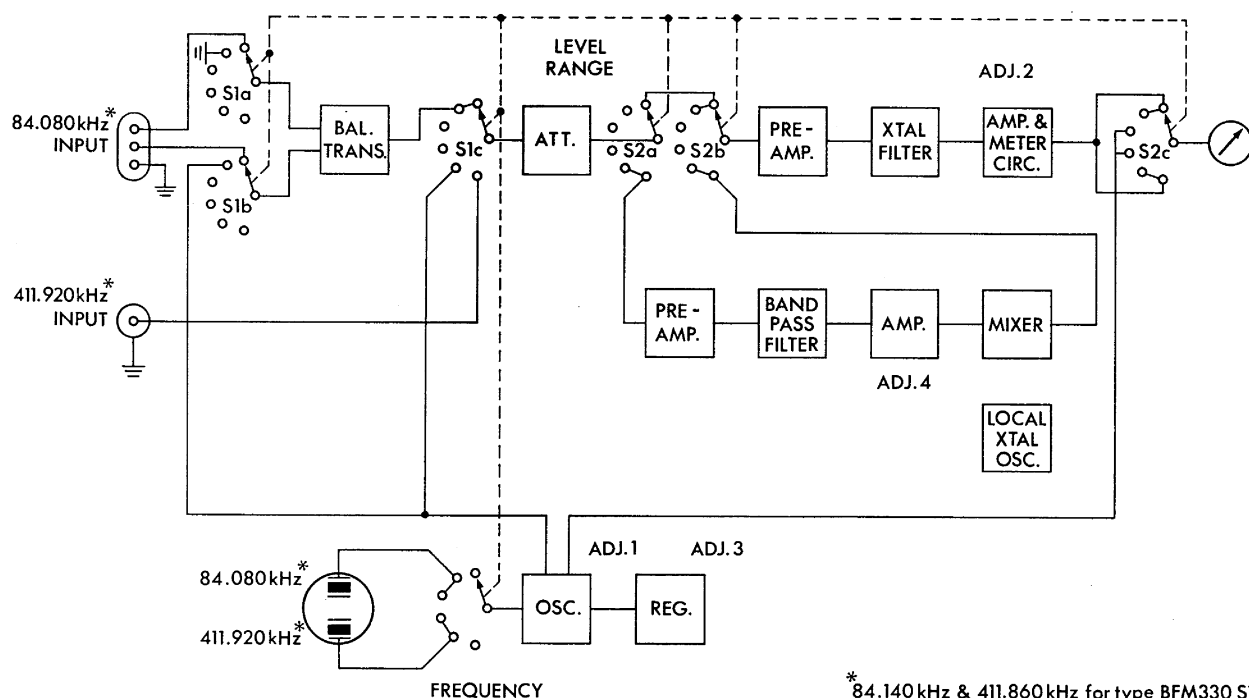
411.920 kHz (411.860 kHz) Channel

The 411.920 kHz (411.860 kHz) signal is fed to the 411.920 kHz (411.860 kHz) INPUT connector and via the wafer S1c of the FREQUENCY switch to the LEVEL RANGE attenuator. Here the signal is attenuated so much that the following amplifier can take it without being over-

loaded. The 84.080 kHz (84.140 kHz) input is disconnected from the attenuator. From the attenuator the signal is fed to a selective amplifier consisting of a pre-amplifier, a band-pass filter, and a final amplifier. From the latter, the 411.920 kHz (411.860 kHz) signal is fed to a mixer. When the mixer is supplied with a 327.840 kHz signal from a local crystal oscillator, the converted signal will have a frequency of 84.080 kHz (84.140 kHz). The selective amplifier suppresses the image frequency 243.760 kHz. From the output of the mixer, the converted signal is fed via the switch wafer S2b to the pre-amplifier, the crystal filter, and the final amplifier used when measuring the 84.080 kHz (84.140 kHz) pilot level. The rectified meter current is fed via the wafer S2c to the meter.

Adjusting Circuits

Adjustment of the two measuring channels is based on the use of a built-in adjusting generator that supplies an adjusting signal with a frequency of either 84.080 kHz (84.140 kHz) or 411.920 kHz (411.860 kHz). The adjusting generator consists of a crystal oscillator combined with a regulator which maintains a constant output level. The regulator has two controls: ADJ 1, which makes it possible to adjust the output level of the 84.080 kHz (84.140 kHz) signal, and ADJ 3, which makes it possible to adjust the output lev-



* 84.140 kHz & 411.860 kHz for type BFM330 SI

Fig.C1. Block Diagram of the Pilot Level Meter, type BFM330

el of the 411.920 kHz (411.860 kHz) signal. In the settings ADJ 1 and ADJ 3 of the FREQUENCY switch, the meter is connected directly to the rectifier circuit of the adjusting generator so that the output level can be measured and adjusted. In the setting ADJ 2 of the FREQUENCY switch, the 84.080 kHz (84.140 kHz) signal is fed to the primary of the balancing transformer. In the setting ADJ 4, the 411.920 kHz (411.860 kHz) signal is fed to the attenuator. Thus, it is possible to adjust the sensitivity of the two channels so that the meter deflects to the mark ADJ. The sensitivity is adjusted by changing the degree of feedback of the pre-amplifier in the 84.080 kHz (84.140 kHz) channel - ADJ 2 - and of the final amplifier in the 411.920 kHz (411.860 kHz) channel - ADJ 4.

CONTROLS AND TERMINALS

As can be seen in Fig.C2, the Pilot Level Meter, type BFM330, is provided with the following controls and terminals:

ON-OFF Line Switch (1)

The line switch ON-OFF switches the power on and off and is monitored by a lamp located just above the switch.

FREQUENCY Switch (2)

The switch FREQUENCY is a six-position rotary switch providing for the following functions:

In position 84.080 kHz (84.140 kHz) INPUT ADJ 1 and ADJ 2, the FREQUENCY switch provides for adjustment of the 84.080 kHz (84.140 kHz) channel.

In position 411.920 kHz (411.860 kHz), ADJ 3 and ADJ 4, the FREQUENCY switch provides for adjustment of the 411.920 kHz (411.860 kHz) channel.

Finally, in position 84.080 kHz (84.140 kHz) INPUT MEASURE and 411.920 kHz (411.860 kHz) INPUT MEASURE, the FREQUENCY switch provides for measurement of the 84.080 kHz (84.140 kHz) and 411.920 kHz (411.860 kHz) pilot levels respectively.

ADJ 1 Potentiometer (3)

The potentiometer ADJ 1 adjusts the output voltage of the adjusting generator for the 84.080 kHz (84.140 kHz) channel.

ADJ 2 Potentiometer (4)

The potentiometer ADJ 2 sets the sensitivity of the 84.080 kHz (84.140 kHz) channel.

ADJ 3 Potentiometer (5)

The potentiometer ADJ 3 adjusts the output voltage of the adjusting generator for the 411.920 kHz (411.860 kHz) channel.

ADJ 4 Potentiometer (6)

The potentiometer ADJ 4 sets the sensitivity of the 411.920 kHz (411.860 kHz) channel.

LEVEL RANGE Switch (7)

The LEVEL RANGE switch varies the sensitivity of the instrument from -10 N to +1 N (-90 dB to +10 dB for types BFM330S3 and BFM330S2S3).

In position ADJ of the LEVEL RANGE, the instrument is set to adjustment.

84.080 kHz (84.140 kHz) INPUT Connectors (8)

The 84.080 kHz (84.140 kHz) INPUT consists of two connectors in parallel for the 84.080 kHz (84.140 kHz) channel. One of the connectors is intended for connecting the measuring cable, the other for the termination, if any.

DUMMY-SOCKETS FOR TERMINATIONS Connectors (9)

The dummy sockets are used to hold the terminations when employed.

411.920 kHz (411.860 kHz) INPUT Connectors (10)

The 411.920 kHz (411.860 kHz) INPUT consists of two 13 mm connectors in parallel for the 411.920 kHz (411.860 kHz) channel. One of the connectors is intended for connecting the measuring cable, the other for the termination, if any.

RECORDER Output (11)

The RECORDER output is a three-pole banana-plug type socket which can supply dc current to an external meter or recorder.

Fuse Holder (12)

The fuse holder adapts a 0.4 A slow-blow fuse for 220 V ac operation.

Line Cord (13)

The line cord provides for connection to a line voltage outlet delivering 220 V ac.

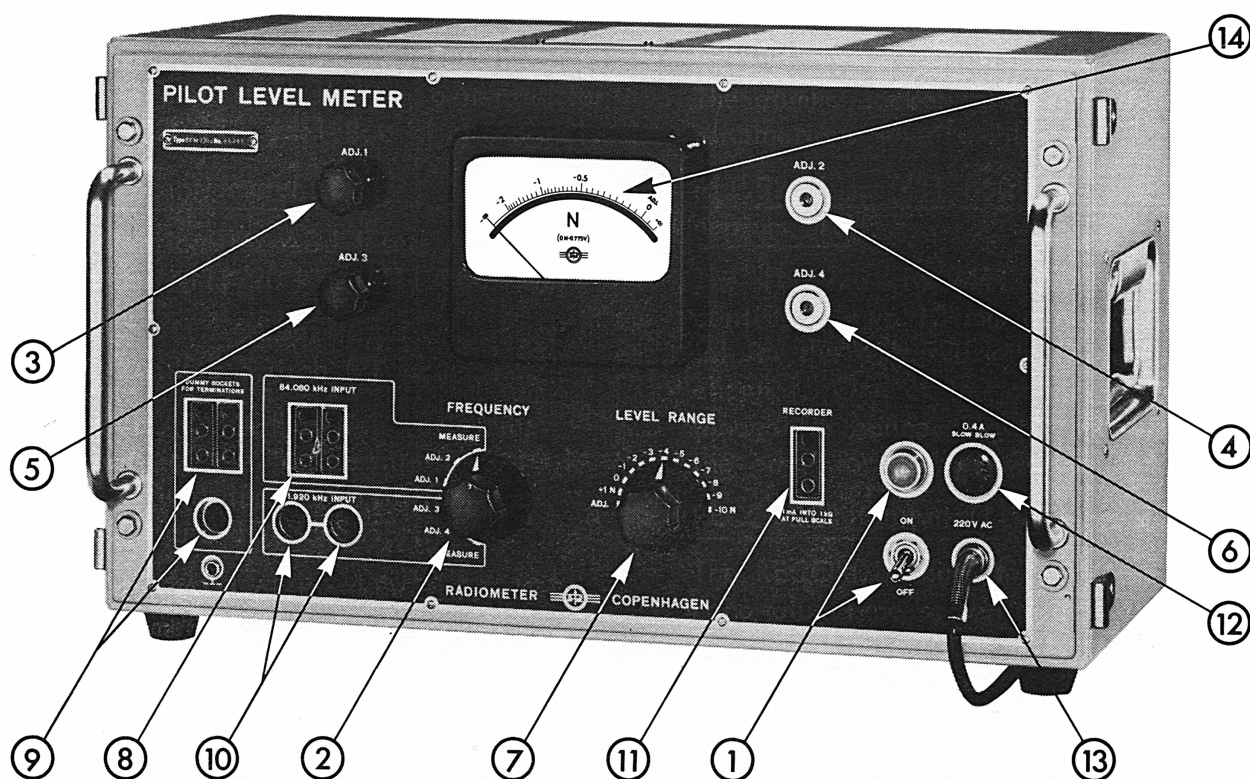


Fig.C2. Front Plate of the Pilot Level Meter, type BFM330

Meter (14)

The meter is mirror-backed and a knife-edge pointer allows for accurate reading

free from parallax. The meter is provided with one scale calibrated from $-\infty$ to $+0.1$ ($-\infty$ to $+1$ for type BFM330S3 and BFM330S2S3).

Section D. Operating Instructions

CONNECTING AND BURNING-IN THE INSTRUMENT

- 1) Connect the instrument to the line with the fixed power cord. Make sure that the line voltage is 220 volts ac.
- 2) Set the line switch to ON.
- 3) Let the instrument burn in for half an hour.

Note: After a burn-in time of half an hour the instrument can be adjusted and put in use. At intervals it should be re-adjusted until the stationary condition is reached. Generally this takes 3 hours.

ADJUSTING THE INSTRUMENT

- 1) Set the LEVEL RANGE switch to ADJ and the FREQUENCY switch to ADJ 1.
- 2) Adjust the ADJ 1 control so that the meter deflects to the mark ADJ.
- 3) Set the FREQUENCY switch to ADJ 2.
- 4) Adjust the ADJ 2 potentiometer with a screwdriver so that the meter again deflects to the mark ADJ. (The 84.080 kHz (84.140 kHz) channel has now been adjusted.)
- 5) Set the FREQUENCY switch to ADJ 3.
- 6) Adjust the ADJ 3 control so that the meter deflects to the mark ADJ.
- 7) Set the FREQUENCY switch to ADJ 4.
- 8) Adjust the ADJ 4 potentiometer with a

screwdriver so that the meter deflects to the mark ADJ. (The 411.920 kHz (411.860 kHz) channel has now been adjusted.)

Note: The instrument is designed so that there can be no interaction between it and the measuring points when the measuring cables are connected to the latter.

MEASURING THE 84.080 kHz (84.140 kHz) PILOT LEVEL

- 1) Connect the measuring cable to one of the two connectors marked 84.080 kHz (84.140 kHz) INPUT.
- 2) Insert the 75 Ω or the 150 Ω termination in the other connector if the measurement is to be made with a terminated measuring cable.
- 3) Set the FREQUENCY switch to MEASURE (84.080 kHz (84.140 kHz)).
- 4) Set the LEVEL RANGE switch to such a position that the meter deflects, preferably, within the range -0.9 to +0.1 N (-9 to +10 dB).
- 5) Read the meter and add the reading to the value indicated by the LEVEL RANGE switch to find the pilot level.

Note: To fulfill the specifications, the sensitivity must not be increased by more than 2 N (17 dB) above the setting which corresponds to the nominal pilot level at the measuring point. It is taken for granted that the nominal pilot level is 2.3 N

(20 dB) below the nominal measuring level at the point in question.

At intervals make sure that the instrument is still correctly adjusted. Proceed as follows:

6) Set the FREQUENCY switch to ADJ 1 and the LEVEL RANGE switch to ADJ.

7) Adjust the ADJ 1 control so that the meter deflects to the mark ADJ.

8) Set the FREQUENCY switch to ADJ 2. The meter should still deflect to the mark ADJ. If it does not:

9) Readjust the ADJ 2 potentiometer with a screwdriver so that the meter deflects to the mark ADJ.

Note: An adjustment of the ADJ 2 potentiometer involves a readjustment of the 411.920 kHz (411.860 kHz) channel.

MEASURING THE 411.920 kHz (411.860 kHz) PILOT LEVEL

1) Connect the measuring cable to one of the two connectors marked 411.920 kHz (411.860 kHz) INPUT.

2) Insert the 75 Ω termination in the other connector if the measurement is to be made with a terminated measuring cable.

3) Set the FREQUENCY switch to MEASURE (411.920 kHz (411.860 kHz)).

4) Set the LEVEL RANGE switch to such a position that the meter deflects, preferably, within the range -0.9 to +0.1 N (-9 to +10 dB).

5) Read the meter and add the reading to the value indicated by the LEVEL RANGE switch to find the pilot level.

Note: To fulfill the specifications, the sensitivity must not be increased by more than 2 N (17 dB) above the setting which corresponds to the nominal pilot level at the measuring point. It is taken for granted that the nominal pilot level is 2.3 N (20 dB) below the nominal measuring level at the point in question.

At intervals make sure that the instrument is still correctly adjusted. Proceed as follows:

6) Set the FREQUENCY switch to ADJ 3 and the LEVEL RANGE switch to ADJ.

7) Adjust the ADJ 3 control so that the meter deflects to the mark ADJ.

8) Set the FREQUENCY switch to ADJ 4. The meter should still deflect to the mark ADJ. If it does not:

9) Readjust the ADJ 4 potentiometer with a screwdriver so that the meter deflects to the mark ADJ.

CONNECTING AN EXTERNAL METER OR RECORDER

Connect the external meter or recorder to the connector marked RECORDER.

Note: The sensitivity of the internal meter is correct as long as the resistance of the externally connected meter or recorder is kept within 1 k Ω \pm 100 Ω .

Section E. Technical Description

GENERAL

In the detailed description below, the various units of the instrument are treated in the following order:

1. Input circuit
2. Attenuator
3. 84.080 kHz (84.140 kHz) channel
4. 411.920 kHz (411.860 kHz) channel
5. Local oscillator
6. Adjusting generator
7. Power supply

INPUT CIRCUIT

84.080 kHz (84.140 kHz) Input Circuit

The 84.080 kHz (84.140 kHz) signal is fed to one of the two connectors J1 or J2, connected in parallel. The other connector is used for the termination, when it is employed. From the connectors, the signal is fed to the contacts K1a and K1b of the relay K1. The diode CR1 suppresses disturbances which might occur when the current in the relay coil is broken.

The current through the relay coil flows via the contacts of the wafer S1d of the FREQUENCY switch and the wafer S3a of the LEVEL RANGE switch. The circuitry is designed so that the current does not run through the relay coil as long as the FREQUENCY switch is set to MEASURE (84.080 kHz (84.140 kHz)), assuming that the LEVEL RANGE switch

is not set to ADJ. This means that the input connectors are connected to the circuits of the instrument. In all other settings of the two switches, the connection between the input connectors and the circuits of the instrument is broken.

When the FREQUENCY switch is set to MEASURE (84.080 kHz (84.140 kHz)), the signal is fed from the relay contacts K1a and K1b via the wafers S1a and S1b of the FREQUENCY switch to the primary of the balancing transformer T1. From the secondary of T1 the signal is fed to the LEVEL RANGE attenuator via the wafer S1c. When the FREQUENCY switch is set to ADJ 2, an adjusting signal (84.080 kHz (84.140 kHz), -1 N (-10 dB)) is fed from the adjusting generator via the wafers S1a and S1b to the primary of the balancing transformer and onward to the attenuator as described above.

411.920 kHz (411.860 kHz) Input Circuit

The 411.920 kHz (411.860 kHz) signal is fed to one of the two connectors J3 or J4, connected in parallel. The other connector is used for the termination, when it is employed. From the connectors, the signal is fed to the contacts K2a of the relay K2. The diode CR2 suppressed any disturbances which might occur when the current in the relay is broken.

The current through the relay coil flows

via the contacts of the wafer S1d of the FREQUENCY switch and wafer S3a of the LEVEL RANGE switch. The circuitry is designed so that the current does not run through the relay coil as long as the FREQUENCY switch is set to MEASURE (411.920 kHz (411.860 kHz)), assuming that the LEVEL RANGE switch is not set to ADJ. This means that the input connectors are connected to the circuits of the instrument. In all other settings of the two switches, the connection between the input connectors and the circuits of the instrument is broken.

When the FREQUENCY switch is set to MEASURE (411.920 kHz (411.860 kHz)), the signal is fed from the relay contacts K2a via wafer S1c of the FREQUENCY switch to the LEVEL RANGE attenuator.

When the FREQUENCY switch is set to ADJ 4, an adjusting signal (411.920 kHz (411.860 kHz), -1 N (-10 dB)) is fed from the adjusting generator via the wafer S1c to the attenuator.

ATTENUATOR

The attenuator serves to attenuate the signal to a level that corresponds to the sensitivity of the preamplifier just behind the attenuator (-10 N (-90 dB) when the meter deflects to 0).

The attenuator is divided into two parts which are totally shielded from each other. One part is a simple voltage divider which consists of resistors connected in series (R1 and R5). The other consists of π -sections (R6 to R18).

When the attenuator is set to -9 N (-80 dB), the capacitive load of the attenuator, caused by the subsequent amplifier, would give rise to a small measuring error at 411.920 kHz (411.860 kHz). However, this error has been eliminated by incorporating the compensating choke L1.

The attenuator comprises two pairs of contacts in the wafer S3a of the LEVEL RANGE switch. When this switch is set to ADJ, one set of contacts turns on the current in the relay coils K1 and K2,

which means that the connection between the input connectors and the circuits of the instrument is completely broken. The other set of contacts turns on the current to the adjusting generator.

84.080 kHz (84.140 kHz) CHANNEL

Preamplifier

When the FREQUENCY switch is set to one of the positions ADJ 1, ADJ 2, or MEASURE (84.080 kHz (84.140 kHz)), the output of the attenuator is connected to the preamplifier of the 84.080 kHz (84.140 kHz) channel via the wafer S2a. The preamplifier consists of three stages, V1, V2, and V3, and has a high degree of feedback, which ensures high stability of the amplifier. The plate circuit of V1 (L101, C102) is tuned to 84 kHz. From the plate of V3, the signal is fed to the crystal filter E101.

Crystal Filter

The crystal filter provides the high selectivity of the instrument.

Final Amplifier

From the crystal filter the signal is fed to the feedback amplifier consisting of V4, V5, and V6. The plate circuit (L201, C202) of V4 is tuned to 84 kHz. The high degree of feedback ensures high stability. By means of the variable resistor R216, ADJ 2, the amplification - and with it the sensitivity of the 84.080 kHz (84.140 kHz) channel - can be varied within certain limits. From the plate of V6, the output signal is fed to a meter rectifier circuit CR201, CR202, C214, and C215. The rectifier current, which is proportional to the mean value of the signal, is fed to the meter M201 via the wafer S2c and S2d, when the FREQUENCY switch is set to ADJ 2, ADJ 4, or MEASURE (84.080 kHz (84.140 kHz) or 411.920 kHz (411.860 kHz)).

When a recorder is connected to the connector J201, the recorder is connected in series with the meter, replacing the resistor R223. The two resistors R221 and R222 make up a shunt of the meter. This

shunt is used when the FREQUENCY switch is set to ADJ 2, ADJ 4, or MEASURE (84.080 kHz (84.140 kHz) or (411.920 kHz (411.860 kHz)) and serves to change the sensitivity of the meter from 0.2 mA to 1 mA. The latter value corresponds to the prescribed sensitivity of the recorder.

411.920 kHz (411.860 kHz) CHANNEL

Preamplifier and Band-pass Filter

When the FREQUENCY switch is set to one of the positions ADJ 3, ADJ 4, or MEASURE (411.920 kHz (411.860 kHz)), the output of the attenuator is connected to the preamplifier of the 411.920 kHz (411.860 kHz) channel via the wafer S2a.

The preamplifier consists of a one-stage feedback amplifier V7. In the plate circuit of this tube is inserted a band-pass filter for 411.920 kHz (411.860 kHz). The filter is critically coupled and provides a certain preselection and a suppression of the image frequencies.

Final Amplifier

The signal is fed from the band-pass filter to a two-stage feedback amplifier, which consists of V8 and V9. The plate circuit (L303, C311) of V8 is tuned to 412 kHz. By means of the variable resistor R311, ADJ 4, the amplification - and with it the sensitivity of the 411.920 kHz (411.860 kHz) channel - can be varied within certain limits. From V9 the signal is fed to a ring modulator.

Ring Modulator

The ring modulator circuit consists of the transformers T301 and T302 and the rectifier unit CR301, which consists of 4 matched diodes. The ring modulator is supplied with a local oscillator signal with a frequency of 327.840 kHz. From the secondary of the transformer T302, a signal with a frequency of 84.080 kHz (84.140 kHz) is fed to the 84.080 kHz (84.140 kHz) channel via the wafer S2a of the FREQUENCY switch.

LOCAL OSCILLATOR

The local oscillator, which supplies a

signal with a frequency of 327.840 kHz to the ring modulator, is a Meacham-bridge stabilized crystal oscillator made up of V10 and V11. One arm of the bridge circuit consists of the incandescent lamp RT401, which acts as a regulating lamp. Any change that occurs in the circuitry of the local oscillator - for example, in the amplification - will cause a change in the resistance of the lamp in such a way that the output voltage of the local oscillator is kept reasonably constant.

A series resonant circuit, L401 and C407, is inserted in series with the crystal Y401. With the variable capacitor C407, it is possible to adjust the frequency of the output signal. The variable resistor R413 adjusts the level of the output signal. Any change in the resistor gives rise to a change in the balance condition of the bridge, which in turn changes the operating point of the incandescent lamp. Then the output signal stabilizes around the new level.

The crystal Y401 is housed in a thermostatically regulated oven, which ensures high stability of the frequency. The frequency can be checked by connecting a frequency counter to the connector J401, accessible from the bottom of the instrument.

ADJUSTING GENERATOR

Oscillator Circuit

The adjusting generator supplies a signal with a frequency of either 84.080 kHz or 411.920 kHz (84.140 kHz or 411.860 kHz). After the output level has been adjusted, the signal is fed to either the 84.080 kHz or the 411.920 kHz (84.140 kHz or 411.860 kHz) channel. The sensitivity of these two channels can then be adjusted.

The adjusting generator consists of an oscillator, V12, combined with a regulator, V13.

For the sake of achieving a high frequency stability, the oscillator is crystal-controlled. The two crystals Y501

and Y502 produce the two different frequencies, and the crystal to be used is selected with the relay K501. The relay coil carries current via a set of contacts in the wafer S2b, when the FREQUENCY switch is set to ADJ 3 or ADJ 4. In either case, the 411.920 kHz (411.860 kHz) crystal is connected to the circuit instead of the 84.080 kHz (84.140 kHz) crystal. The crystals are housed in a common thermostatically controlled oven.

The plate current to the oscillator, V12b, is drawn from the series regulator, V13a. The signal is fed from the oscillator to a cathode-follower, V12a, to which the following circuits are connected: the output circuit, the measuring circuit, and the regulating circuit.

Output Circuit

The adjusting signal is drawn from the secondary of the transformer T501 and fed to the wafers S1b and S1c. When the FREQUENCY switch is set to either ADJ 2 or ADJ 4, the adjusting signal is fed to the attenuator, which is designed so that the sensitivity of the instrument is -1 N (-10 dB) (corresponding to the nominal level of the adjusting signal) when the LEVEL RANGE switch is set to ADJ. Therefore, the meter deflects to the mark ADJ.

The frequency can be checked by connecting a frequency counter to the connector J501, accessible from the bottom of the instrument.

Measuring Circuit

The measuring circuit is necessary for the level adjustment of the signal which is used when adjusting the two channels of the instrument. The level is measured at the primary of the transformer T501, because a voltage high enough for good rectification is present here. The rectifier is a peak-value rectifier consisting of the diode CR502 with the appropriate filter R501, C502, L501, and C501. The rectified voltage is fed via the wafers S2c and S2d to the meter M201. When

the FREQUENCY switch is set to ADJ 1, the resistors R524 and R525 act as voltmeter resistors, and when it is set to ADJ 3, the resistors R526 and R527 act as voltmeter resistors. Because the resistors R525 and R527 are variable, the measuring circuit can be adjusted internally.

Regulating Circuit

The regulating circuit keeps the output level constant. The signal at the primary of the transformer T501 is rectified by the diode CR501. In V13b, the rectified positive voltage is compared with the reference voltage from the zener diode CR503. The difference between these two voltages is amplified and used as a control voltage for the series regulator, V13a, so that any change in the output level of the oscillator is counteracted. The operating point - and with it the output level - is adjusted with the potentiometer R511, ADJ 1, for 84.080 kHz (84.140 kHz) and the potentiometer R519, ADJ 3, for 411.920 kHz (411.860 kHz). The two potentiometers are connected to the circuit via the relay contacts K502a, because the relay K502 is connected in parallel with the relay K501. The diodes CR504 and CR505 suppress any disturbances which might occur when the current in the relay coils is broken.

The plate voltage is fed to the adjusting generator only when the FREQUENCY switch is set to one of the positions ADJ and the LEVEL RANGE switch is set to ADJ.

POWER SUPPLY

The power supply delivers the voltages necessary to operate the instrument. The transformer T602 supplies an ac voltage which, after rectification in the bridge rectifier CR602 and smoothing in the filter L601, C603, and C604, is fed to the various circuits of the instrument via the terminals A, B, C, D, and E. From the voltage regulator, V14, a stabilized voltage is fed to the adjusting generator. The filament voltage for all tubes of the instrument is drawn from the transformer T602.

The transformer T601 supplies voltage to the thermostatically controlled ovens and to the pilot lamp. The transformer also

supplies a voltage which, after rectification in the bridge rectifier CR601, is used to operate the relays.

Section F. Maintenance

GENERAL

As the Pilot Level Meter, type BFM330, is a very delicate instrument, unnecessary repairs or attempts to improve the accuracy should not be made.

Such repairs as may become necessary should be made only by skilled personnel, provided with sufficient equipment to ensure that the repair is properly made.

If the equipment is transported, handled, and operated with care, its useful life will be prolonged and trouble will be reduced to a minimum.

REMOVING THE INSTRUMENT FROM THE CABINET

The instrument can be removed from the cabinet when the four mounting screws at the corners of the front panel have been removed, as shown in Fig. F1.



Fig. F1. How to Dismount the Pilot Level Meter, type BFM330

REPLACING THE TUBES

In general, the tubes of the instrument need not be replaced until they cause some kind of trouble. The feedback of the circuits is so strong that the mutual conductance can be allowed to drop to 70% of the guaranteed value without affecting the stability.

A tube is worn out when one or more of the characteristics I_a , I_{g2} , S , or $-I_{g1}$ have changed from the typical values to the limiting values.

	Pentode section	Triode section
E80CF:		
Typical values:	$V_a = 170 \text{ V}$	$V_a = 100 \text{ V}$
	$V_{g2} = 170 \text{ V}$	$R_k = 120 \Omega$
	$R_k = 155 \Omega$	$I_a = 14 \text{ mA}$
	$I_a = 10 \text{ mA}$	$S = 5 \text{ mA/V}$
	$I_{g2} = 2.8 \text{ mA}$	$-I_g = 0.3 \mu\text{A}$
	$S = 6.2 \text{ mA/V}$	
Limiting values:	$-I_{g1} = 0.3 \mu\text{A}$	
	$I_a < 6 \text{ mA}$	$I_a < 8.4 \text{ mA}$
	$S < 4.3 \text{ mA/V}$	$S < 3.5 \text{ mA/V}$
	$-I_{g1} < 1 \mu\text{A}$	$-I_g < 1 \mu\text{A}$

E83F:	
Typical values:	$V_a = 210 \text{ V}$
	$V_{g3} = 0 \text{ V}$
	$V_{g2} = 120 \text{ V}$
	$R_k = 165 \Omega$
	$I_a = 10 \text{ mA}$
	$I_{g2} = 2.1 \text{ mA}$
Limiting values:	$S = 9 \text{ mA/V}$
	$-I_{g1} = 0.5 \mu\text{A}$
	$I_a < 7 \text{ mA}$
	$I_{g2} < 1.25 \text{ mA}$
	$S < 6.4 \text{ mA/V}$
	$-I_{g1} < 1 \mu\text{A}$
E188CC:	(per system)
Typical values:	$V_a = 100 \text{ V}$
	$V_g = +9 \text{ V}$
	$R_k = 680 \Omega$
	$I_a = 15 \text{ mA}$
	$S = 12.5 \text{ mA/V}$
Limiting values:	$I_a < 13.5 \text{ mA}$
	$S < 9 \text{ mA/V}$
	$-I_g < 1 \mu\text{A}$

ALIGNING THE TUNED CIRCUITS

Preamplifier of the 84.080 kHz (84.140 kHz) Channel

The resonant circuit C102-L101 should be tuned to 84.080 kHz (84.140 kHz) ± 100 Hz. The feedback of the amplifier must be neutralized during tuning. Proceed as follows:

1) Break the connection between the resistors R108 and R117.

- 2) Unsolder the cable W101 at the capacitor C111 and connect a VM instead.
- 3) Unsolder the capacitor C101 at the wafer S2a and connect a signal generator to the amplifier through the capacitor.
- 4) Adjust the signal generator to a frequency of 84.080 kHz (84.140 kHz) ± 100 Hz.
- 5) Tune the resonant circuit C102-L101 to resonance, indicated by a maximum deflection on the VM.
- 6) Then resolder the circuit.

Final Amplifier of the 84.080 kHz (84.140 kHz) Channel

The resonant circuit C202-L201 should be tuned to 84.080 kHz (84.140 kHz) ± 100 Hz. The feedback of the amplifier must be neutralized during tuning. Proceed as follows:

- 1) Break the connection between the resistors R209 and R216.
- 2) Unsolder the cable W201 at the resistor R201 and connect a signal generator instead.
- 3) Adjust the signal generator to a frequency of 84.080 kHz (84.140 kHz) ± 100 Hz.
- 4) Tune the resonant circuit C202-L201 to resonance, indicated by a maximum deflection on the meter of the amplifier.

5) Then resolder the circuit.

Preamplifier of the 411.920 kHz (411.860 kHz) Channel

The band-pass filter L301-C303-L302-C307 should be tuned to a center frequency of 411.920 kHz (411.860 kHz) and be flat within ± 0.01 N (± 0.1 dB) in a range of ± 1 kHz. Proceed as follows:

- 1) Unsolder the capacitor C301 at the wafer S2a and connect a signal generator to the preamplifier via the capacitor C301.
- 2) Connect a VM to the plate of V9. V11 of the local oscillator can be withdrawn so that the signal from the local oscillator does not disturb the reading of the VM.
- 3) Connect a load resistance of 1 kilohm across one circuit and tune the second circuit to resonance, indicated by a maximum deflection on the VM.
- 4) Connect the load resistance to the second circuit and tune the first circuit to resonance.
- 5) Remove the load resistance and check the filter curve by detuning the signal generator and watching the corresponding change of the deflection of the VM.
- 6) First try to get a weak overcritical coupling.
- 7) Then turn the coupling capacitor C306 so far backwards that critical coupling is only just obtained, i.e., the two peaks of the curve disappear and the curve becomes flat. Any change of the coupling capacitor causes a detuning of the band-pass filter. Therefore, it must be retuned, according to the method stated above, before the filter curve is checked.
- 8) Resolder the circuit.

Final Amplifier of the 411.920 kHz (411.860 kHz) Channel

The resonant circuit C311-L303 should be tuned to 411.920 kHz (411.860 kHz) ± 100 Hz. The feedback of the amplifier

must be neutralized during tuning. Proceed as follows:

- 1) Unsolder the capacitor C316 at the plate of V9 and connect a VM to the plate instead. V11 of the local oscillator can be withdrawn so that the signal from the local oscillator does not disturb the reading of the VM.
- 2) Unsolder the capacitor C308 and connect a signal generator to the final amplifier via the capacitor C308.
- 3) Tune the signal generator to 411.920 kHz (411.860 kHz) ± 100 Hz.
- 4) Now tune the resonant circuit C311-L303 to resonance, indicated by a maximum deflection on the VM.
- 5) Then resolder the circuit.

ADJUSTING THE LOCAL OSCILLATOR

Adjusting the Frequency

The tuning of the series resonant circuit C407-L401, which is in series with the crystal Y401 of the local oscillator, determines the frequency. Note that the thermostatically controlled oven should burn for at least 15 minutes before the frequency is adjusted. Proceed as follows:

- 1) Connect a frequency counter to the test jack J401.
- 2) Adjust the capacitor C407 so that the frequency is 327.840 kHz ± 0.1 Hz.
- 3) Set the capacitor C407 to the center position and adjust the coil L401 so that the frequency is 327.840 kHz. If this cannot be obtained, a capacitor parallel to C407 can be connected in order to obtain the right frequency.
- 4) Then see whether it is possible to obtain a frequency displacement of approximately ± 5 Hz by varying the capacitor C407. If this cannot be obtained, change the coil and repeat the procedure.

Adjusting the Amplitude

- 1) Adjust the output voltage of the local oscillator with the potentiometer R413.

2) Measure the voltage at the test jack J401 with a VM. It should be approximately 2.5 volts. If the crystal has been replaced, the bridge ratio may be wrong, which will make it impossible to get the right output voltage. The bridge ratio can be corrected by changing the resistor R411. However, the voltage across the regulating lamp RT401 should be approximately 0.75 volts to obtain good regulation.

ADJUSTING THE ADJUSTING GENERATOR

Adjusting the Frequencies

The exact value of the two adjusting frequencies depends on the setting of the capacitors C513 and C514. Note that the thermostatically controlled oven should burn for at least 15 minutes before the frequency is adjusted. Then proceed as follows:

- 1) Connect a frequency counter to the test jack J501.
- 2) Set the LEVEL RANGE switch to ADJ and the FREQUENCY switch to ADJ 1.
- 3) Adjust the capacitor C513 so that the frequency is 84.080 kHz (84.140 kHz) ± 0.1 Hz.
- 4) Then set the FREQUENCY switch to ADJ 3 and adjust the capacitor C514 so that the frequency is 411.920 kHz (411.860 kHz) ± 0.1 Hz.

If the crystals have been replaced, the oscillator may have been brought out of the regulating range. Make a check as follows:

- 5) First set the FREQUENCY switch to ADJ 1 and note on the meter whether it is possible to vary the voltage with the potentiometer ADJ 1.
- 6) Next set the FREQUENCY switch to ADJ 3 and vary the voltage with the potentiometer ADJ 3.

If it is not possible to vary the voltage, the regulating circuit is not working. This is mainly because the crystal oscillates either too little or too much. The

feedback of the oscillator is easily changed by changing the ratio between the capacitors C509 and C510 for the 84.080 kHz (84.140 kHz) frequency and the capacitors C511 and C512 for the 411.920 kHz (411.860 kHz) frequency. When the capacitors are changed, the frequency is also changed a little. This can be corrected with the variable capacitors C513 or C514, but it should still be possible to change the frequency by some ± 5 Hz.

Calibrating the 84.080 kHz (84.140 kHz) Adjusting Signal

The measuring accuracy of the instrument depends directly on the adjusting generator, which is calibrated in the following way:

- 1) Use a sending level standard such as the Radiometer Sending Level Standard, type SNN1, to standardize an 84.080 kHz (84.140 kHz) signal to -1.00 N (-10 dB).
- 2) Feed the output voltage of the SNN1 to the input of the instrument.
- 3) Set the FREQUENCY switch to MEASURE (84.080 kHz (84.140 kHz)) and the LEVEL RANGE switch to -1 N (-10 dB).
- 4) Set the deflection of the meter exactly to the ADJ mark with the screwdriver control ADJ 2.
- 5) Then set the FREQUENCY switch to ADJ 2 and the LEVEL RANGE switch to ADJ.
- 6) Adjust the control ADJ 1 so that the meter again deflects to the ADJ mark. After this operation, do not change the setting of the control ADJ 1.
- 7) Next set the FREQUENCY switch to ADJ 1.
- 8) Disconnect the input cable and remove the instrument from the cabinet without turning it off.
- 9) Now set the internal potentiometer R524 (P2) so that the meter deflects exactly to the ADJ mark.
- 10) Lock the potentiometer with the lock-

ing device and put the instrument back in the cabinet.

The 84.080 kHz (84.140 kHz) adjusting signal has now been calibrated. Make a check as follows:

11) First adjust the instrument internally (ADJ 1 and ADJ 2).

12) Then measure with the instrument an external 84.080 kHz (84.140 kHz) signal with a level of exactly -1 N (-10 dB). The meter should now deflect exactly to the ADJ mark.

Calibrating the 411.920 kHz (411.860 kHz) Adjusting Signal

1) Use a sending level standard such as the Radiometer Sending Level Standard, type SNN1, to standardize a 411.920 kHz (411.860 kHz) signal to -1.00 N (-10 dB).

2) Feed the output voltage of the SNN1 to the input of the instrument.

3) Set the FREQUENCY switch to MEASURE (411.920 kHz (411.860 kHz)) and the LEVEL RANGE switch to -1 N (-10 dB).

4) Set the deflection of the meter exactly to the ADJ mark with the screwdriver control ADJ 4.

5) Then set the FREQUENCY switch to ADJ 4 and the LEVEL RANGE switch to ADJ.

6) Adjust the control ADJ 3 so that the meter again deflects to the ADJ mark. After this operation, do not change the setting of the control ADJ 3.

7) Next set the FREQUENCY switch to ADJ 3.

8) Disconnect the input cable and remove the instrument from the cabinet without turning it off.

9) Now set the internal potentiometer R526 (P3) so that the meter deflects exactly to the ADJ mark.

10) Then lock the potentiometer with the

locking device and put the instrument back in the cabinet.

The 411.920 kHz (411.860 kHz) adjusting signal has now been calibrated. Make a check as follows:

11) First adjust the instrument internally (ADJ 3 and ADJ 4).

12) Then measure with the instrument an external 411.920 kHz (411.860 kHz) signal with a level of exactly -1 N (-10 dB). The meter should now deflect exactly to the ADJ mark.

OPERATING VOLTAGES

The dc voltages listed at the end of the manual can be used as references when the instrument is serviced. The values are average values from a series of measurements, and deviations of up to 20% may usually be neglected. All voltages are measured to ground.

ADJUSTMENT OF THE CRYSTAL FILTER

The crystal filter is adjusted at the factory, and unless serious changes in the flatness of the passband have taken place, no adjustments should be made. However, experience has shown that crystal filters are delicate elements, so that changes in the frequency response may occur in the course of time. By following the instructions given below, it should be possible to readjust the crystal filter, but in some cases the readjustment may turn out to be very troublesome and time-consuming. Therefore it is recommended to send the instrument to the factory if adjustments are necessary.

Measuring Flatness of Passband

This measurement requires the following instruments:

1) A frequency-stable and level-stable signal generator capable of delivering an output voltage of approx. 1 volt to a 75 Ω load.

2) A 1 MHz frequency counter with at least 6 digits. Accuracy: 10^{-6} .

3) A sending level standard such as the

Radiometer Sending Level Standard, type SNN1.

4) A 75 Ω step-wise variable attenuator. Smallest step should be 0.01 N (0.1 dB).

The measurement is made in the following way:

1) Turn on the Pilot Level Meter and let it warm up for 3 hours, so that the crystal filter attains the working temperature.

2) Connect the signal generator to the 84.080 kHz (84.140 kHz) INPUT of the Pilot Level Meter via the sending level standard and the attenuator.

3) Connect the frequency counter to the signal generator.

4) Adjust the sending level standard to -1 N (-10 dB), the attenuator to -1 N (-10 dB) and the LEVEL RANGE control to -2 N (-20 dB).

5) Adjust the frequency to 84.080 kHz (84.140 kHz).

6) Adjust ADJ 2 so that the meter deflects to the ADJ mark.

7) Increase the generator frequency by ± 3 , ± 6 , ± 9 , ± 12 and ± 15 Hz.

8) For each of the specified frequencies adjust the sending level standard output - and, if necessary, also the attenuator - so that the meter deflects to the ADJ mark.

9) Read the change in the input level of the Pilot Level Meter on the sending level standard and the attenuator.

10) Draw the frequency response curve and compare it with the one specified in SECTION B - SPECIFICATIONS.

Note: Although the guaranteed flatness of the passband is within ± 0.025 N (± 0.22 dB) over the frequency range 84.080 kHz (84.140 kHz) ± 7 Hz, the crystal filter is adjusted at the factory to be flat within ± 0.015 N (± 0.13 dB).

Adjustment of Terminating Resistors R118 and R201

To a certain degree the flatness of the

passband can be corrected by slightly changing the value of the terminating resistors R118 and R201, whereas a displacement of the bandpass curve with respect to the centre frequency 84.080 kHz (84.140 kHz) mostly depends on the capacitive trimmers of the crystal filter. There is, however, some interaction between these two adjustments.

This item describes how to correct the flatness of the passband. Use the same measuring setup as described above and proceed as follows:

1) Remove the instrument from the cabinet. (The crystal filter will keep its internal working temperature for some hours).

2) Supply an 84.080 kHz (84.140 kHz) signal, level -2 N (-20 dB), and set the ADJ2 control so that the meter deflects to the ADJ mark.

3) Remove R118 and replace it by a small carbon potentiometer of approx. 500 Ω .

4) Adjust the potentiometer to obtain a deflection to the ADJ mark.

5) Remove R201 and replace it by a small carbon potentiometer of approx. 500 Ω .

6) Adjust the potentiometer to obtain a deflection to the ADJ mark.

7) Increase experimentally the value of R118 a little.

8) Decrease the value of R201 so that the meter again deflects to the ADJ mark.

9) Measure the flatness of the passband in the range ± 15 Hz as described above.

10) If an improvement has taken place, proceed with the adjustment as outlined in items 7) to 9) above.

11) If, however, a deterioration has taken place, decrease the value of R118, and increase the value of R201 when making the adjustment.

12) When an acceptable flatness has been obtained, remove the potentiometer R118 without changing the setting.

13) Measure the value of the potentiometer and replace it by a metal film resistor.

Note: If the correct value cannot be found, a carbon resistor can be used for shunting the metal film resistor.

14) Measure the flatness of the bandpass curve.

15) Now remove the potentiometer R201 without changing the setting.

16) Proceed as described in items 13) and 14) above.

Adjustment of the Built-in Trimmers of the Crystal Filter

It may turn out that the centre of the bandpass curve is displaced 1 or 2 Hz with respect to 84.080 kHz (84.140 kHz). To a certain degree the built-in trimmers of the crystal filter may be used for correcting this matter. The following instructions are based on experience only, and no universally valid rule can be given.

1) Measure the bandpass curve and de-

termine the centre frequency of the pass-band.

Note: The centre frequency will usually fall at a minimum of the curve. One maximum is reached 4 to 8 Hz upwards, and another maximum 4 to 8 Hz downwards.

2) Adjust the signal generator to the frequency just determined.

3) Unscrew the covers of the trimmers and adjust the trimmers to obtain an increase in the meter deflection. Preferably a maximum deflection should be obtained, but some manipulation may prove necessary.

4) Measure the bandpass curve and repeat item 3) if necessary.

Note: In some cases a minor adjustment of the terminating resistors R118 and R201 may be called for.

Section G. Parts List

When ordering spare parts, please include:

A complete description of the part

The circuit reference in wiring diagram

The complete type designation of your instrument

The series number of your instrument

If the component wanted is not listed below, please describe its function and state its location in the instrument.

Circuit reference	Designation	Code			Manufacturers
Capacitors					
C1	Polyester	0.1 μ F	200 V		Eromet
C3	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C4	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C5	Feed-through	10 nF	500 V	B37020	Siemens
C6	Feed-through	10 nF	500 V	B37020	Siemens
C6a	Polyester	1.2 nF	400 V		Philips
C101	Polyester	0.1 μ F	250 V		Eromet
C102	Polystyrene	1 nF	500 V 5%	B31012	Siemens
C103	Polyester	0.27 μ F	400 V		Philips
C104	Ceramic	100 pF	500 V	9/0121, 3P	Ferroperm
C105	Tantalum	6.8 μ F	618 V		
C106	Polyester	0.1 μ F	250 V		Eromet
C107	Polyester	0.1 μ F	250 V		Eromet
C108	Ceramic	100 pF	500 V	9/0121, 3P	Ferroperm
C109	Tantalum	6.8 μ F	618 V		
C110	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C111	Polyester	0.1 μ F	250 V		Eromet
C112	Tantalum	6.8 μ F	618 V		
C201	Polyester	0.1 μ F	250 V		
C202	Polystyrene	1 nF	500 V 5%	B31012	Siemens

Circuit reference	Designation			Code	Manufacturers
Capacitors					
C203	Polyester	0.27 μ F	400 V	9/0121, 3P	Philips
C204	Ceramic	100 pF	500 V		Ferroperm
C205	Tantalum	6.8 μ F	618 V	9/0121, 3P	Eromet
C206	Polyester	0.1 μ F	250 V		Eromet
C207	Polyester	0.1 μ F	250 V		Ferroperm
C208	Ceramic	100 pF	500 V	SKT2281/MP	Eromet
C209	Tantalum	6.8 μ F	618 V		Siemens
C210	Polyester	0.1 μ F	250 V	SKT2281/MP	Eromet
C211	Feed-through	0.1 μ F	250 V		Eromet
C212	Polyester	0.1 μ F	250 V	9/0121, 3P	Eromet
C213	Tantalum	6.8 μ F	618 V		Eromet
C214	Polyester	0.1 μ F	250 V	9/0121, 3P	Eromet
C215	Polyester	0.1 μ F	250 V		Eromet
C216	Polyester	0.1 μ F	250 V	9/0121, 3P	Eromet
C217	Polyester	0.1 μ F	250 V		Ferroperm
C301	Ceramic	100 pF	500 V	SKT2281/MP	Siemens
C302	Feed-through	0.1 μ F	250 V	B26120	T.C.C.
C303	Mica	700 pF	350 V 2%		SMP
C304	MP	10 nF	200 V	82016B/E4	Evox
C305	Polyester	0.1 μ F	160 V		MM
C306	Variable	6.4 pF	500 V	9/0121, 3P	T.C.C.
C307	Mica	700 pF	350 V 2%		SMP
C308	Ceramic	100 pF	500 V	B26120	Siemens
C309	MP	10 nF	200 V		Eromet
C310	Polyester	0.1 μ F	250 V	9/0121, 3P	Eromet
C311	Mica	700 pF	350 V 2%		SMP
C312	Ceramic	100 pF	500 V	SKT2281/MP	Ferroperm
C313	Polyester	0.1 μ F	160 V		MM
C314	Feed-through	0.1 μ F	250 V	MM	Siemens
C315	Polyester	0.1 μ F	160 V		Eromet
C316	Polyester	0.1 μ F	250 V	C281AB	Philips
C317	Polyester	0.22 μ F	250 V		C281AB
C318	Polyester	0.22 μ F	250 V	SKT2281/MP	Siemens
C401	Feed-through	0.1 μ F	250 V		9/0121, 3P
C402	Ceramic	300 pF	500 V	B26120	Eromet
C403	Polyester	0.1 μ F	250 V		9/0121, 3P
C404	Ceramic	100 pF	500 V	82074B/10E	Siemens
C405	MP	10 nF	200 V		Eromet
C406	Polyester	0.1 μ F	250 V	TK-O IB	Philips
C407	Variable	10 pF	650 V		9/0112, 3
C408	Ceramic	15 pF 5%		SKT2281/MP	Siemens
C501	Feed-through	0.1 μ F	250 V		Eromet
C502	Polyester	0.1 μ F	250 V	SKT2281/MP	Siemens
C503	Feed-through	0.1 μ F	250 V		Eromet
C504	Polyester	0.1 μ F	250 V	SKT2281/MP	Eromet
C505	Polyester	0.1 μ F	250 V		Eromet
C506	Polyester	0.1 μ F	250 V		Eromet

Circuit reference	Designation			Code	Manufacturers
Capacitors					
C507	Polyester	0.1 μ F	250 V		Eromet
C508	Ceramic	100 pF	500 V	9/0121,3P	Ferroperm
C509	Ceramic	30 pF	500 V	9/0121,3P	Ferroperm
C510	Ceramic	200 pF	500 V	9/0121,3P	Ferroperm
C511	Ceramic	100 pF	500 V	9/0121,3P	Ferroperm
C512	Ceramic	47 pF	500 V	9/0121,3P	Ferroperm
C513	Variable	10 pF	650 V	82074B/10E	Philips
C514	Variable	10 pF	650 V	82074B/10E	Philips
C515	Polyester	0.1 μ F	250 V		Eromet
C516	Polyester	0.1 μ F	250 V		Eromet
C517	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C518	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C519	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C520	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C521	Feed-through	0.1 μ F	250 V	SKT2281/MP	Siemens
C523	Polyester	0.22 μ F	160 V		Evox
C524	MP	0.1 μ F			Siemens
C601	Paper	50 nF	1000 V		T. Jensen
C602	Polyester	0.47 μ F	400 V	C296AC/A	Philips
C603	Electrolytic	32+32 μ F	450 V	EAL	T. Jensen
C604	Electrolytic	32+32 μ F	450 V	EAL	T. Jensen
CR1	Diode			OA91	Philips
CR2	Diode			OA91	Philips
CR201	Diode			OA9	Philips
CR202	Diode			OA9	Philips
CR301	Diode			GD1Q	Siemens
CR501	Diode			OA47	Philips
CR502	Diode			OA47	Philips
CR503	Zener diode			OAZ207	Philips
CR504	Diode			OA91	Philips
CR505	Diode			OA91	Philips
CR601	Rectifier		30 V 60 mA	B30 C600	Siemens
CR602	Rectifier		250 V 150 mA	B250 C150	Siemens
E101	Crystal filter			ref. drwg. No. 1549-A4	
F601	Fuse, slow blow		0.4A/250 V		Schurter
H601	Socket for fuse			701M/705G	Schurter
H602	Socket for pilot lamp			FOO1AA/01 white	Philips
HR401	Thermostatically controlled oven for crystals			ref. drwg. No. 1499-A4 item E	
HR501	Thermostatically controlled oven for crystals			ref. drwg. No. 1499-A4 item C	
I601	Pilot lamp		0.21A/6.3 V	8000D	Philips
J1	Connector (2x2)			9 Rel kli 6b	
J3					
J4					

Circuit reference	Designation	Code	Manufacturers
Capacitors			
J5	Connector	9 Rel kli 6b	
J7			
J8	Banana jack, non-insulated 4mm	TS6200	
J201	Balanced connector (2-poles) with a pair of contacts	9 Rel kli 6a 9 Rel KFs 2e	
J401			
J501			
K1	Relay	24 V 1250 Ω Trls 151Y/TBv65022/74d	Siemens
K2	Relay	24 V 1250 Ω Trls 151Y/TBv65022/74d	Siemens
K501	Relay	24 V 1250 Ω Trls 151Y/TBv65022/74d	Siemens
K502	Relay	24 V 1250 Ω Trls 151Y/TBv65022/74d	Siemens
L1	RF choke	175 μ H	ref. drwg. No. 1260-A3
L2	Coil	1.8 mH	ref. drwg. No. 1260-A3
L101	Coil	3.5 μ H	ref. drwg. No. 1260-A3
L102	Filament choke	100 mH	ref. drwg. No. 1260-A3
L201	Coil	3.5 μ H	ref. drwg. No. 1260-A3
L202	RF choke	10 mH	158/10
L203	RF choke	10 mH	158/10
L204	Filament choke	100 mH	ref. drwg. No. 1260-A3
L301	Coil	202 μ H	ref. drwg. No. 1260-A3
Inductors			
L302	Coil	202 μ H	ref. drwg. No. 1260-A3
L303	Coil	202 μ H	ref. drwg. No. 1260-A3
L401	Coil	6 mH	ref. drwg. No. 1260-A3
L501	RF choke	10 mH	158/10
L502	RF choke	10 mH	158/10
L601	Choke	16 H	11220
M201	Meter		
Resistors			
R1	Metal film	7036 Ω	0.2% 0.25 W
R2	Metal film	2588 Ω	0.2% 0.25 W
R3	Metal film	952.2 Ω	0.2% 0.25 W
R4	Metal film	350.3 Ω	0.2% 0.25 W
R5	Metal film	128.8 Ω	0.2% 0.25 W
R6	Metal film	88.14 Ω	0.2% 0.25 W
R7	Metal film	88.14 Ω	0.2% 0.25 W
R8	Metal film	88.14 Ω	0.2% 0.25 W
R9	Metal film	88.14 Ω	0.2% 0.25 W
R10	Metal film	88.14 Ω	0.2% 0.25 W
R11	Metal film	88.14 Ω	0.2% 0.25 W
R12	Metal film	162.3 Ω	0.2% 0.25 W
R13	Metal film	81.15 Ω	0.2% 0.25 W
R14	Metal film	81.15 Ω	0.2% 0.25 W

Circuit reference	Designation	Code		
	Resistors			
R15	Metal film	81.15 Ω	0.2%	0.25 W
R16	Metal film	81.15 Ω	0.2%	0.25 W
R17	Metal film	81.15 Ω	0.2%	0.25 W
R18	Metal film	51.23 Ω	0.2%	0.25 W
R18A	Carbon film	3.9 k Ω	5%	0.5 W
R19	Metal film	75.0 Ω	0.5%	0.25 W
R101	Carbon film	0.47 M Ω	5%	0.5 W
R102	Carbon film	1 k Ω	5%	0.5 W
R103	Carbon film	270 Ω	5%	0.5 W
R104	Carbon film	10 Ω	5%	0.5 W
R105	Carbon film	2.2 k Ω	5%	0.5 W
R106	Carbon film	1 k Ω	5%	0.5 W
R107	Carbon film	0.15 M Ω	5%	0.5 W
R108	Carbon film	180 Ω	5%	0.5 W
R109	Carbon film	0.1 M Ω	5%	0.5 W
R110	Carbon film	22 k Ω	5%	0.5 W
R111	Carbon film	1.2 k Ω	5%	0.5 W
R112	Carbon film	1 k Ω	5%	0.5 W
R113	Carbon film	1 k Ω	5%	0.5 W
R114	Carbon film	0.47 M Ω	5%	0.5 W
R115	Carbon film	1 k Ω	5%	0.5 W
R116	Carbon film	560 Ω	5%	0.5 W
R117	Carbon film	10 Ω	5%	0.5 W
R118	Carbon film	180 Ω	5%	0.5 W
R201	Carbon film	150 Ω	5%	0.5 W
R202	Carbon film	0.47 M Ω	5%	0.5 W
R203	Carbon film	1 k Ω	5%	0.5 W
R204	Carbon film	270 Ω	5%	0.5 W
R205	Carbon film	10 Ω	5%	0.5 W
R206	Carbon film	2.2 k Ω	5%	0.5 W
R207	Carbon film	1 k Ω	5%	0.5 W
R208	Carbon film	0.15 M Ω	5%	0.5 W
R209	Carbon film	56 Ω	5%	0.5 W
R210	Carbon film	0.1 M Ω	5%	0.5 W
R211	Carbon film	22 k Ω	5%	0.5 W
R212	Carbon film	1.2 k Ω	5%	0.5 W
R213	Carbon film	1 k Ω	5%	0.5 W
R214	Carbon film	1 k Ω	5%	0.5 W
R215	Carbon film	0.47 M Ω	5%	0.5 W
R216	Potentiometer			
	wire wound	100 Ω		2 W
R217	Carbon film	0.1 M Ω	5%	0.5 W
R218	Carbon film	22 k Ω	5%	0.5 W
R219	Carbon film	560 Ω	5%	0.5 W
R220	Carbon film	10 Ω	5%	0.5 W
R221	Wirewound	2.4 k Ω	1%	0.1 W
R222	Wirewound	8 k Ω	1%	0.25 W
R223	Carbon film	1 k Ω	5%	0.5 W

Circuit reference	Designation				Code
Resistors					
R301	Carbon film	0.1 MΩ	5%	0.5 W	
R302	Carbon film	1 kΩ	5%	0.5 W	
R303	Carbon film	0.1 MΩ	5%	0.5 W	
R304	Carbon film	22 kΩ	5%	0.5 W	
R305	Carbon film	330 Ω	5%	0.5 W	
R306	Carbon film	10 kΩ	5%	0.5 W	
R307	Carbon film	22 kΩ	5%	0.5 W	
R308	Carbon film	1 kΩ	5%	0.5 W	
R309	Carbon film	33 kΩ	5%	0.5 W	
R310	Carbon film	270 Ω	5%	0.5 W	
R311	Potentiometer, wire wound	500 Ω		2 W	
R312	Carbon film	220 Ω	5%	0.5 W	
R313	Carbon film	1 kΩ	5%	0.5 W	
R314	Carbon film	0.1 MΩ	5%	0.5 W	
R315	Carbon film	1 kΩ	5%	0.5 W	
R316	Carbon film	1 kΩ	5%	0.5 W	
R317	Carbon film	470 Ω	5%	0.5 W	
R318	Carbon film	2.2 kΩ	5%	0.5 W	
R319	Carbon film	220 Ω	5%	0.5 W	
R320	Carbon film	220 Ω	5%	0.5 W	
R401	Carbon film	1 kΩ	5%	0.5 W	
R402	Carbon film	82 Ω	5%	0.5 W	
R403	Carbon film	1 kΩ	5%	0.5 W	
R404	Carbon film	1 kΩ	5%	0.5 W	
R405	Carbon film	390 Ω	5%	0.5 W	
R406	Carbon film	0.1 MΩ	5%	0.5 W	
R407	Carbon film	10 kΩ	5%	0.5 W	
R408	Carbon film	47 kΩ	5%	0.5 W	
R409	Carbon film	1.2 MΩ	5%	0.5 W	
R410	Carbon film	1 kΩ	5%	0.5 W	
R411	Carbon film	8.2 kΩ	5%	0.5 W	
R412	Carbon film	82 Ω	5%	0.5 W	
R413	Potentiometer, wire wound	50 Ω		2 W	
R414	Carbon film	3.3 kΩ	5%	0.5 W	
R501	Carbon film	56 kΩ	2%	0.5 W	
R502	Carbon film	0.33 MΩ	5%	0.5 W	
R503	Carbon film	5.6 kΩ	5%	1 W	
R504	Carbon film	2.2 kΩ	5%	0.5 W	
R505	Carbon film	100 Ω	5%	0.5 W	
R506	Carbon film	1 MΩ	5%	0.5 W	
R507	Carbon film	1 MΩ	5%	0.5 W	
R508	Carbon film	1 MΩ	5%	0.5 W	
R509	Carbon film	4.7 kΩ	5%	0.5 W	
R510	Carbon film	39 kΩ	5%	0.5 W	
R511	Potentiometer, wire wound	5 kΩ		2 W	

Circuit reference	Designation	Code		
Resistors				
R512	Carbon film	matched	5%	0.5 W
R513	Carbon film	1 MΩ	5%	0.5 W
R514	Carbon film	39 kΩ	5%	0.5 W
R515	Potentiometer, wire wound	5 kΩ		2 W
R516	Carbon film	matched	5%	0.5 W
R517	Carbon film	0.1 MΩ	5%	0.5 W
R518	Carbon film	0.1 MΩ	5%	0.5 W
R519	Carbon film	0.56 MΩ	5%	0.5 W
R520	Carbon film	0.1 MΩ	5%	0.5 W
R521	Carbon film	68 kΩ	5%	0.5 W
R522	Carbon film	68 kΩ	5%	0.5 W
R523	Carbon film	39 kΩ	5%	1 W
R524	Potentiometer, wire wound	10 kΩ		2 W
R526	Potentiometer, wire wound	10 kΩ		2 W
R528	Carbon film	68 kΩ	5%	0.5 W
R601	Carbon film	10 Ω	5%	0.5 W
R602	Wirewound	3 kΩ	10%	3 W
R603	Carbon film	1 kΩ	5%	0.5 W
R604	Carbon film	1 kΩ	5%	0.5 W
R605	Carbon film	1 kΩ	5%	0.5 W
R606	Carbon film	1 kΩ	5%	0.5 W
R607	Carbon film	1 kΩ	5%	0.5 W
RT	Ballast lamp	2 V 10 mA		

Switches

S1 FREQUENCY

Circuit reference	Designation	code
----------------------	-------------	------

Switches

S2 FREQUENCY
S3 LEVEL RANGE
S601 Line switch

RP1915

Transformers

T1	Bal. transformer	See drwg. No. 1847-A4
T301	RF transformer	See drwg. No. 1848-A4
T302	RF transformer	See drwg. No. 1849-A4
T401	RF transformer	See drwg. No. 1855-A4
T501	RF transformer	See drwg. No. 1850-A4
T601	Line transformer	
T602	Line transformer	

Circuit reference	Designation	Code
	Switches	

Y401	Crystal	327.840 kHz
Y501	Crystal	84.080 kHz
Y502	Crystal	411.920 kHz

Tubes

No.			
1-11	E83F		Philips
12	E188CC		Philips
13	E80CF		Philips
14	OA2		Philips

Type BFM330S1

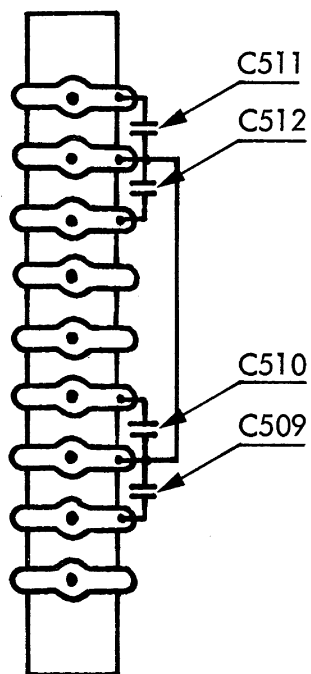
Circuit reference	Designation	
Y501	Crystal	84.140 kHz
Y502	Crystal	411.860 kHz

Types BFM330S3 and BFM330S2S3

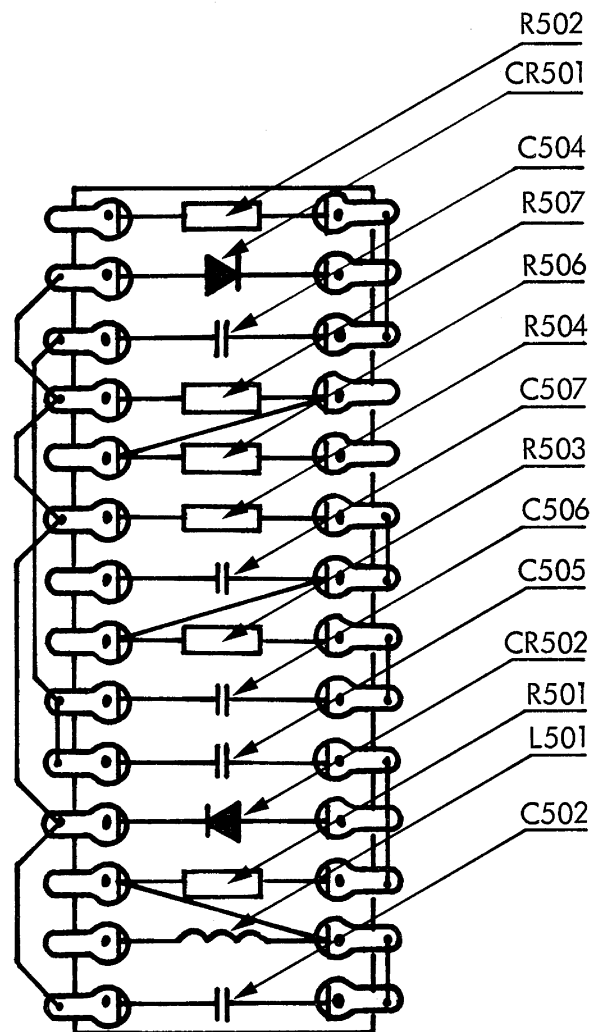
Circuit reference	Designation			
	Resistors			
R2	Metal film	6838 Ω	0.2%	0.25 W
R3	Metal film	2162 Ω	0.2%	0.25 W
R4	Metal film	638.8 Ω	0.2%	0.25 W
R5	Metal film	216.3 Ω	0.2%	0.25 W
R6	Metal film	142.3 Ω	0.2%	0.25 W
R7	Metal film	142.3 Ω	0.2%	0.25 W
R8	Metal film	142.3 Ω	0.2%	0.25 W
R9	Metal film	142.3 Ω	0.2%	0.25 W
R10	Metal film	142.3 Ω	0.2%	0.25 W
R11	Metal film	142.3 Ω	0.2%	0.25 W
R12	Metal film	192.5 Ω	0.2%	0.25 W
R13	Metal film	96.25 Ω	0.2%	0.25 W
R14	Metal film	96.25 Ω	0.2%	0.25 W
R15	Metal film	96.25 Ω	0.2%	0.25 W
R16	Metal film	96.25 Ω	0.2%	0.25 W
R17	Metal film	96.25 Ω	0.2%	0.25 W
R18	Metal film	65.81 Ω	0.2%	0.25 W

Section H. Component Identifications

The following twelve figures are provided as a help in finding a component. The first five figures represent the sixteen component boards of the instrument. The next two figures give details of the two rotary switches (FREQUENCY and LEVEL RANGE). The remaining five illustrations show the position of the single components.

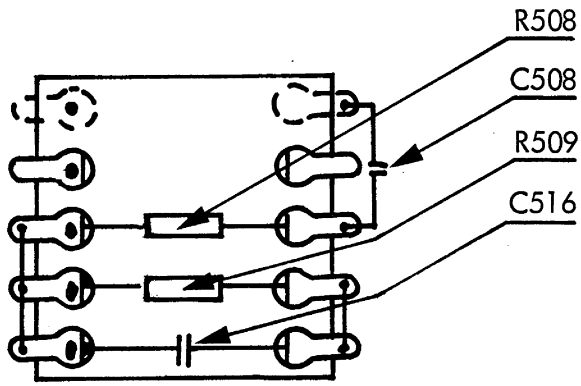


Component Board No.1

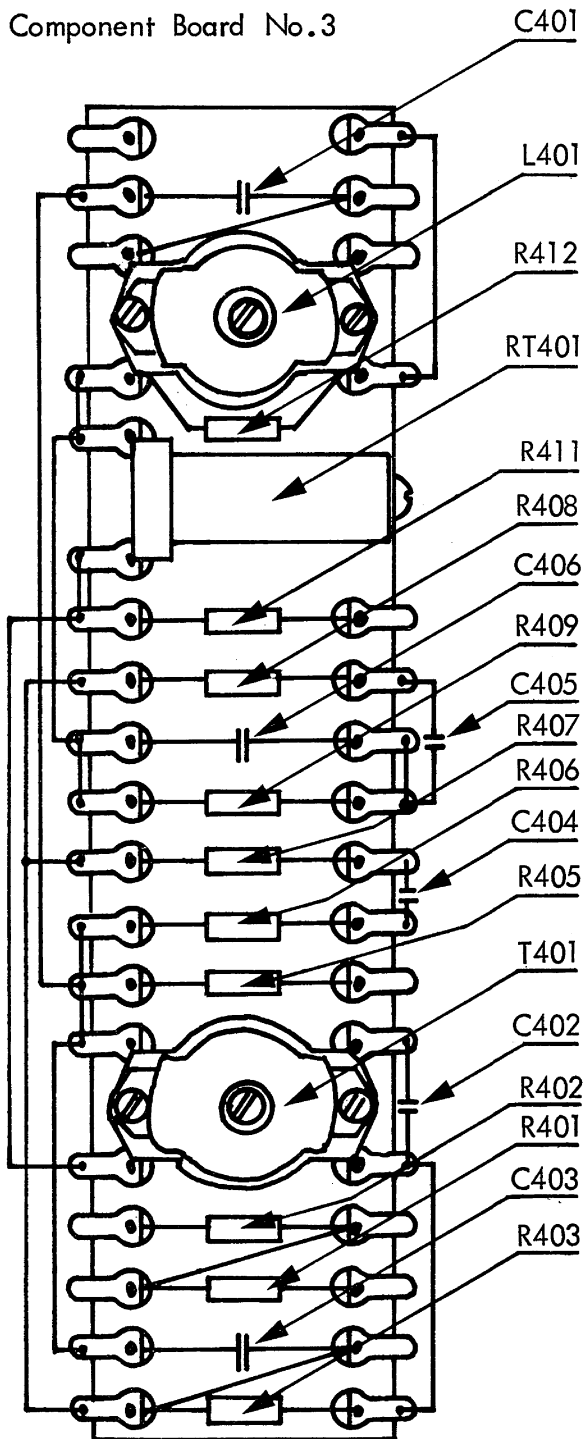


Component Board No.2

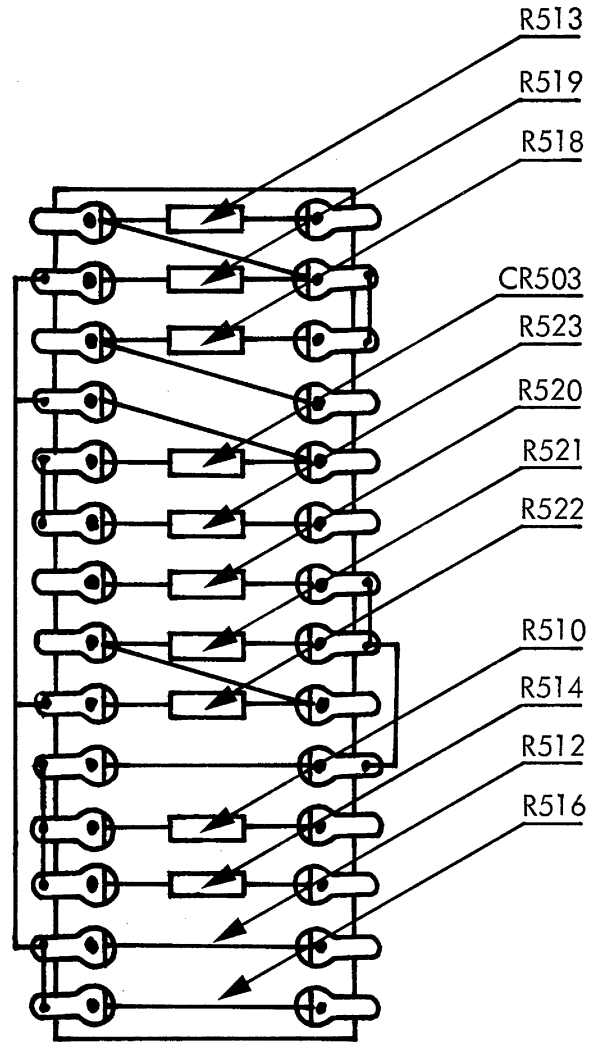
Fig.H1. Component Identification



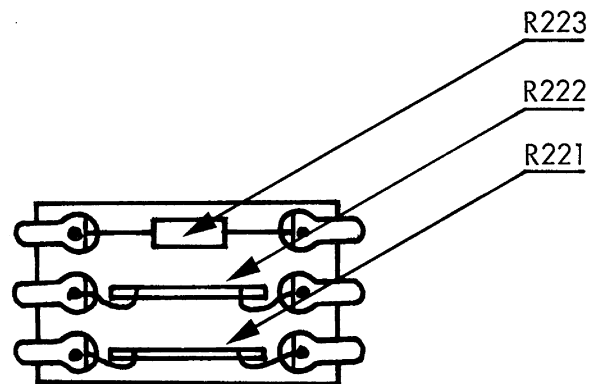
Component Board No.3



Component Board No.4

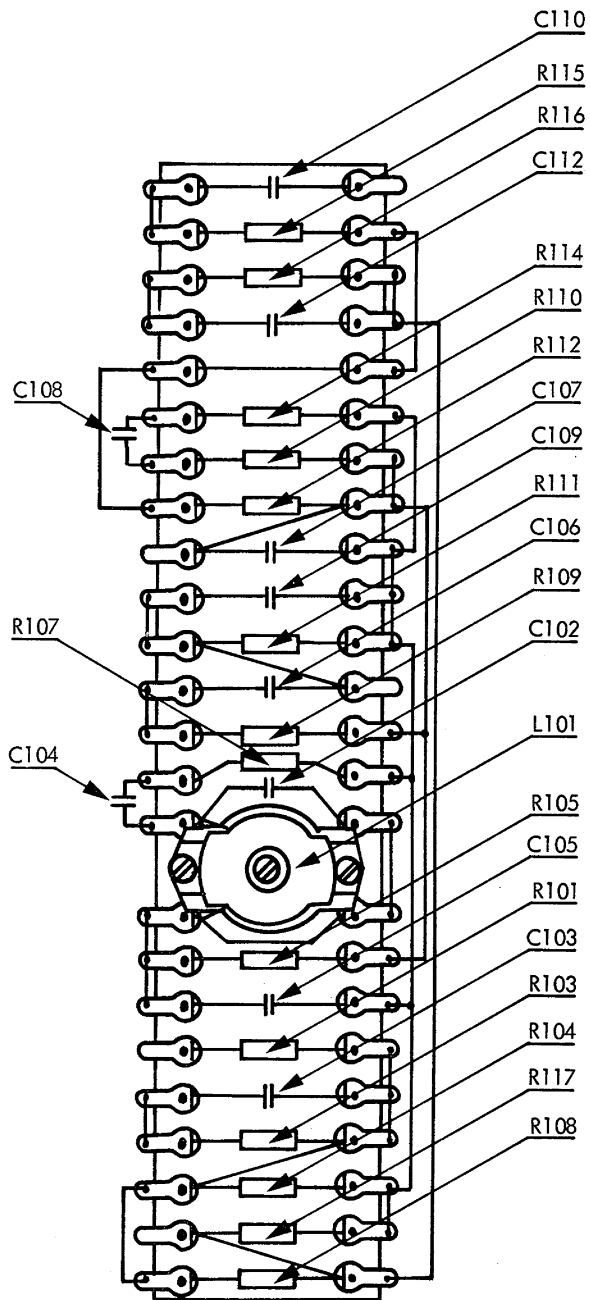


Component Board No.5

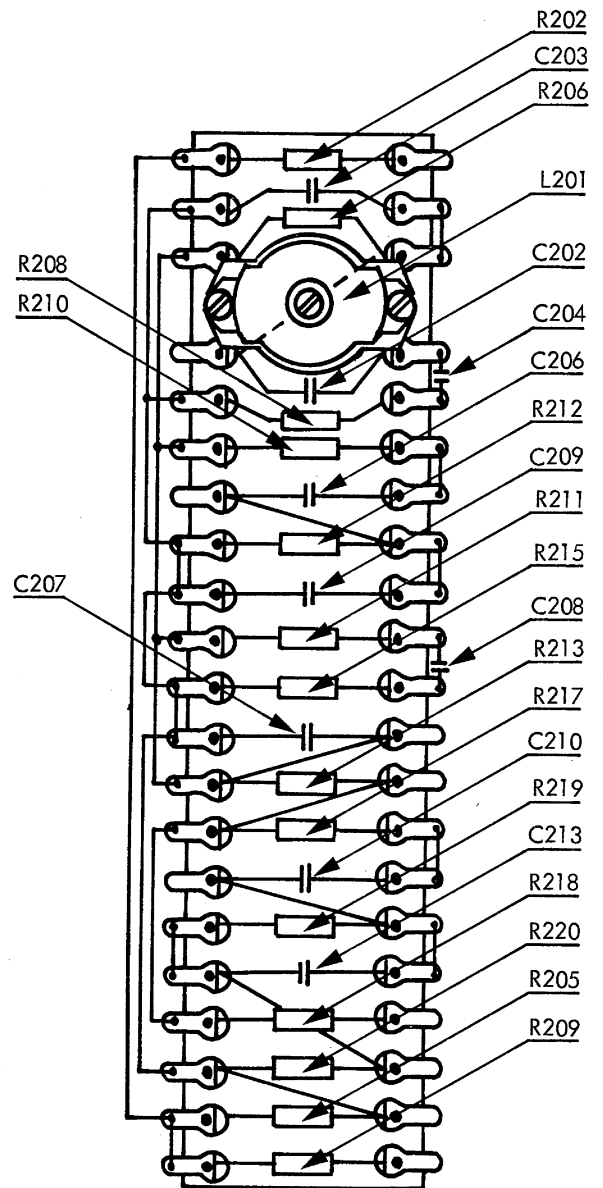


Component Board No.6

Fig.H2. Component Identification

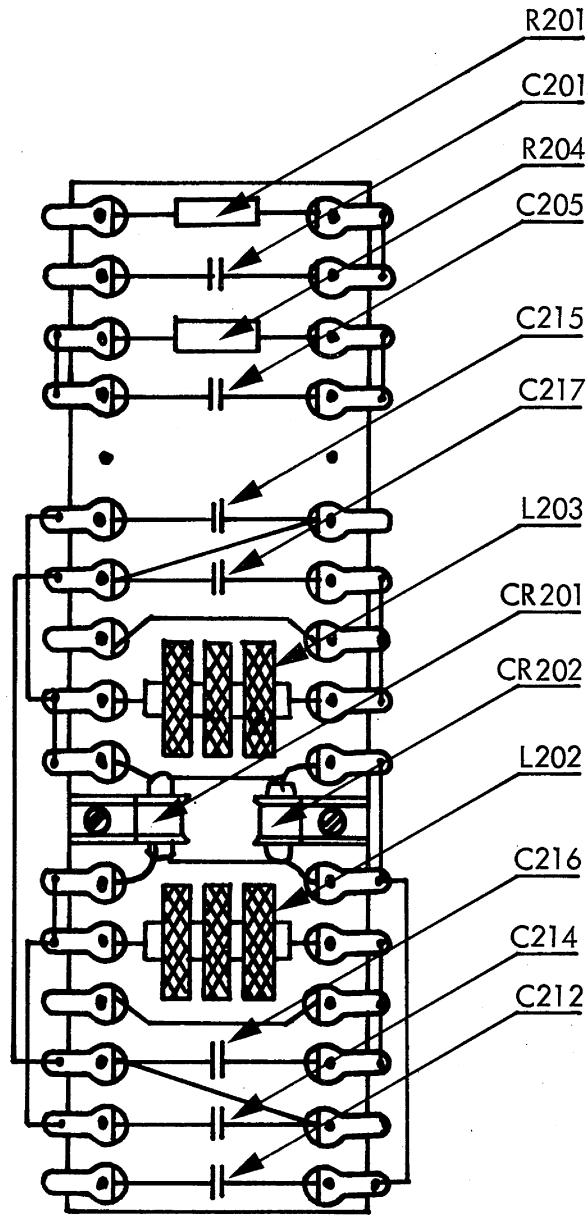


Component Board No.7

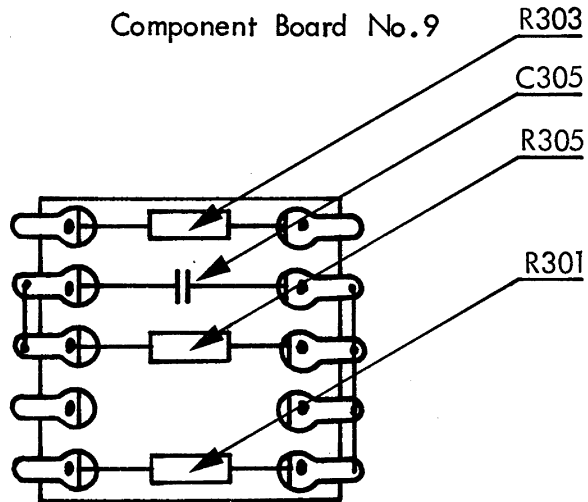


Component Board No.8

Fig.H3. Component Identification

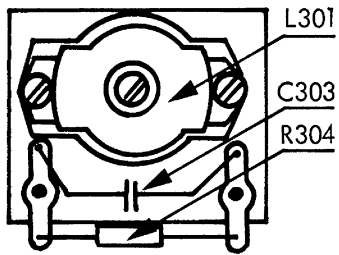


Component Board No.9

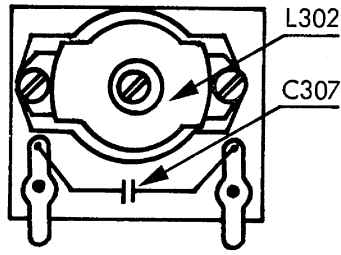


Component Board No.10

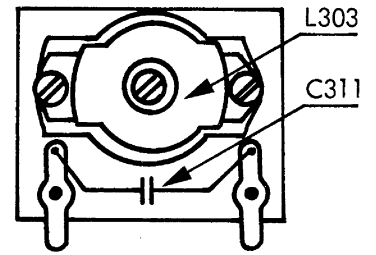
Fig.H4. Component Identification



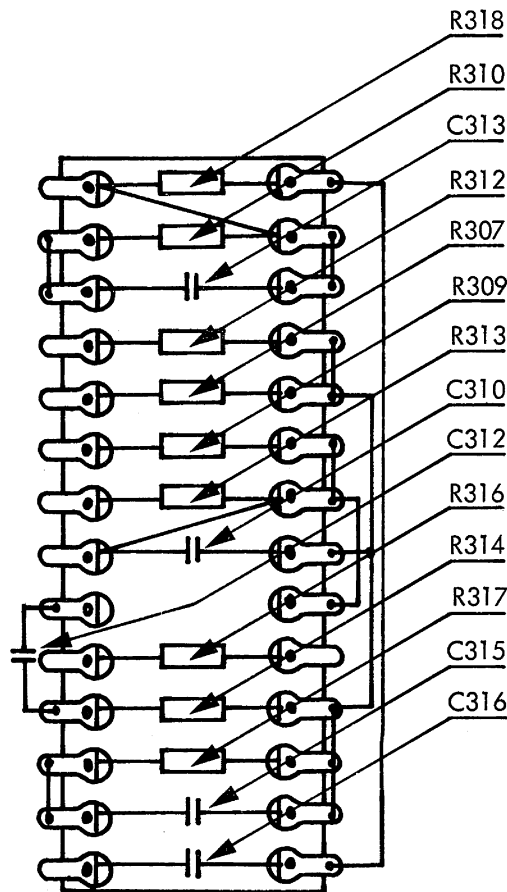
Component Board No.11



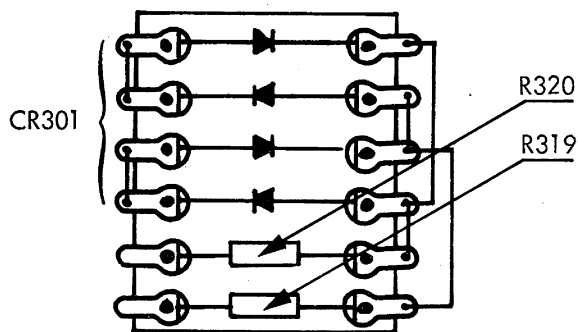
Component Board No.12



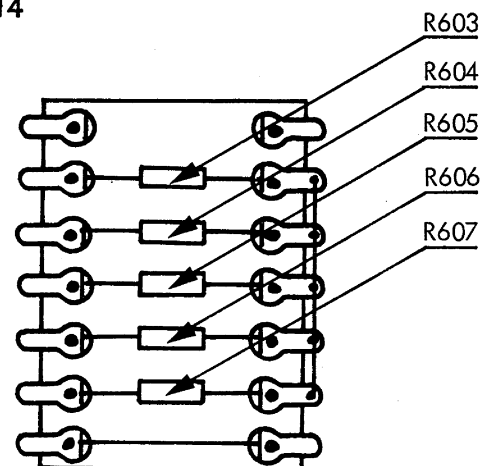
Component Board No.13



Component Board No.14



Component Board No.15



Component Board No.16

Fig.H5. Component Identification

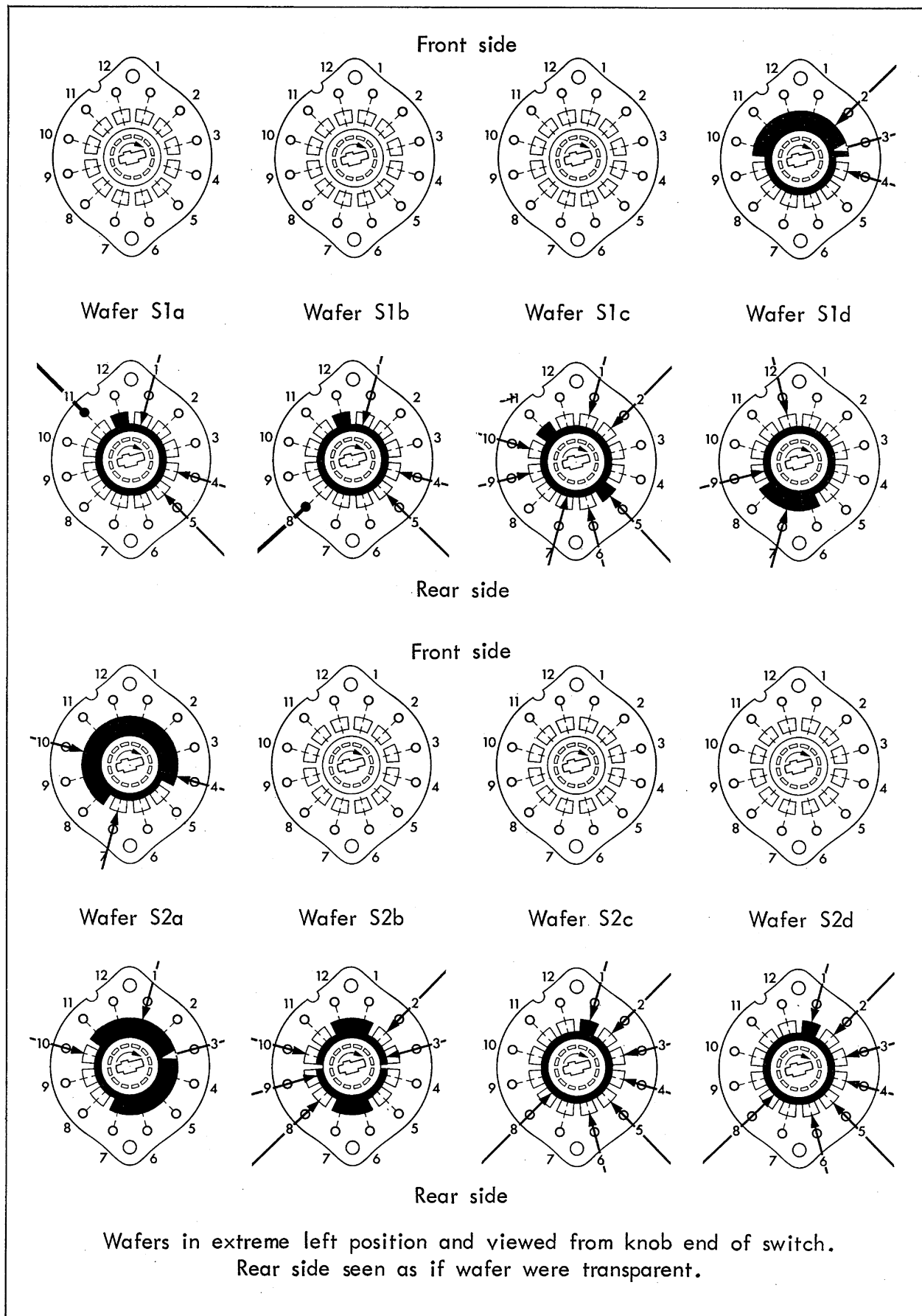
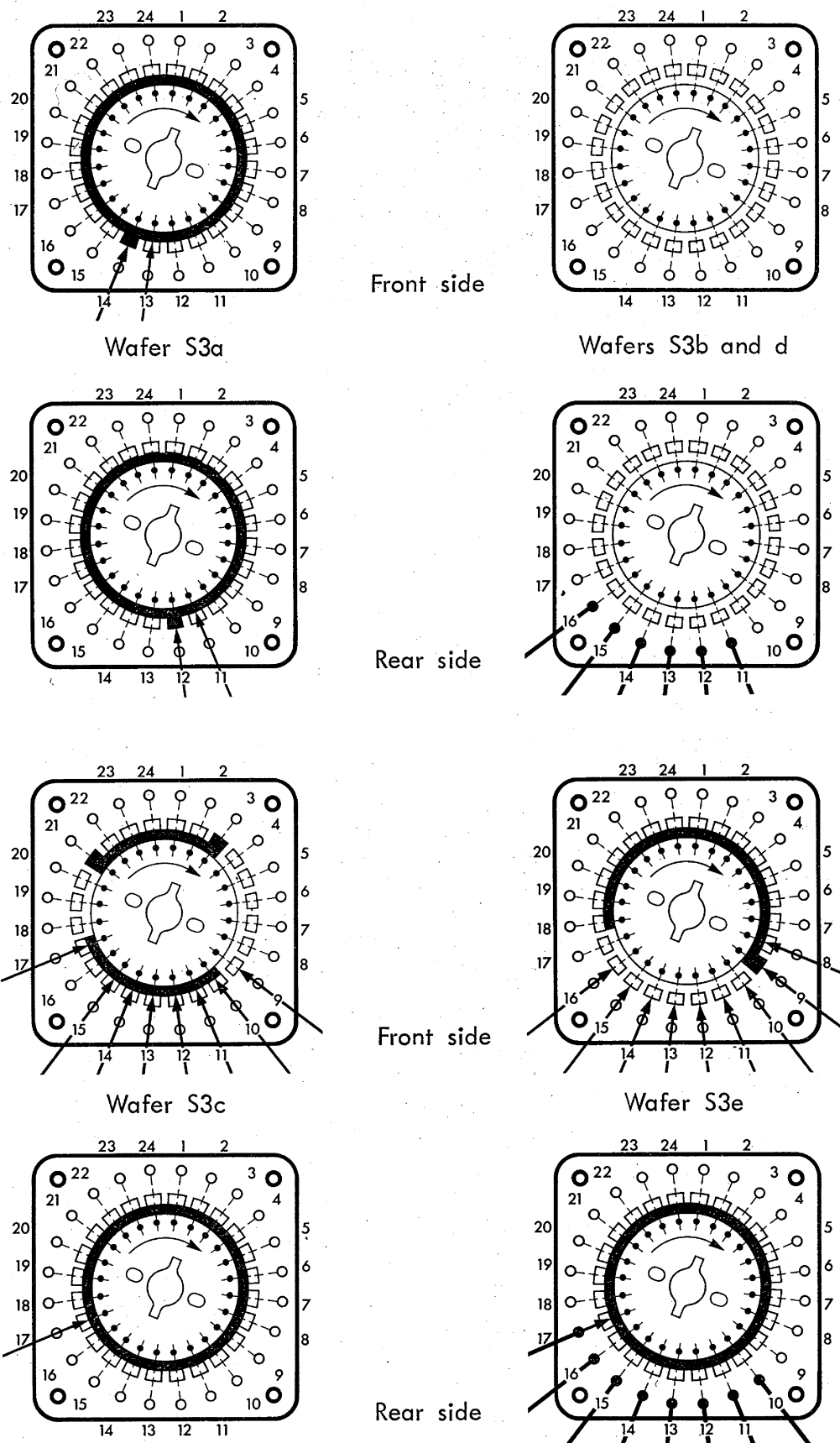


Fig.H6. Wafers of the FREQUENCY switch S1-S2.



Wafers in extreme left position and viewed from knob end of switch.
Rear side seen as if wafer were transparent.

Fig.H7. Wafers of the LEVEL RANGE switch S3.

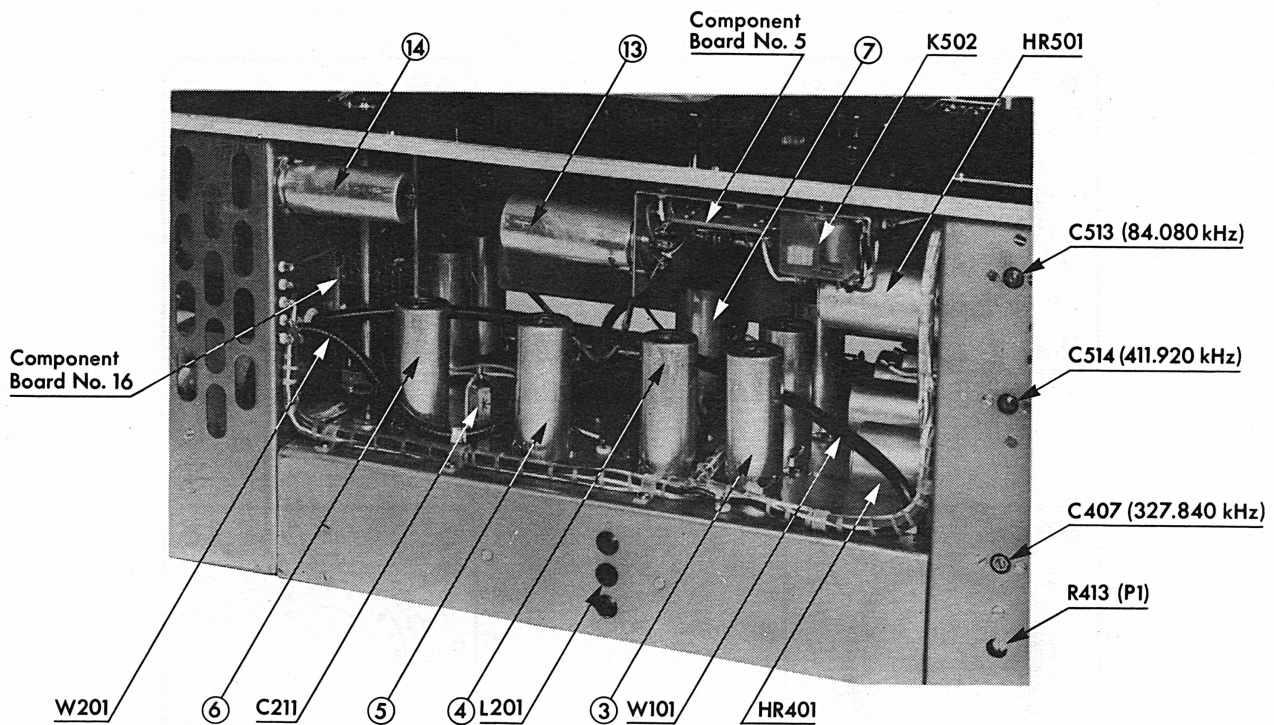


Fig.H8. Top view

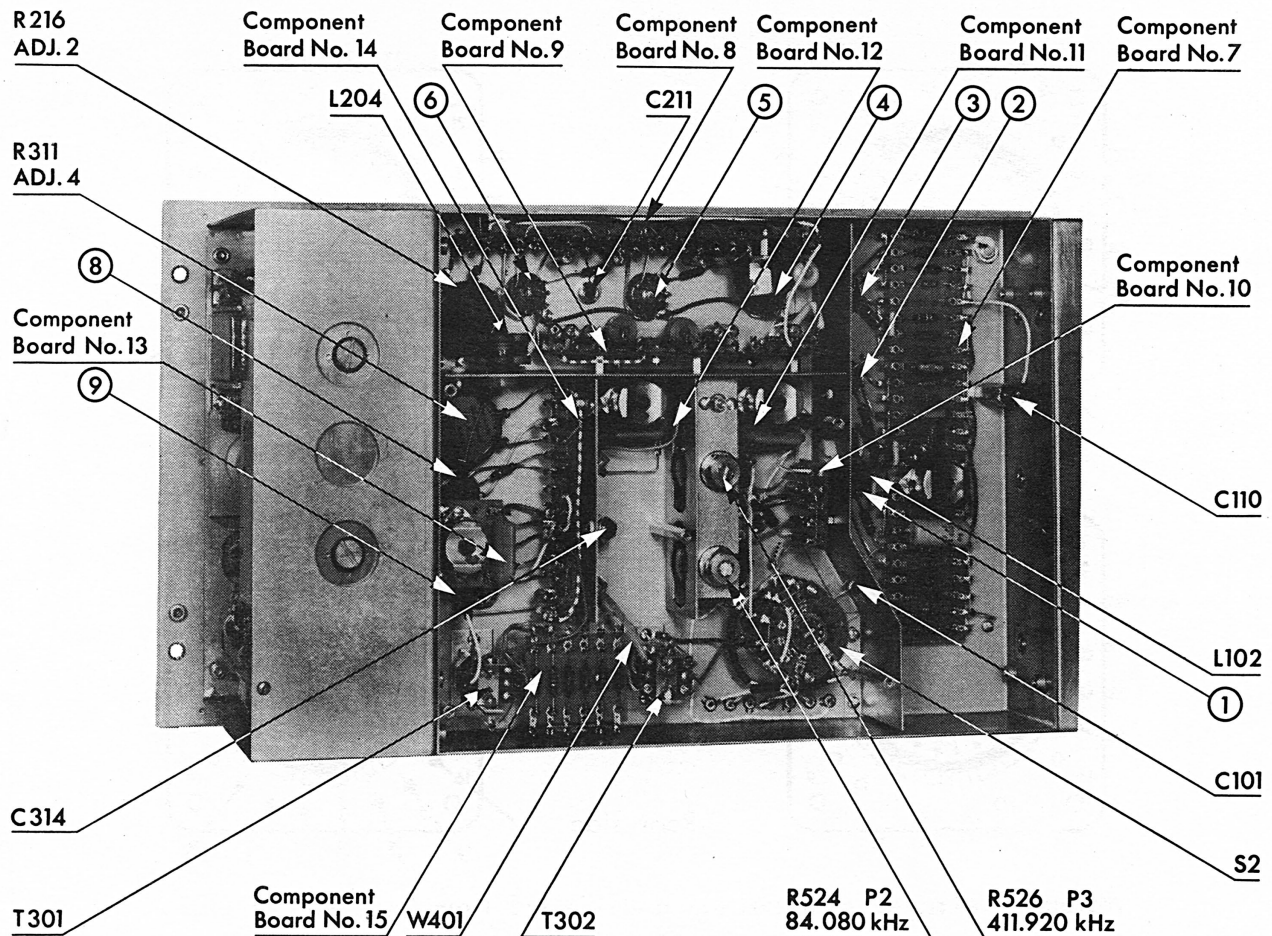


Fig.H9. Rear view

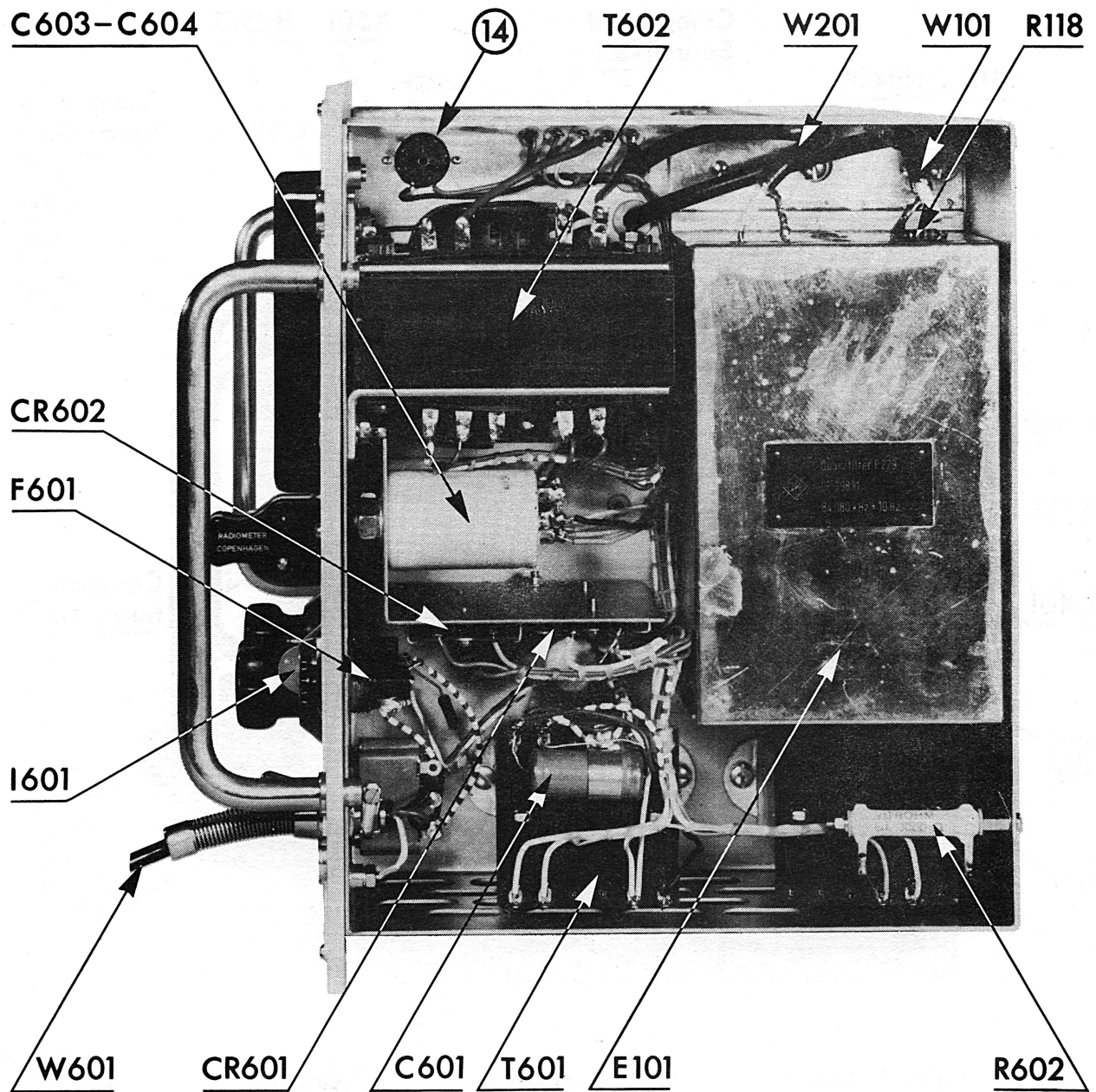


Fig.H10. Right-side view

H10

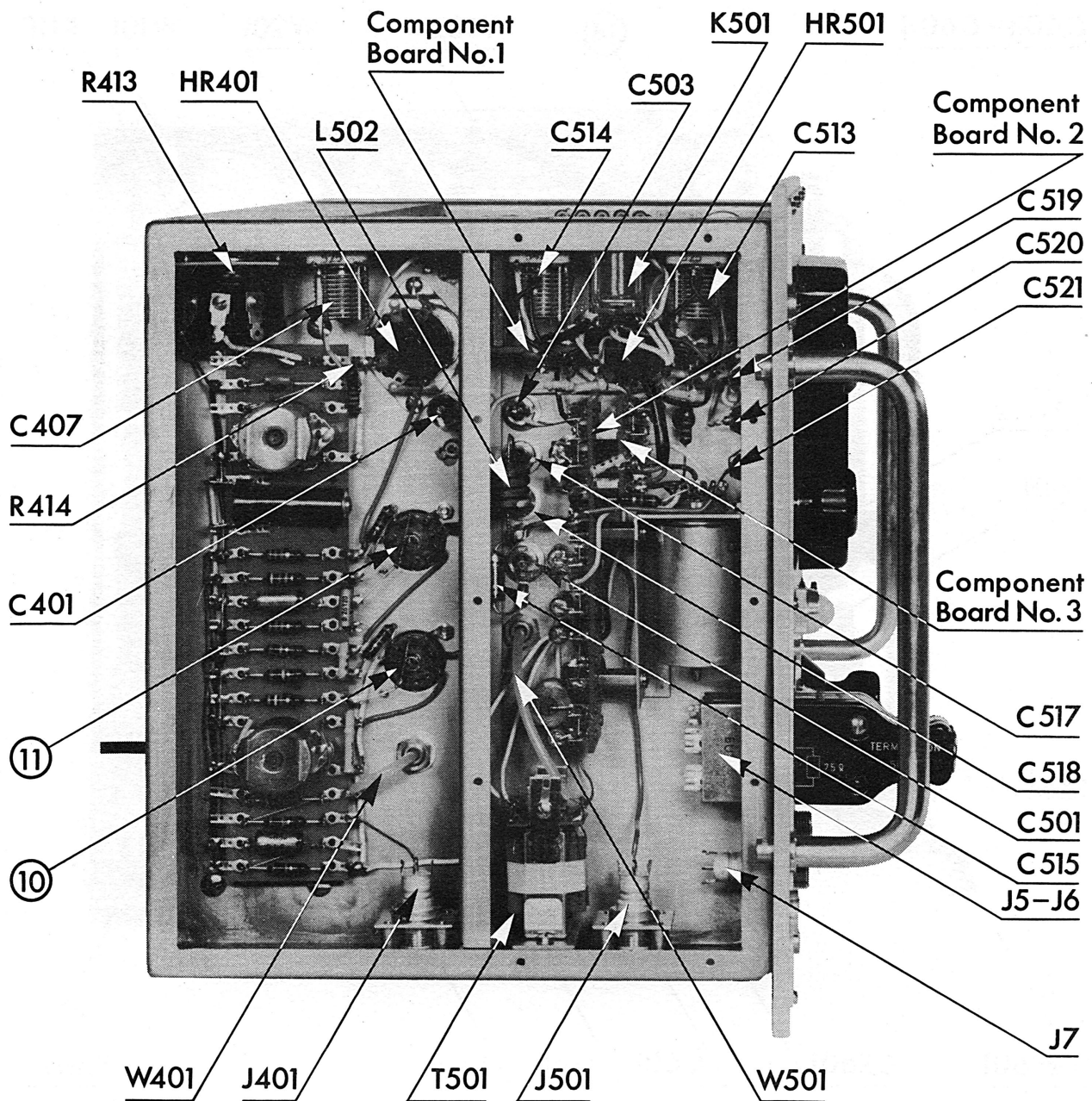


Fig.H11. Left-side view

H11

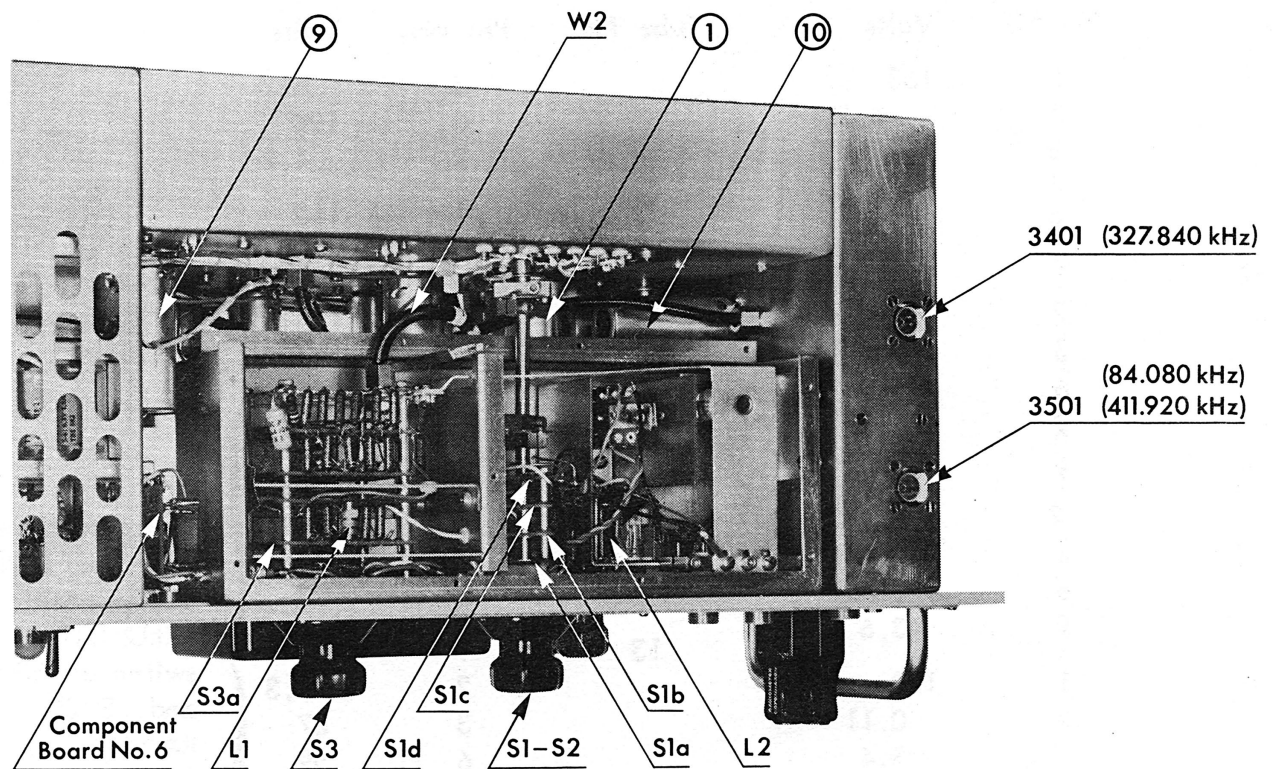
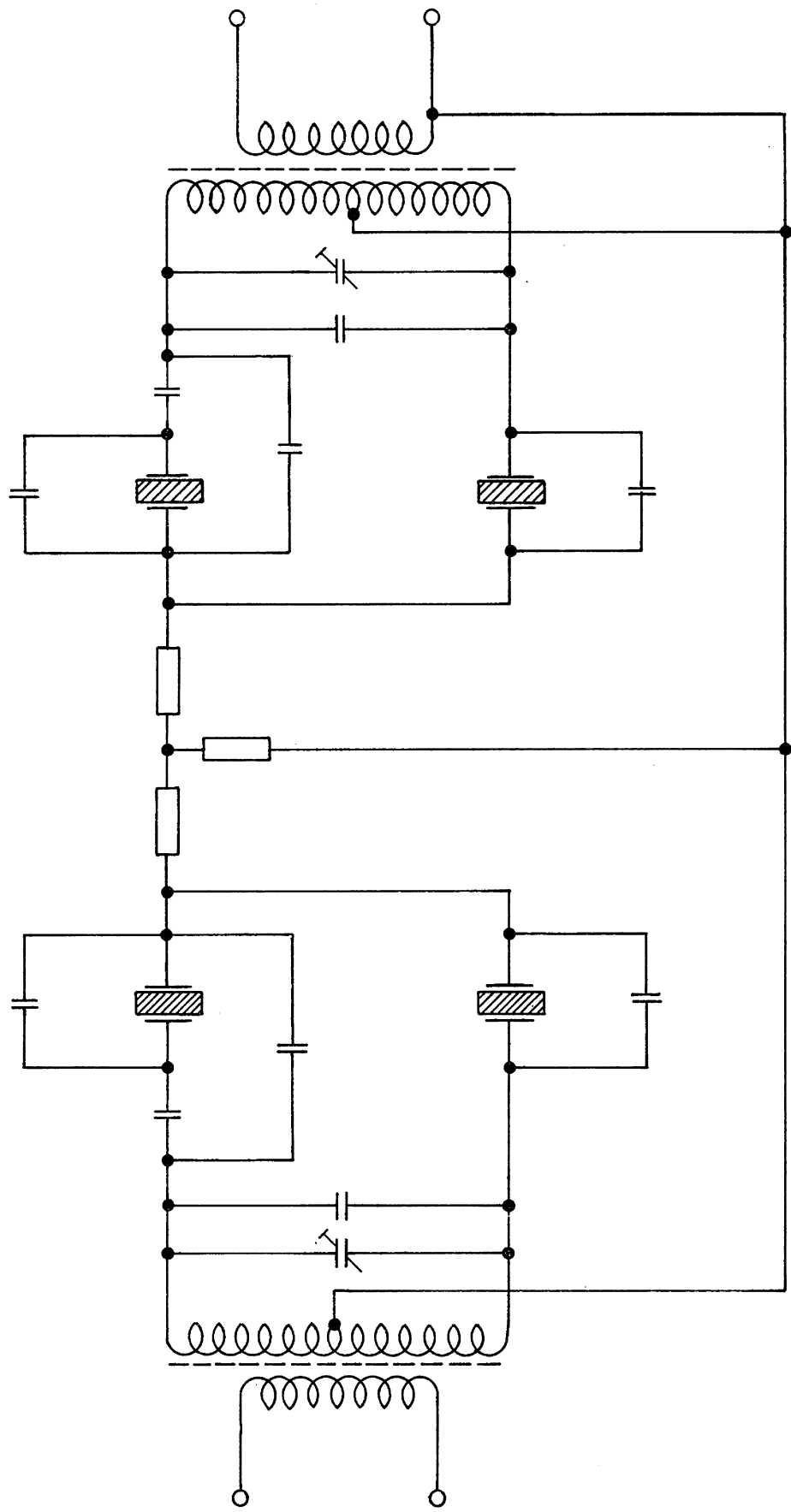


Fig.H12. Underside view

Tube No.	Pin No.	Volts	Tube No.	Pin No.	Volts
1	1	163		3	4.2
	2	0.12		6	194
	3	3.3		9	4.2
	6	163	11	1	165
	9	3.3		2	0
2	1	125		3	4.2
	2	0		6	165
	3	3.3		9	4.2
	6	125	12	1	68
	9	3.3		2	-13.5
3	1	189		3	0.5
	2	0		6	150
	3	3.6		7	75
	6	178		8	77
	9	3.6	13	1	150
4	1	170		2	8.3
	2	0.11		3	67
	3	3.4		6	59
	6	170		7	9.4
	9	3.4		8	68
5	1	132		9	59
	2	0			
	3	3.4			
	6	132			
	9	3.4			
6	1	115			
	2	0			
	3	2.6			
	6	115			
	9	2.6			
7	1	120			
	2	35			
	3	37			
	6	210			
	9	37			
8	1	160			
	2	0			
	3	3.7			
	6	189			
	9	3.7			
9	1	193			
	2	0			
	3	3.6			
	6	193			
	9	3.6			
10	1	194			
	2	0			

The potentiometer
 ADJ 1 set to the
 center position.
 FREQUENCY
 switch at ADJ 1
 and LEVEL
 RANGE switch at
 ADJ.



CRYSTAL FILTER: 84.080 kHz \pm 7 Hz

PILOT LEVEL METER
TYPE BFM 330

RADIOMETER

1549-A4

