SHORTWAVE RECEIVER

1.6 to 30 mc/s · Type Rel 445 E 311a,b

Parts List · Fault Locating · Fault Eliminating

Parts List

Fault Locating

F A U L T   L O C A T I N G

I. FAULT LOCATING WITH SIMPLE MEANS

Systematic fault location with simple testing instruments (e.g. an A-V-Ω Multizet meter) alone is often successful.

Many faults, such as burnt resistors, broken leads, defective insulation, and other mechanical damage can mostly be recognized by visual examination alone. Thus the tube checks listed in the NOTES ON MAINTENANCE section often permit to localize a fault rapidly.

It is important that not only the defective components but also the cause of the fault be found out and eliminated.

Example: A resistor is burnt (which can be recognized from its black or brown discoloration).

Cause: Overloading due to breakdown of a capacitor in the following circuitry. Thus not only the resistor, but also the capacitor must be replaced.

A. Examining the Energized Receiver

1. Functional Check of the Receiver

The various functions of the receiver are checked in all frequency bands with different classes-of-emission, and in all possible positions of the controls.

(a) Rotate the controls AUDIO, RF and SQUELCH to the CW stop. Pull the knob AUDIO. Rotate the noise-limiter switch counterclockwise, the bandwidth switch clockwise (6 kc/s). No antenna is connected.

The green oven lamps must light up immediately after the energization of the cold device. After the tubes have warmed up, a distinct hissing noise must be heard in the loudspeaker.

(b) Rotate the bandwidth switch in steps counterclockwise. The loudspeaker noise must gradually decrease. Rotate the bandwidth switch clockwise again. The class-of-emission switch is preferably set to position "A1".

(c) Rotate the noise-limiter switch clockwise. Noise must decrease. Rotate the noise-limiter switch counterclockwise again.

(d) Operate the preselector tuning correction knob. It must be possible to adjust a clear noise maximum.

(e) Set the mode of operation CALIBRATION. Operate the coarse tuning control to FREE and the fine tuning control to "OO KC/S". When the coarse tuning control is rotated through its range, a loud whistle must be heard on all bands at the interrupted scale marks. There are also other (weaker) whistles. For this reason do not fully open the RF control. At the whistling points the panel meter must show a deflection both in the position "E_{RF}" and the position "E_{AUDIO}".

(f) Adjust the coarse tuning to LOCKED and rotate the tuning control through all bands. Near the 100-kc/s marks the lock-in lamp must light steadily, while in-between it will normally flicker. Otherwise, the coaxial leads between the subassemblies may possibly be interchanged.

(g) When the SQUELCH control is rotated counterclockwise, the noise must almost disappear.

2. Checking the Tube Currents

Check the tube currents as outlined in the NOTES ON MAINTENANCE section by means of an A-V-Ω Multizet meter. Be cautious, even exposed components may be live with dangerous potentials (e.g. some trimmers in the RF amplifier).

3. Relay Check

When the fault is assumed to be due to the relays, check the relay functions by reference to the following information.

(a) Withdraw the slide-in chassis after pulling out the mains plug and loosening the four panel screws.

(b) For checking the relays BA, BE, CA, CE, DA, DE in the IF amplifier and the relays E and F in the audio amplifier, withdraw and open these subassemblies (see the FAULT ELIMINATING part, section I).

(c) Now connect the subassemblies via adapter cords to the slide-in chassis and reconnect the receiver to the mains. Be cautious, even exposed components may be live with dangerous potentials.

4. Relay Functions

a. Relays in the IF Amplifier

In the switch position	Calibration	6 kc/s	3 kc/s	1 kc/s	0.3 kc/s	A3A Upper Sideband	A3A Lower Sideband
the following relays operate	G	-	DA,DE	DA,DE CA,CE	BA,BE	CA,CE	A CA,CE

b. Relays in the Audio Amplifier

In the switch position	A3	A1	A3A	Calibrating
the following relays operate	-	E,F	E	E,F

c. Relay J on the Spectrum Unit

In the switch position LOCKED and when the coarse tuning control is adjusted to the interval between two 100-kc/s marks, relay J must periodically operate and drop out (and the lock-in lamp flashes accordingly at a rate of 0.5 to 2 seconds).

d. Relay L on the Power Supply Subassembly

When the receiver is turned on, relay L must operate immediately. After the heating-up of the crystal oven in the interpolator (i.e. after about 15 to 20 minutes at an ambient temperature of 20°C), it must momentarily drop out for the first time.

B. Examining the Deenergized Receiver

(a) Withdraw the mains plug, loosen the four nickeled panel screws and withdraw the slide-in chassis. Make sure that no tube or crystal is damaged or incorrectly plugged in. Take special care that the coaxial leads between the subassemblies have not been interchanged (cf. Fig. 1 in the NOTES ON MAINTENANCE).

(b) Check, if lines or soldering joints are broken. For this purpose, withdraw the plug-in subassemblies (IF subassembly, spectrum unit, audio subassembly), if necessary (see section I of the FAULT ELIMINATING part). The power supply subassembly is readily accessible from the left side of the slide-in chassis.

(c) Check whether insulations are damaged or insulating parts broken or resistors overloaded (which can be recognized by a brown to black discoloration).

Overloaded resistors, transformers, and reactors frequently smell burnt. This is also true of transformers and reactors with short-circuited turns.

(d) Make sure that no non-insulated live components touch the chassis or other components.

(e) Check if screwed and riveted connections are firm and if they have continuity as far as metallic parts are involved.

II. FAULT LOCATING WITH SPECIAL DEVICES

If the checks outlined in section I have failed to reveal the cause of the fault, it must be located by a series of further measurements, above all concerning the sensitivity and selectivity of the complete receiver as well as by DC voltage measurements at the tubes, and gain measurements of the individual stages.

For the measurements on the subassemblies a plug-in subassembly (IF amplifier, audio amplifier or spectrum unit) must in each separate case be withdrawn and the shielding plate be screwed off. The open subassembly is connected to the slide-in chassis via one (or two) adapter cable(s).

Only when the fault is most likely not due to one of the plug-in subassemblies, dismount, open, and check the permanently installed subassembly by reference to the instructions (FAULT ELIMINATING section I). First carry out the checks outlined in I. A, B and II. B, as required.

When a subassembly has been repaired, it must be checked according to the test instructions in this section. After reinsertion of the subassemblies of the entire receiver, carry out the checks outlined in I. and II. B.

With the illustrated parts list, the circuit diagrams, and the color coding of the resistors and capacitors (section II. D) the components can easily be located and determined.

A. List of the Principal Measuring Instruments and Devices for Checking and Aligning Work

1. A-V-Ω Multizet meter
2. μa-Multizet meter
3. Audio tube voltmeter 20 mv to 3 v (e.g. Type Rel 3 U 122)
4. RF tube voltmeter 20 kc/s to 30 mc/s, 3 mv to 10 v
   C_{input} less than 10 pf, 3 mv to 30 mv
   C_{input} less than 3 pf from 30 mv upward
   (in many cases an RF Multizet meter will do)
5. DC tube voltmeter 1 v to 100 v

6. Audio generator for 300 c/s to 6 kc/s; k $\leq$ 2%,
   output voltage 20 mv to 3 v (e.g. Type Rel 3 W 29)
7. Measuring oscillator for 30 kc/s, capable of modulation
   (e.g. Type Rel 3 W 220)
8. Measuring oscillator for 370 kc/s (e.g. Type Rel 3 W 29)
9. Measuring oscillator for 1.45 to 32.8 mc/s, capable of modulation
10. Frequency counter 1 kc/s to 1 mc/s, reading error less than 1×10^{-5}
11. Frequency meter or detector for 2.85 to 31.55 mc/s
    reading error less than $\pm$1 kc/s (up to 30.1 mc/s, a receiver Type Rel 445 E 311 can be used for this purpose)
12. Psophometer 15 to 5000 c/s (e.g. Type Rel 3 U 32)
13. Adapter A: Funk stv 63a with capacitive voltage divider 12 pf/100 pf+
14. Adapter A1: Funk stv 63a, terminated into 100 Ω $\pm$5% in parallel:
    coaxial jack Rel kli 110a+
15. Adapter A2: Funk stv 63a, terminated into 6 pf
16. 2 adapter cables Type Rel Bv 657 C 151c for connecting the slide-in
    chassis to the subassembly
17. Aligning screwdriver B 63399-A2
18. Aligning tool Type Funk empf 138 Tz 48
19. Superheterodyne receiver 5 to 250 mc/s
20. Variable attenuator 0 to 120 db Type Rel 3 D 118b
    (with use of measuring oscillators without incorporated attenuator)

When examining withdrawn subassemblies, it may become necessary to establish coaxial connections also between the subassemblies. They must on principle be kept as short as possible.

The following components are required:

Plug: Type Funk stv 63b

Jack: Type Funk stv 63a

Cable: 02YCY (7x0.15)/5.5

+ See FAULT ELIMINATING Fig. 12

B. Overall Check of the Receiver

The following measurements show whether gain and selectivity of the receiver correspond to the specified values. In particular the sensitivity check must be carried out after any greater action inside the receiver.

Measuring values of the complete receiver that deviate from the nominal ones will mostly suggest the subassembly where the fault is located.

Insufficient image frequency rejection and IF breakthrough selectivity as well as a poor signal-to-noise ratio with respect to the input voltage, for instance, will suggest a faulty RF amplifier. Off-normal nearby selectivity will be due to a fault in the IF amplifier.

When the voltage at the audio output is too low in spite of a fully opened audio control and sufficient IF output, the fault may be located in the audio amplifier.

When the functioning of the automatic gain control system is insufficient, the regulating amplifier arrangement in the audio amplifier, the RF amplifier, and the IF amplifier must be examined in particular.

Excessive parasitic oscillator radiation suggests missing or wrongly arranged metallic bonds or capacitive bypasses in RF amplifier or spectrum oscillator. Excessive harmonic emission suggests that no toroidal RF cores are provided in the critical lines.

Measuring Instruments

Measuring oscillator for 1.4 to 32.8 mc/s, capable of modulation
Psophometer 15 to 5000 c/s (e.g. Rel 3 U 32)
Variable attenuator Z = 60 Ω, 0 to 122 db (e.g. Type Rel 3 D 118b)
Superheterodyne receiver 5 to 250 mc/s
Level meter (e.g. Type Rel 3 D 311g) or RF tube voltmeter for 30 kc/s

1. Measuring the Sensitivity

Connect the measuring oscillator to the antenna jack of the receiver and the headphone output to the psophometer. The CCI A-filter must be inserted in circuit for all of the following measurements. This measurement is effected at either end of each range. For this purpose vary the coarse tuning control by about one turn, starting from the lower and the upper stops, respectively. The following settings apply to all measurements:

RF control at CW stop,
squelch control at CW stop,
noise-limiter switch at OFF,
regulating time 0.2 sec,
LOCKED (tuning in spectrum steps), interpolator at 0.

(a) Set the class-of-emission A1 and a bandwidth of 0.3 kc/s. Set the receiver on band 1 as outlined above and adjust the unmodulated measuring oscillator to the same frequency. Adjust the audio gain of the receiver at an input voltage of 0.3 µv so that the 1-kc/s beat note in the psophometer results in a deflection of 0 db (775 mv).

Note: Use double-shielded cable between the measuring oscillator and the receiver to avoid parasitic pickup.

Turn off the measuring oscillator and terminate the receiver into 60 Ω.

The psophometer should now read not more than 245 mv (signal-to-noise ratio 10 db). Repeat this measurement at the upper end of band 1 and in the rest of the bands at both the upper and the lower ends. Again, the signal-to-noise ratio should be at least 10 db.

(b) Effect the measurements with a bandwidth of 1 kc/s as outlined under (a). The signal-to-noise ratio should be at least 10 db.

(c) Set the class-of-emission A3 and a bandwidth of 3 kc/s and rotate the RF control fully clockwise. Adjust the receiver on band 1 as just outlined and set the measuring oscillator modulated at 30% with 1 kc/s to the same frequency. Adjust the audio gain of the receiver with an input voltage of 5 µv so that the 1-kc/s modulation signal in the psophometer results in a deflection of 0 db (775 mv).

Remove the modulation of the measuring oscillator. The psophometer should now indicate not more than 77 mv (signal-to-noise ratio 20 db). Repeat this measurement at the upper end of band 1 and at the upper and the lower ends of the rest of the bands. Again, the signal-to-noise ratio should be at least 20 db.

(d) Carry out the measurements as outlined unter (c) using a bandwidth of 6 kc/s. The signal-to-noise ratio should be at least 20 db.

(e) Set the class-of-emission A3A. Adjust the receiver on band 1 as outlined above and adjust the measuring oscillator so that a beat note of about

1 kc/s results. Adjust the audio gain of the receiver with an input voltage of 2 µv so that the beat note in the psophometer results in a deflection of 0 db (775 mv). Turn off the oscillator. The psophometer should now indicate not more than 77 mv (signal-to-noise ratio 20 db). Repeat this measurement at the upper end of band 1 and the lower and upper ends of the other bands. Again, the signal-to-noise ratio should be at least 20 db.

2. Measuring the Image-Frequency Rejection

(a) Connect to the antenna jack of the receiver the measuring oscillator modulated at 30% with 1 kc/s.

Set the class-of-emission A3 using a bandwidth of 6 kc/s. Switch the panel meter to E_{AUDIO}. Rotate the RF control to the CW stop, and the coarse tuning control to FREE.

(b) Tune the measuring oscillator and the coarse tuning control of the receiver to 30 mc/s, and the fine tuning control to 0. Set the input voltage to 1 µv. Adjust the audio control so that the panel meter shows a distinctly visible deflection (e.g. 15 scale divisions).

(c) Set now the measuring oscillator to 32.8 mc/s (image frequency) and increase the input voltage, with the same receiver setting, so that the meter shows the same deflection again. The related input voltage must at least be 10 mv (image frequency rejection $\geqq$ 80 db). When the range of the measuring oscillator extends to 30.0 mc/s only, the measurement can be made at 27.2 and 30.0 mc/s, if the need arises.

3. Measuring the IF Breakthrough Selectivity

(a) Establish the measuring setup as illustrated under 2., but set the measuring oscillator and the receiver to 1.55 mc/s (coarse tuning control, the fine tuning control is set at 0). Adjust the audio control so that the panel meter shows a distinctly visible deflection.

(b) Set the measuring oscillator at 1.4 mc/s and increase the input voltage of 1 µv, with the same receiver setting, so that the meter again reads the same deflection. The related input voltage must be at least 10 mv (IF breakthrough selectivity $\geqq$ 80 db for $f_{input} \geqq$ 1.55 mc/s).

4. Measuring the Regulating Characteristic

(a) Connect the measuring oscillator to the antenna jack of the receiver and a level meter to the headphone output.

Set both the receiver and the measuring oscillator to 10 mc/s. Modulate the measuring oscillator at 30% with 1000 c/s.

(b) Set the class-of-emission A3. Rotate the RF and audio controls to the CW stop, disconnect the loudspeaker, and set a bandwidth of 6 kc/s.

(c) Increase the input voltage from 5 µv to 500 mv. This measure must not cause the audio level to vary by more than the factor 2 (6 db). If the need arises, the panel meter can be used in place of the level meter.

5. Measuring the Gain

(a) Establish the measuring setup as outlined under 4.

(b) For input voltages of at least 5 µv about 1 volt must be measured at the IF output connected to a 600-Ω load. The voltage at the audio output must be at least 5 volts across 600 Ω when the audio control is fully opened and the loudspeaker in circuit.

6. Measuring the Selectivity

(a) For measuring the selectivity curves, connect the unmodulated measuring oscillator (signal strength about 1 µv) to the receiver input. Choose the input voltage so that on the one hand, the AVC does not yet operate, and on the other that the IF output voltage is no longer greatly affected by noise. Connect a tube voltmeter to the IF output. Detune the measuring oscillator and increase the input voltage so that the tube voltmeter indicates the same deflection.

(b) Plot the required voltage rise in decibel as a function of the detuning.

The overall selectivity is essentially determined by the selectivity of the 30-kc/s filter (for the selectivity curves see the FAULT ELIMINATING part, section II. C, Figs. 10 and 11).

7. Measuring the Parasitic Oscillator Radiation

After working on the RF amplifier or the spectrum oscillator, it is advisable to carry out random checks of the parasitic oscillator radiation on the bands 3, 4, and 5 at the terminated antenna jack by using a superheterodyne receiver. For the fundamental and harmonics it should not exceed 30 µv on all bands.

C. Guiding Values for the Tube Voltages and Currents

Unless otherwise stated a μA-Multizet meter is used for all measurements. The voltages are measured with respect to the chassis with neither input signal nor regulating voltage being present.+ All tube base diagrams are shown in the circuit diagrams. The specified data are guiding values and may vary due to circuit tolerances and production variations of the tubes. The most important direct voltage values can also be found in the test circuit diagram (FAULT ELIMINATING III).

Tube	Measmt.	Instrument	Meas. Range	Meas. Value
1	E_b		300 v DC	+160 v DC
	I_b		10 ma DC	7 ma DC
	E_k		3 v DC	+1.2 v DC
	I_k		10 ma DC	9.5 ma DC
	E_{c2}		100 v DC	+76 v DC
	I_{c2}		3 ma DC	2.5 ma DC
	Ma1	A-V-Ω Multizet	60 mv DC	8 to 10 scale div.
2	E_b		300 v DC	+168 v DC
	I_b		10 ma DC	5.3 ma DC
	E_k		1 v DC	+0.9 v DC
	I_k		10 ma DC	7.4 ma DC
	E_{c2}		100 v DC	+66 v DC
	I_{c2}		3 ma DC	2.1 ma DC
	Ma2	A-V-Ω Multizet	60 mv DC	6 to 10 scale div.
3	E_{bH}		300 v DC	+170 v DC
	I_{bH}		10 ma DC	4.4 ma DC
	E_k		3 v DC	+1.1 v DC
	I_k		10 ma DC	7.2 ma DC
	E_{c2+4}		100 v DC	+74 v DC
	I_{c2+4}		3 ma DC	2.8 ma DC
	Ma3	A-V-Ω Multizet	60 mv DC	8 to 11 scale div.

+The negative terminal of the instrument is connected to chassis except for the measurement at Ma11/I and the measurement of the bias voltages of the control grids. The RF control must be at the CW stop and the receiver be equipped for operation, i.e. all subassemblies and tubes must be inserted and the cords plugged in.

Class of Emission	Tube	Measurement	Instrument	Measuring Range	Measured Value
	4	E_{bH}		300 v DC	+177 v DC
		E_{bT}		10 v DC	+2.2 v DC
		E_{c2+4}		100 v DC	+67 v DC
		E_k		3 v DC	+0.95 v DC
		Ma4	A-V-Ω Multizet meter	60 mv DC	4 to 5 scale div.
	5	E_{bH}		300 v DC	+174 v DC
		E_{bT}	DC tube voltmeter	100 v DC	+24 v DC
		E_{c2+4}		100 v DC	+67 v DC
		E_k		3 v DC	+0.8 v DC
		Ma5	A-V-Ω Multizet meter	60 mv DC	6,5 to 10 scale div.
	6	E_b		300 v DC	+168 v DC
		E_{c2}		100 v DC	+95 v DC
		E_k		3 v DC	+1.6 v DC
		Ma6	A-V-Ω Multizet meter	60 mv DC	8 to 12 scale div.
A1	7	E_{bH}		300 v DC	+112 v DC
		E_{c2+4}		100 v DC	+70 v DC
		E_{c3}	tube voltmeter	10 v AC	6 to 9 v AC
A3		E_{bH}		100 v DC	+95 v DC
		E_{c2+4}		100 v DC	+75 v DC
A3	7	E_{bT}	A-V-Ω Multizet meter	100 v DC	+23 v DC
(crystal oscillator)		Ma7		60 mv DC	6 to 9 scale div.

Tube	Measurement	Instrument	Measuring Range	Measured Value
8 (regulating amplifier)	E_{c2+4}		100 v DC	+69 v DC
8 (noise limiter)	E_{bT}		100 v DC	+56 v DC
	Ma8	A-V-Ω Multizet meter	60 mv DC	10 to 12 scale div.
9/II (audio amplifier)	E_{bII}		300 v DC	+160 v DC
	E_{kII}		30 v DC	+12.5 v DC
9/I (phase inverter)	E_{bI}		300 v DC	+125 v DC
	E_{kI}		100 v DC	+58 v DC
	Ma9	A-V-Ω Multizet meter	60 mv DC	9 to 11 scale div.
10/I, II (final stage)	R21/22		10 v DC	-4 v DC
	Ma10/I, II	A-V-Ω Multizet meter	60 mv DC	8 to 14 scale div.
11/I	Ma11/I	A-V-Ω Multizet meter	60 mv	9 to 15 scale div.
11/II	Ma11/II	A-V-Ω Multizet meter	60 mv	10 to 15 scale div.
12/II	Ma12/II	A-V-Ω Multizet meter	60 mv	9 to 11 scale div.
13/I	Ma13/I	A-V-Ω Multizet meter	60 mv	7 to 10 scale div.
14/I	Ma14/I	A-V-Ω Multizet meter	60 mv	14 to 18 scale div.
14/II	Ma14/II	A-V-Ω Multizet meter	60 mv	8 to 12 scale div.
15/I	Ma15/I	A-V-Ω Multizet meter	60 mv	8 to 12 scale div.
15/II	Ma15/II	A-V-Ω Multizet meter	60 mv	9 to 12 scale div.
16	Ma16	A-V-Ω Multizet meter	60 mv	9 to 11 scale div.

+ Depending upon position of control R9 (cf. FAULT ELIMINATING section II.F.3)

++ Depending upon position of control R8 (cf. FAULT ELIMINATING section II.A.3)

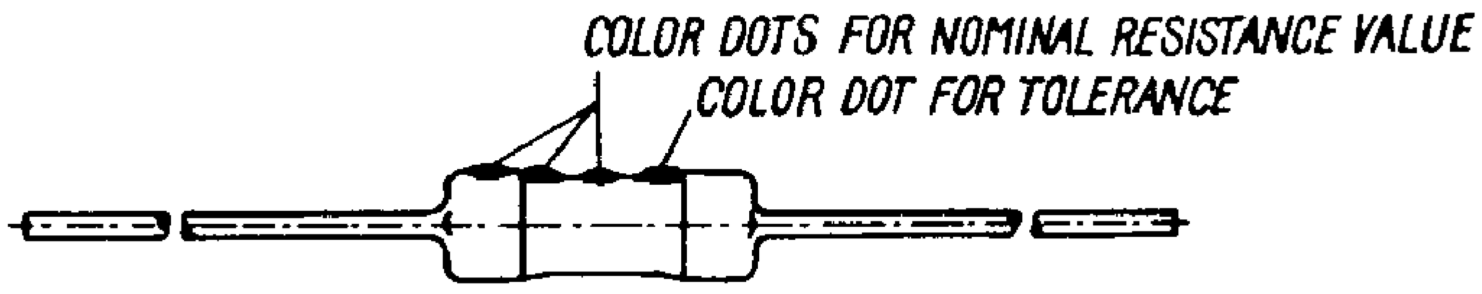
+++ Positive terminal of the instrument connected to chassis

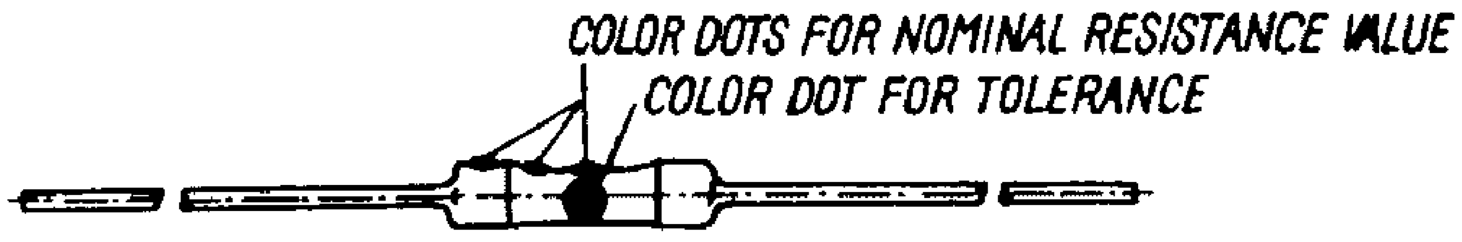
Tube	Measurement	Measuring conditions	Measuring Range	Measured Value
11 (spectrum oscillator)	E_{bI}	Band 5, variable capacitor fully meshed	100 v DC	+60 v DC
	E_{bII}	a. Coarse tuning control FREE, turret in intermediate position between detents	100 v DC	+48 v DC
		b. Coarse tuning control LOCKING IN SPECTRUM STEPS, turret in intermediate position between detents	100 v DC	+89 v DC
12 (spectrum unit)	E_{bI}		100 v DC	+80 v DC
	E_{bII}		100 v DC	+64 v DC
13 (spectrum unit)	Grid resistors R3/R15		100 v DC	-8.5 ±1 v+
	E_{bI}		100 v DC	+92 v DC
	E_{bII}		30 v DC	+10 v DC
14 (spectrum unit)	E_{bI}		100 v DC	+52 v DC
	E_{bII}		100 v DC	+30 v DC
15 (interpolation oscillator)	E_{bI}	Counter at 0 kc/s	300 v DC	+156 v DC
	E_{bII}	Counter at 0 kc/s	300 v DC	+156 v DC

+Positive terminal of the instrument connected to chassis

D. Color Coding of Resistors

Part of the resistors used in the Shortwave Receiver E 311 have a color coding instead of printed numbers for nominal value and tolerance.





This grouping holds in particular for miniature resistors

Color	Resistance value in Ω 1st color dot = 1st figure	 2nd color dot = 2nd figure	 3rd color dot = multiplier	Tolerance 4th color dot
no color	-	-		±20%
silver	-	-	$x\ 10^{-2}\ \Omega$ = 0.01 Ω	±10%
gold	-	-	$x\ 10^{-1}\ \Omega$ = 0.1 Ω	±5%
black	(0)	0	$x\ 10^{0}\ \Omega$ = 1.0 Ω	-
brown	1	1	$x\ 10^{1}\ \Omega$ = 10 Ω	±1%
red	2	2	$x\ 10^{2}\ \Omega$ = 100 Ω	±2%
orange	3	3	$x\ 10^{3}\ \Omega$ = 1 kΩ	-
yellow	4	4	$x\ 10^{4}\ \Omega$ = 10 kΩ	-
green	5	5	$x\ 10^{5}\ \Omega$ = 100 kΩ	-
blue	6	6	$x\ 10^{6}\ \Omega$ = 1 MΩ	-
violet	7	7	$x\ 10^{7}\ \Omega$ = 10 MΩ	-
gray	8	8	$x\ 10^{8}\ \Omega$ = 100 MΩ	-
white	9	9	$x\ 10^{9}\ \Omega$ = 1000 MΩ	-

Examples:

red 2	green 5	brown x 10 Ω	silver ±10%	= 25 x 10 Ω = 250 Ω ±10%
brown 1	blue 6	yellow x 10 kΩ	no color ±20%	= 16 x 10 kΩ = 160 kΩ ±20%

Color coding of quality grade

Quality grade		5	2	0.5
Color of body	≦ 2 W	reddish brown	reddish brown	gray
	> 2 W	red	red	gray
Lettering		black	yellow	black

Fault Eliminating

The Parts List section enumerates essentially the electrical components along with their ordering data and significant characteristics. The various components of the receiver and its subassemblies are alphabetically grouped in accordance with their designations on the circuit diagrams. The Fault Locating section illustrates how a fault is traced down to the respective subassembly or component. The Fault Eliminating section provides detailed information about service checks.

F A U L T   E L I M I N A T I N G

I. DISMOUNTING THE SUBASSEMBLIES

Caution: Be sure to withdraw the mains plug before pulling out the slide-in chassis from the casing and starting with installation work.

The components of the power supply unit are readily accessible through an aperture at the left side of the slide-in chassis, without dismounting of this subassembly.

The IF amplifier, the spectrum unit, and the audio amplifier are of the plug-in style (see section I. A).

For checking and repairing the receiver, the withdrawal of the other subassemblies or the removel of the front panel may become necessary. This is outlined in I.B. to E.

A. Removing the Spectrum Unit, IF Amplifier, and Audio Amplifier Subassemblies

(a) Put the slide-in chassis on one of its lateral surfaces.

(b) Loosen at the bottom of the slide-in chassis the four fastening screws of the subassembly to be taken out (Fig. 1).

(c) Withdraw the subassembly towards the top of the slide-in chassis.

(d) Loosen the fastening screws for the shielding cover and withdraw the cover in an upward or downward direction.

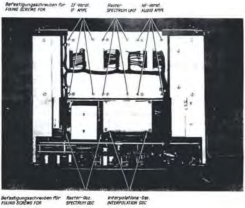


Bild 1 Einschub-Unterseite, Abdeckblech abgenommen
Fig. 1 BOTTOM VIEW OF RECEIVER CHASSIS, COVER TAKEN DOWN

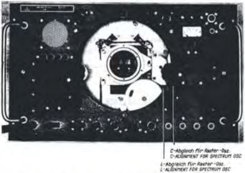


Bild 2 Einschub von vorn, Abdeckplatte und Skale abgenommen
Fig. 2 FRONT VIEW OF RECEIVER CHASSIS, COVER PLATE AND SCALE TAKEN DOWN

B. Removing the Front Panel (Figs. 2,3)

The front panel must be removed for replacing switches and potentiometers, which are bolted on the front panel, or for repair work on the wiring leading to these components.

(a) Rotate all switches and controls to the CCW stop or note their position. Get hold of the central cover plates of the rotary control with finger nail or pocket knife and pull them off. Loosen the now exposed setscrews and pull off the rotary controls. Remove the fuses.

(b) Screw off the carrying handles by passing the wrench through the lateral slots. When lossening the lower right nut take care not to damage the sliding face of the cam (see Fig. 4).

(c) Screw off the type plate. Loosen the two upper fastening nuts of the scale window.

(d) Remove the cover plate.

(e) Unsolder the antenna lead.

(f) Loosen the fastening screws at the right and left bars and the countersunk screws at the left and the right of the scale aperture.

(g) Remove the front panel in a forward direction.

(h) The front panel is reapplied in the reverse order.

C. Dismounting the RF Amplifier

(a) Note scale position and frequency band.

(b) Remove the RF cables 1, 2, and 5 after opening the tensioning straps and unsolder the power leads at the rear wall.

(c) Loosen two fastening screws each at the front and the rear.

(d) Unhook the coupling spring (Fig. 4). Do not screw off the bushing with follower pin and the tensioning hook.

(e) Pull the subassembly slightly to the rear and lift it off.

(f) The RF amplifier is re-installed in the reverse order. Take care that the tensioning pins (see Fig. 6) are located in the corresponding holes.

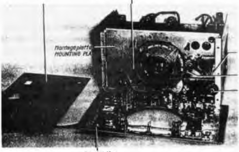


Bild 3 Einschub von vorn, Abdeckplatte und Frontplatte abgenommen

Fig. 3 FRONT VIEW OF RECEIVER CHASSIS, COVER PLATE AND FRONT PANEL TAKEN DOWN

Make sure that, when the coarse tuning control is adjusted to the lowest frequency (CCW stop) and the RF tuning correction control to the CCW stop, the stop plate (Fig. 4) is close to the stop pin (clearance of about 0.1 mm). Check subsequently if, when the coarse tuning control is set to the highest frequency (CW stop) and the RF tuning correction control to the CW stop, the stop plate is again close to the stop pin (but at the other side of the pin). If necessary, always adjust for the low frequency first. Provided the tensioning hook is firmly mounted and the subassembly is re-installed in the same position as it was before (i.e. protected against axial shifting by tensioning pins) the variation range of the variable capacitor does not change, i.e. tracking in the interpolator position 0 and with the RF tuning correction control at 0 is secured.

D. Dismounting the Spectrum Oscillator

(a) Withdraw the IF amplifier.

(b) Remove the RF cables 1, 7, and 8 after opening the tensioning straps and unsolder the power supply lines for the spectrum oscillator at the bottom of the slide-in chassis. Mark the relative positions of the clamping piece K and the coupling flange F by a pencil line (M in Fig. 5).

(c) Loosen the clamping piece (Figs. 5 and 6) by loosening the fillister-head cap screw rather than the setscrew.

(d) Loosen the four fastening screws of the subassembly acting from the rear of the mounting plate (two from the bottom, see Fig. 1, and two from the upper side of the slide-in chassis).

(e) Carefully withdraw the subassembly to the rear. Make sure that the shaft leaves the coupling.

Caution: The band-control gearing unit must not be switched when the spectrum oscillator is dismounted. Band 5 is marked by a red dot on the coil spindle (visible from the front through the aligning opening of the cover plate). The aperture disk must not be turned either.

(f) The spectrum oscillator is re-installed in the reverse order. The follower pin S must be seated in the partially milled slot of the clamping piece (see mounting diagram Fig. 5). Minor deviations (amounting to the width of a line) between the 400-kc/s calibrating marks and the whistling points in

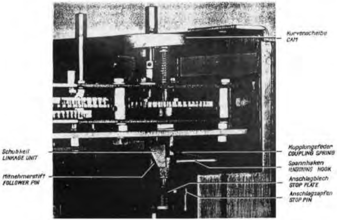


Bild 4 Drehkondensator-Antrieb des HF-Verstärkers
Fig. 4 VARIABLE-CAPACITOR GEARING IN THE RF AMPLIFIER

the position CALIBRATING can be compensated for with the scale correction screw. Greater deviations require that the clamping piece K be loosened again and turned accordingly with respect to the flange F. Under no circumstances must L and C be readjusted. If necessary, connect a measuring oscillator of adequate accuracy to the receiver input, set the receiver scale to its frequency and adjust the variable capacitor of the spectrum oscillator so that in position "A1" a 1-kc/s tone is produced, whose frequency remains the same when the sideband switch is operated. Now check the 400-kc/s marks on all bands.

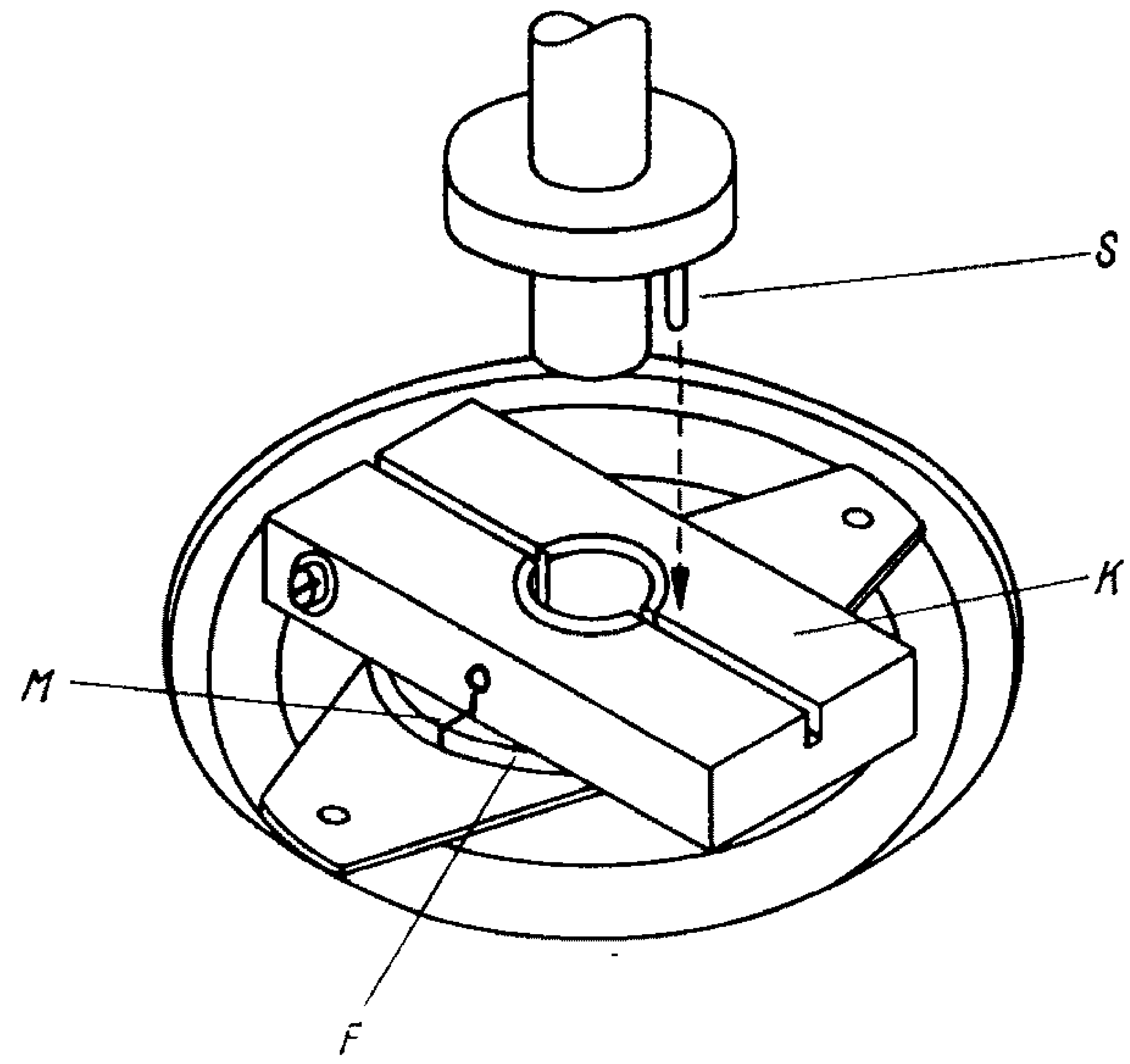


Bild 5 Richtige Lage von Klemmstück und Mitnehmerstift (s. I D)
Fig. 5 CORRECT POSITION OF CLAMPING PIECE AND FOLLOWER PIN (SEE I D)

Note: The relation between spectrum oscillator and receiver scale is no longer correct when frequency-determining parts of the spectrum oscillator are replaced. In such case, a new, individually calibrated scale will mostly be required. For this purpose the entire receiver must be forwarded to the factory.

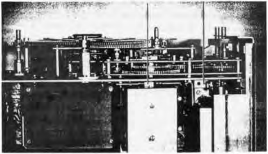


Bild 6 Getriebe von unten gesehen
Fig. 6 BOTTOM VIEW OF GEARING SYSTEM

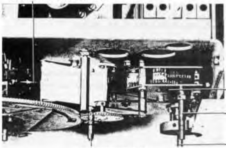


Bild 7 Bereichsgetriebe und Lamellenkupplung
Fig. 7 BAND GEARING AND FLEXIBLE COUPLING

E. Dismounting the Interpolation Oscillator

(a) Note the counter position at the CCW and CW stops.

(b) Remove the corresponding coaxial cables, the spectrum unit, and the audio amplifier.

(c) Unsolder the cableform (Fig. 6 at left).

(d) Loosen the four screws at the flexible coupling (Fig. 7) (two are accessible from the top and two from the bottom of the receiver with a long slender screwdriver), and shift the coupling away from the interpolation oscillator.

(e) Loosen the four fastening screws at the mounting plate (Fig. 3), from behind (two are accessible from the top and two from the bottom, see Fig. 1).

(f) Withdraw the interpolation oscillator toward the rear.

(g) The interpolation oscillator is re-installed in the reverse order. Check if the stops take effect at about the same counter positions as before (about 99.4 and 103.3). Otherwise, loosen the flexible coupling and correct the position.

The alignment of the interpolation oscillator is shown in the NOTES ON MAINTENANCE section.

The relation between the positions of the variable capacitor and the counter is fixed and not affected by dismounting of the interpolation oscillator.

Caution: The relation between the variable capacitor and the counter would no longer be correct, however, if gearing components (such as the worm gear) were removed and re-installed. In such case an individual recalibration of the variable capacitor along with the counter would become necessary, which can only be effected at the factory.

II. CHECKING AND ALIGNING WORK ON THE SUBASSEMBLIES

In many cases it is advisable to use the test circuit diagram (overall circuit diagram) of the receiver along with the individual circuit diagrams (see section III).

A. Checking the Power Supply Unit (Rel str 451 N 300 b or c En)

Measuring Instruments

A-V-Ω Multizet meter
Audio voltmeter (e.g. Type Rel 3 U 122)

1. Operating Voltages and Currents

In operation from 220-v mains, the power supply unit (with tube 16) should take 65 to 72 ma with no load connected to it, and 475 to 500 ma when the subassemblies (or corresponding load resistors) are connected.

The following values apply to the operational voltages as measured with an A-V-Ω Multizet meter and with the loads connected (measuring points at the soldering strip below the transformer, see also Rel str 451 N 300 En or c En):

Measurement	Load Resistor	Measuring Point	Voltage Range	Measured Value
Anode voltage	5.4 kΩ	a4 - b4[1]	300 v DC	184 to 190 v DC
Anode voltage	2.6 kΩ	a5 - b4	300 v DC	178 to 183 v DC
Regulated anode voltage	3.75 kΩ	a6 - b4	300 v DC	150 v DC[2]
Oven heating system	16 Ω	a9 - b9	60 v AC	21 to 22 v AC
Relay voltage	125 Ω	a3 - b3	60 v DC	-27 to -29 v DC
Heater voltage	1.2 Ω	a7 - b7	15 v AC	6.1 to 6.3 v AC
Signal voltage	12.5 Ω	a8 - b8	15 v AC	6.1 to 6.3 v AC
Manual control voltage	3.3 kΩ	a2 - b3[3] a10 - b3[4]	15 v DC	-7 v DC

1 Switching plug in position "AC"
2 See section II.A.3
3 With Type Rel 451 N 300b
4 With Type Rel 451 N 300c

2. Hum Voltage

AC ripple is superimposed on the DC voltages. It has the following approximate values as measured under load with an audio voltmeter (see list under

II.A.1) (be particularly careful when establishing this measuring setup, avoid multiple grounding):

Measurement	Measuring Point	Voltage Range	Measured Value
Anode voltage 185 v	a4 - b4	10 v AC	< 4 v AC
Anode voltage 180 v	a5 - b4	100 mv AC	< 45 mv AC
Regulated anode voltage	a6 - b4	10 mv AC	< 10 mv AC
Relay voltage	a3 - b3	10 mv AC	< 2 mv AC
Manual control voltage	a2 - b3[1] a10 - b3[2]	30 mv AC	< 25 mv AC

[1] With Type Rel 451 N 300b
[2] With Type Rel 451 N 300c

3. Stabilizing Circuit

With an A-V-Ω Multizet meter the following voltages are measured under load:

At the cathode of tube 16: +70 v to 72 v DC (voltage range 100 v)

Voltage regulating range: R8 at CCW stop 135 to 140 v DC, R8 at CW stop 165 to 170 v DC } voltage range 300 v DC

as measured with respect to chassis at a point <u>following</u> the 0.05-amp fuse (be cautious, a short-circuit might damage the regulating transistor).

(Subsequently adjust the nominal value of +150 v under load with R8). Between Ma16 and b4 10 scale divisions (measuring range 60 mv).

When the mains voltage drops from 220 v to 187 v (-15%) at a load current of 40 ma, the regulated voltage may fall from 150 to 143 v.

4. Switching Relay L

When the soldering pins b2 and b3 are interconnected, relay L must operate. When the relay has operated, the same voltage must appear between a9 and b6 as between a9 and b9. No voltage must be between a9 and b6 when the relay has dropped out.

B. Checking the Audio Amplifier (Rel str 452 V 300a En)

Measuring Instruments

A-V-Ω Multizet meter

μA-Multizet meter

Measuring oscillator 20 to 40 kc/s, capable of modulation, output voltage about 0.1 v (e.g. Type Rel 3 W 220)

Audio generator 300 c/s to 6 kc/s, $k \leq 2\%$, output voltage variable between 20 mv and 3 v (e.g. Type Rel 3 W 29)

Audio tube voltmeter, range 30 mv to 3 v (e.g. Type Rel 3 U 122)
Tube voltmeter for 30 kc/s, voltage range 30 mv to 10 v.
Distortion meter (distortion measurement will not be necessary in general).

1. Operational Voltages

Measure the voltages by reference to table II.C in the FAULT LOCATING section. For this purpose withdraw the subassembly after removing the IF cable and loosening the four fastening screws (see Fig. 1), open it and connect it via adapter cables to the associated clip contact strips in the slide-in chassis. In many cases, however, a check of the tubes at the measuring terminals will be sufficient.

In no-signal condition and with nominal voltage the current input of the subassembly is 30 to 34 ma.

2. Gain and Distortion Factor

(a) Disconnect the internal loudspeaker.
When the output voltage is measured at the 5-Ω output with the aid of a plug PL55, the resistor R4, which is automatically taken out of circuit by the switching jack, must be replaced by a 5-Ω resistor rated at 2 watts.

The measuring voltage is fed into jack 6, the measurement being made with the audio tube voltmeter. It should result in the following values:

Class-of-Emission	Frequency of Measuring Oscillator	Voltage of Measuring Oscillator at Jack 6	Voltage across 5 Ω	Voltage at Headphone output
A1	1 kc/s	50 mv (-24.3 db; -2.8 N)	0.5 to 0.65 v	2.4 to 3.0 v
A1	30 kc/s	50 mv (-24.3 db; -2.8 N)	0.5 to 0.65 v	2.4 to 3.0 v
A3A	31 kc/s	50 mv (-24.3 db; -2.8 N)	0.5 to 0.65 v	2.4 to 3.0 v

(b) Apply a 30-kc/s measuring signal of 0.29 v (-8.7 db; -1 N) modulated at 30% with a 1-kc/s signal to jack 6. Select class-of-emission A3 and set a voltage of 2.2 v (1 watt) across the 5-Ω termination with the audio control. Under these conditions the distortion factor should not exceed 5%. (The measurement of the distortion factor for checking and fault elimination will in general not be necessary.)

3. A1 Oscillator

In operation with the crystals Kr4 or Kr5 (30 kc/s and 31 kc/s) the following voltages should be measured with respect to chassis with a high-impedance tube voltmeter:

Measuring Point		Measuring Range	Measured Value
Relay F	Soldering pin 9	3 v AC	2.8 to 4.3 v AC
	Soldering pin 6	3 v AC	1.7 to 2.5 v AC
g3, tube 7		10 v AC	6 to 9 v AC

4. IF Output

With a 30-kc/s measuring signal of 22 mv applied to jack 6 and in class-of-emission A1, the voltage at the IF output (soldering pin B5 - chassis) should be at least 70 mv AC. The maximum of this voltage should appear between 29 and 31 kc/s and should drop by 1.5 to 3.5 db with a detuning of ±8 kc/s.

5. Regulating Voltage

Set class-of-emission A1. Connect the negative terminal of the µA-Multizet meter to the soldering pin B13 and the positive terminal to chassis. Connect the measuring oscillator to jack 6. Adjust the voltage of the measuring oscillator working at 30 kc/s so that the µA-Multizet meter reads 16 µA. The voltage of the measuring oscillator should be between 550 mv (-3 db; -0.35 N) and 450 mv (-4.8 db; -0.55 N). The µA-Multizet meter should read the following values:

at B15:	6.5 to 7.5 v
at B12:	9.5 to 10.5 v
at B10:	4 to 5 v
at B8:	0.8 to 1.3 v

6. Noise Limiter

In the absence of a signal, a direct voltage of about +6.1 v should be measured between the junction R1/R2 in the regulating amplifier assembly and chassis, while between the junction Gr2/Gr3 and chassis about +6.2 v should appear (µA-Multizet meter, 30-v range). This voltage should increase to 7.2 v if in class-of-emission A3 a 30-kc/s signal of 70 mv modulated at 30% with 1-kc/s is applied to jack 6.

7. Squelch Circuit

Set class-of-emission A3. Apply to jack 6 a 30-kc/s signal modulated at 30% with 1 kc/s. With an input voltage between 85 mv (-19 db; -2.2 N) and 70 mv (-20.8 db; -2.4 N), the output voltage must change at a ratio of 1:2 when the squelch control is advanced from the CCW to the CW stop.

8. Frequency Response in Class A3

Set class-of-emission A3 and connect the 30-kc/s measuring oscillator to jack 6. Vary the modulation frequency of the oscillator from 300 to 3000 c/s with 30% modulation. At these limit frequencies the voltage decrease at the 5-Ω output should not exceed 2 db as referred to 1000 c/s. At 6000 c/s the output voltage must drop by 7 db to 13 db (0.8 to 1.5 N).

9. Hum Voltage

Set class-of-emission A3. Rotate the volume control to the CW stop. The hum voltage now measured at the 5-Ω output should be below 12 mv.

C. Checking and Aligning the IF Amplifier (Rel str 454 V 300a En)

Measuring Instruments

A-V-Ω Multizet meter
μA-Multizet meter
Tube voltmeter 20 to 400 kc/s, 30 mv to 1 v
Tube voltmeter for DC voltages, 1 v to 100 v
30-kc/s measuring oscillator
370-kc/s measuring oscillator (e.g. Type Rel 3 W 29)
Frequency counter 1 kc/s to 1 mc/s, reading error less than 1×10^{-5}.

1. Operational Voltages

Measure the voltages by reference to the table II.C in the FAULT LOCATING section. For this purpose withdraw the subassembly after removing the RF cables and loosening the four fastening screws (see Fig. 1), open it and connect it via adapter cables to the related clip contact strip in the slide-in chassis. However, in many cases a check of the tubes at the measuring terminals will be sufficient.

2. Anode Input Current

The subassembly draws a current

$$I_{total} = 24 \text{ ma} \pm 10\% \text{ at } E_b = 180 \text{ v}$$

3. Oscillating Voltage of the Third Oscillator

The following oscillating voltages should be measured with a high-impedance RF tube voltmeter:

	Voltage with respect to chassis at C15	C16
400-kc/s crystal (Kr1) in operation (relay A deenergized)	0.8 to 1.8 v AC	1.5 to 3.5 v AC
340-kc/s crystal (Kr2) in operation (relay A energized)	0.8 to 1.8 v AC	1.5 to 3.5 v AC
Calibrating position 400-kc/s crystal (Kr1) in operation (relay A deenergized, relay G energized)	1.8 to 3.0 v AC	3.5 to 6 v AC

4. Calibrating Output

In the position CALIBRATION (i.e. when relay G has operated), about 25 to 35 mv shall be measured at jack "5" with an RF tube voltmeter.

5. Stage Gain

When no regulating bias is applied, i.e. when the two regulating leads are connected to chassis (terminals 2 and 3 of the blade contact strip), the following level values apply:

Bandwidth Setting	Measuring Frequency and Oscillator Voltage Required at: Jack 2	Grid 1 of tube 5	Grid 1 of tube 6	For Voltage at Output of IF Amplifier (Jack 3) of:
	370 kc/s	370 kc/s	30 kc/s	
0.3 kc/s	32-64 µv	420-840 µv	2.5-4.9 mv	500 mv, 30 kc/s (with tube voltmeter)
1 kc/s	40-74 µv	550-990 µv	2.6-4.8 mv	
3 kc/s	32-72 µv	430-970 µv	2.3-5.1 mv	
6 kc/s	22-56 µv	290-710 µv	2.1-5.3 mv	
SSB	32-64 µv	420-840 µv	2.5-4.9 mv	

6. Regulation

When the regulating voltage is applied, the following approximate values apply:

Grid Bias Voltages	Bandwidth Setting	Input Voltage Required at Jack 2	For a Voltage at Output of IF Amplifier (Jack 3) of
-3 v at grid 1 of tube 4 -0.6 v at grid 1 of tube 5 and tube 6	6 kc/s	5 to 6 db (1.78 to 2 times) higher than in measurement under 5	0.5 v/30 kc/s

7. Measuring Setup for Filter Alignment

For the alignment it must be possible to set the frequencies of

29.975 kc/s	33.00 kc/s
29.94 kc/s	33.50 kc/s
29.70 kc/s	33.80 kc/s
29.40 kc/s	38.20 kc/s

to within 10 c/s, and the frequencies of 369.70 kc/s and 370.00 kc/s to within 100 c/s.

For setting and supervising the frequency, a frequency meter of adequate accuracy, e.g. a frequency counter, is used.

For the arrangement of the coils and measuring points see Fig. 8.

Alignment and checking is as follows:

(a) Align the 370-kc/s filter by reference to the tuning instructions (II.C.8).

(b) Align the 30-kc/s IF filter by reference to the tuning instructions (II.C.9).

(c) Check the overall selectivity (see also II.B.6 of the FAULT LOCATING part)
by inserting the crystals Kr1 (400 kc/s) and Kr2 (340 kc/s),
connecting the measuring oscillator to grid 1 of tube 4,
connecting the millivoltmeter via a capacitor of 10 pf to the 30-kc/s output (jack 3).

When the measuring oscillator is correspondingly detuned the following attenuation values should be measured:

in the position BANDWIDTH 6 KC/S: not more than 3 db at ±3 kc/s from mid-band

in position SINGLE-SIDEBAND:

not more than 6 db at 30.3 kc/s	measuring oscillator frequency	
at least 30 db at 30.0 kc/s		
not more than 3 db at 33 kc/s		

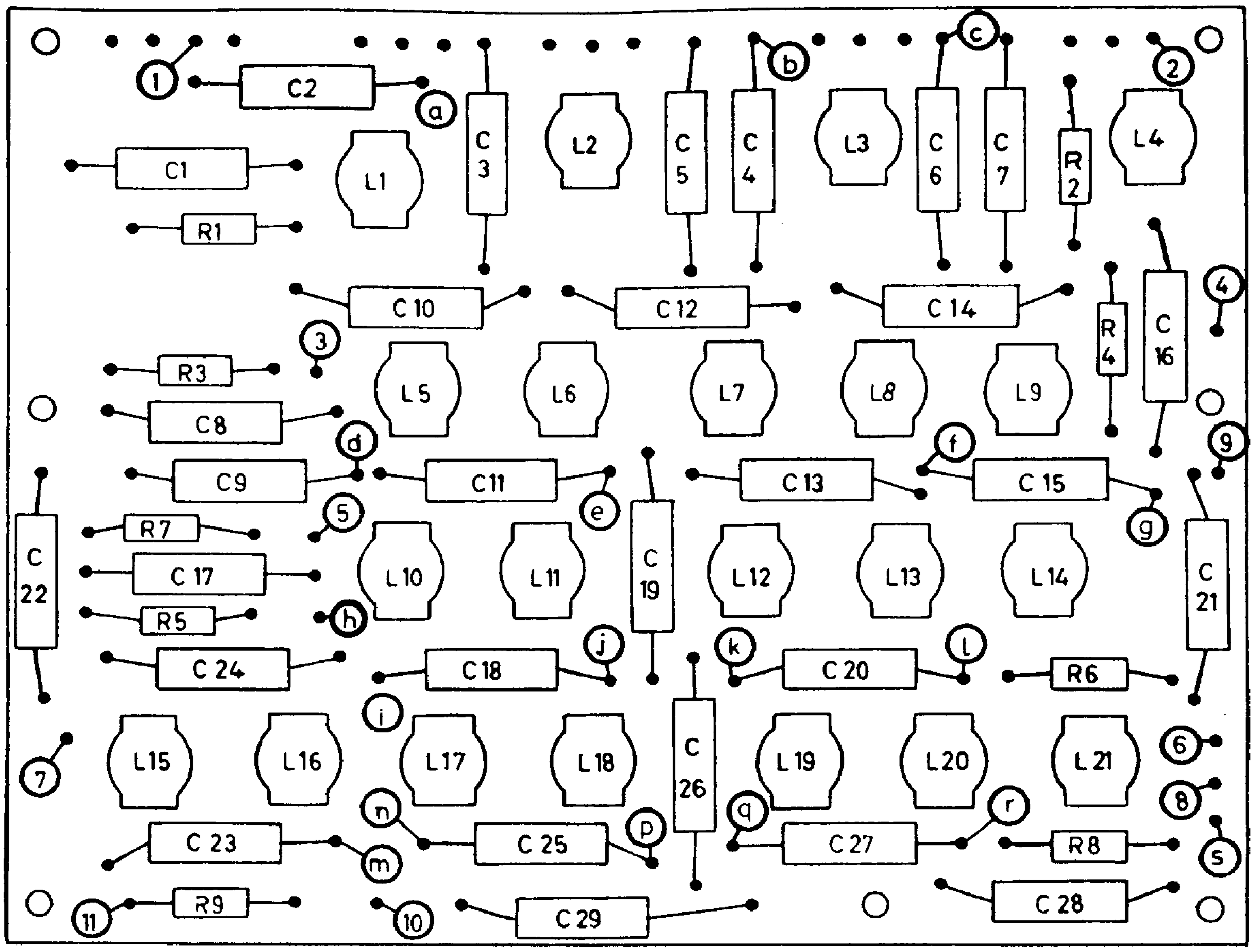
8. Aligning Instructions for the 370-kc/s Filter (Type Rel 454 F 303a)

Withdraw the control crystals Kr1 and Kr2 before checking and aligning the filter.

(a) Connect the measuring oscillator to jack 2. Set the frequency of 369.70 kc/s (to within 100 c/s). The required RF voltage at grid 1 is about 10 mv. For the measuring setup see II.C.7.

(b) Connect a high-impedance millivoltmeter via a capacitor of about 0.4 pf to the anode of tube 4.

Filtergruppe
FILTER GROUP
Rel 452 F300a
(30-kHz Filter)
(30-KC/S FILTERS)



Filtergruppe
FILTER GROUP
Rel 454 F303a
(EB-Filter,
370-kHz-Filter,
30-kHz-Kreis)
(SSB FILTER,
370-KC/S FILTER,
30-KC/S CIRCUIT)

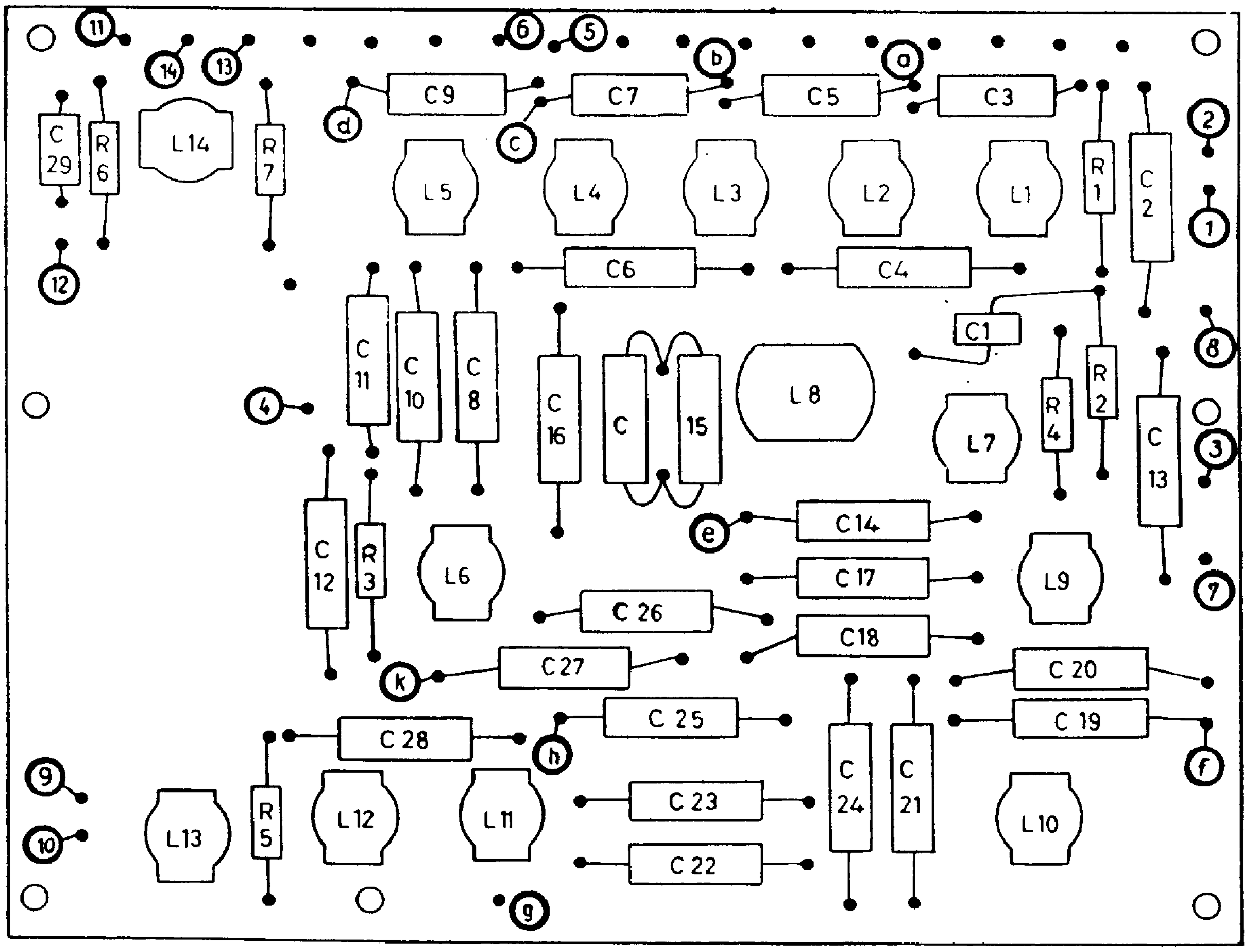


Bild 8 Meßpunkte für den ZF-Abgleich
Fig. 8 MEASURING POINTS FOR IF ALIGNING

(c) Connect the measuring point "a" (Fig. 8 and Rel str 454 F 303a En) to chassis.

(d) Adjust coil L1 for maximum deflection of the millivoltmeter.

(e) Cancel the short-circuit of "a" and connect "b" to chassis.

(f) Adjust coil L2 for minimum deflection.

(g) Cancel the short-circuit of "b" and connect "c" to chassis.

(h) Adjust coil L3 for maximum deflection.

(i) Cancel the short-circuit of "c" and connect "d" to chassis.

(k) Tune coil L4 for minimum deflection.

(l) Cancel the short-circuit of "d" and connect pin 4 to chassis.

(m) Tune coil L5 for maximum deflection.

(n) Cancel the short-circuit of pin 4.

(o) Tune coil L6 for minimum deflection.

9. Aligning Instructions for the 30-kc/s Filters (Type Rel 452 F 300a)

Withdraw the control crystals Kr1 and Kr2 before checking and aligning the filters.

a. Filter with the Bandwidth b = 0.3 kc/s

(a) Connect the measuring oscillator working at f = 30.00 kc/s to grid 1 of tube 5. RF voltage required at grid 1 about 50 mv, frequency accuracy ±10 c/s.

For the measuring setup see II.C.7, set the bandwidth switch to "0.3 KC/S".

(b) Connect a high-impedance millivoltmeter through a capacitor of about 0.4 pf to the anode of tube 5.

(c) Connect the measuring point "a" (Fig. 8 and Rel str 452 F 300a En) to chassis.

(d) Tune coil L1 for maximum deflection of the millivoltmeter.

(e) Cancel the short-circuit of "a" and connect "b" to chassis.

(f) Tune coil L2 for minimum deflection.

(g) Cancel the short-circuit of "b" and connect "c" to chassis.

(h) Tune coil L3 for maximum deflection.

(i) Cancel the short-circuit of "c".

(k) Tune coil L4 for minimum deflection.

b. Filter with the Bandwidth b = 1 kc/s

(a) Connect the measuring oscillator working at f = 29.975 kc/s to grid 1 of tube 5. Required RF voltage at grid 1 about 50 mv, frequency accuracy ±10 c/s. For the measuring setup see II.C.7, set the bandwidth switch to "1 KC/S".

(b) Connect a high-impedance millivoltmeter via a capacitor of about 0.4 pf to the anode of tube 5.

(c) Connect the measuring point "d" to chassis.

(d) Tune coil L5 for maximum deflection of the millivoltmeter.

(e) Cancel the short-circuit of "d" and connect "e" to chassis.

(f) Tune coil L6 for minimum deflection.

(g) Cancel the short-circuit of "e" and connect "f" to chassis.

(h) Tune coil L7 for maximum deflection.

(i) Cancel the short-circuit of "f" and connect "g" to chassis.

(k) Tune coil L8 for minimum deflection.

(l) Cancel the short-circuit of "g".

(m) Tune coil L9 for maximum deflection.

c. <u>Filter with Bandwidth b = 3 kc/s</u>

(a) Connect the measuring oscillator (frequency f = 29.94 kc/s) to grid 1 of tube 5. Required RF voltage at grid 1 approx. 50 mv, frequency accuracy ±10 c/s.

For the measuring setup see II.C.7, set the bandwidth switch to "3 KC/S".

(b) Connect a high-impedance millivoltmeter via a capacitor of about 0.4 pf to the anode of tube 5.

(c) Interconnect the test points h and i via a capacitor of 1000 pf (Caution: Anode Voltage).

(d) Tune the coil L10 for maximum deflection of the millivoltmeter.

(e) Interrupt the connection between h and i and connect "j" to chassis.

(f) Tune coil L11 for minimum deflection.

(g) Cancel the short-circuit of "j". Interconnect "j" and "k" via a capacitor of 1000 pf.

(h) Tune coil L12 for maximum deflection.

(i) Interrupt the connection between "j" and "k" and connect "l" to chassis.

(k) Tune the coil L13 for minimum deflection.

(l) Cancel the short-circuit of "l".

(m) Tune the coil L14 for maximum deflection.

d. <u>Filter with the Bandwidth b = 6 kc/s</u>

(a) Connect the measuring oscillator (frequency f = 29.7 kc/s) to grid 1 of tube 5. Required RF voltage at grid 1 is about 50 mv, frequency accuracy ±10 c/s.

For the measuring setup see II.C.7. Set the bandwidth switch to "6 KC/S".

(b) Connect a high-impedance millivoltmeter via a capacitor of about 0.4 pf to the anode of tube 5.

(c) Interconnect the test points "m" and "n" via a 1000-pf capacitor.
(d) Tune coil L15 for maximum deflection of the millivoltmeter.
(e) Interrupt the connection between "m" and "n" and connect "n" to chassis.
(f) Tune coil L16 for minimum deflection.
(g) Cancel the short-circuit of "n" and interconnect "p" and "q" via a capacitor of 1000 pf.
(h) Tune coil L17 for maximum deflection.
(i) Interrupt the connection between "p" and "q" and connect "q" to chassis.
(k) Tune coil L18 for minimum deflection.
(l) Cancel the short-circuit of "q" and interconnect "r" and "s" via a capacitor of 1000 pf.
(m) Tune coil L19 for maximum deflection.
(n) Interrupt the connection between "r" and "s" and connect "s" to chassis.
(o) Tune coil L20 for minimum deflection.
(p) Cancel the short-circuit of "s".
(q) Tune coil L21 for maximum deflection.

e. Single-Sideband Filter

(a) Connect the measuring oscillator to grid 1 of tube 5. The oscillator must be capable of supplying the frequencies of 33.50; 33.80; 29.70; 38.20; 29.40 kc/s. RF voltage required at grid 1 is about 50 mv, frequency accuracy ±10 c/s. For the measuring setup see II.C.7. Set the class-of-emission switch to "A3A".
(b) Connect a high-impedance millivoltmeter via a capacitor of about 0.4 pf to the anode of tube 5.

Before the alignment the inductance L8 must be minimized by screwing out the coil core.
(c) Unsolder capacitor C14 from the test soldering pin "e" (Fig. 8 and Rel str 454 F 303a En).
(d) At 33.50 kc/s tune coil L7 for maximum deflection of the millivoltmeter.
(e) Unsolder capacitor C27 from "k".
(f) Connect the measuring oscillator to "k" via a resistor of about 500 kΩ.
(g) Connect the millivoltmeter to the IF amplifier output (jack 3).
(h) At 33.80 kc/s tune coil L13 for maximum deflection.
(i) Solder the capacitors C14 and C27 again in position.
(k) Connect the measuring oscillator to grid 1 of tube 5.
(l) At 38.20 kc/s tune coil L9 for minimum deflection.
(m) Connect the measuring points "g" and "h" to chassis.
(n) At 29.40 kc/s tune the coil L10 for minimum deflection.

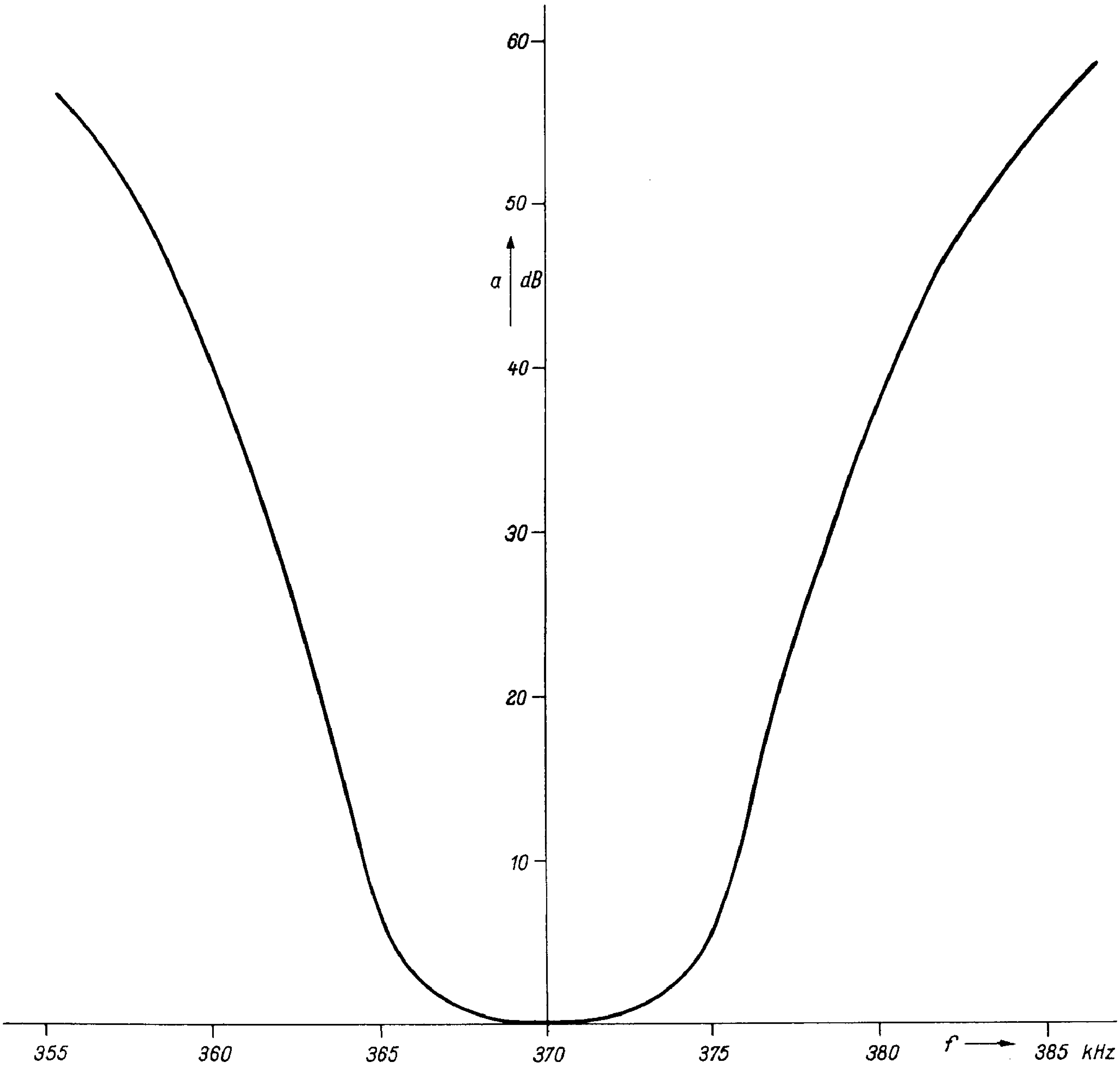


Bild 9 Durchlaßkurve des 370-kHz-Filters
Fig. 9 PASS-BAND CURVE OF 370-KC/S FILTER

(o) Cancel the short-circuit of "g" and connect "f" and "h" to chassis.

(p) At 29.40 kc/s tune the coil L11 for minimum deflection.

(q) Interrupt the connection between chassis and "h" and connect "f" and "g" to chassis.

(r) At 29.40 kc/s tune the coil L12 for minimum deflection.

(s) At 29.75 kc/s tune the coil L8 for minimum deflection.

10. Checking the Pass-Band Characteristic of the 370-kc/s Filter

Interrupt the anode voltage lead to tube 5 and connect the anode of this tube directly to the anode voltage (of +180 v) via a resistor of 2.2 kΩ. Connect the RF millivoltmeter via a capacitor of about 1 pf to the anode of tube 5.
Connect the measuring oscillator to jack 2 (input of the IF amplifier). Voltage required is about 5 mv.
Withdraw the control crystals Kr1 and Kr2.

The filter characteristic must meet the following demands (Fig. 9):

(a) At 367 kc/s and 373 kc/s, the attenuation with respect to 370 kc/s must not exceed 1.5 db.

(b) At 364 kc/s and 376 kc/s, an attenuation of at least 7 db must be achieved.

(c) At 360 kc/s and 380 kc/s, an attenuation of at least 35 db must be achieved.

(d) At 340 kc/s and at 400 kc/s, an attenuation of at least 60 db must be achieved.

11. Checking the Pass-Band Characteristics of the 30-kc/s Filter

Interrupt the anode voltage lead to tube 6 and connect the anode of this tube via a resistor of 2.2 kΩ directly to the anode voltage (+180 v). Connect the millivoltmeter via a capacitor of about 1 pf to the anode of tube 6.
Connect the measuring oscillator operating at 30 kc/s with a signal strength of about 5 mv to grid 1 of tube 5 (when checking the SSB filter the oscillator should supply a 370-kc/s signal of about 5 mv to the input jack 2 instead).

Set the bandwidth accordingly. When checking the single-sideband filter, the sideband selector switch must be set at LOWER SIDEBAND (340-kc/s crystal Kr2 operative).
The filters must meet the following demands (Fig. 10):

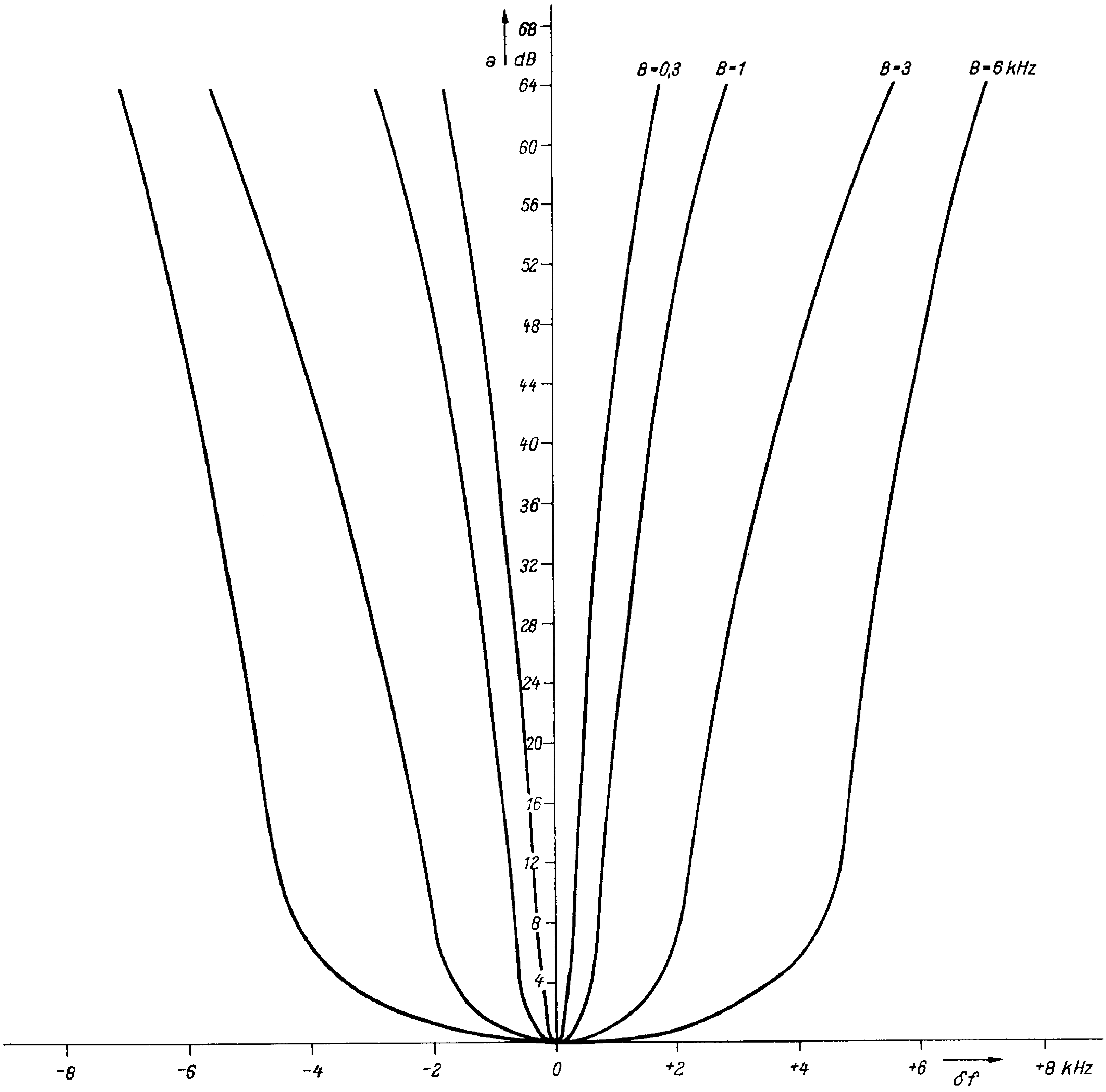


Bild 10 Gesamtselektion des Empfängers bei Zweiseitenband-Betrieb

Fig. 10 OVERALL SELECTIVITY OF THE RECEIVER WITH DOUBLE-SIDEBAND OPERATION

(a) For the filter with the bandwidth b = 0.3 kc/s:
not more than 3 db drop at the band edges (29.85 and 30.15 kc/s), attenuation at least 40 db at 29 and 31 kc/s.

(b) For the filter with the bandwidth b = 1 kc/s:
drop at the band edges (29.5 and 30.5 kc/s) not more than 3 db, attenuation at 28 and 32 kc/s at least 40 db.

(c) For the filter with the bandwidth b = 3 kc/s:
drop at the band edges (28.5 and 31.5 kc/s) not more than 3 db, attenuation at 26 and 34 kc/s at least 40 db.

(d) For the filter with the bandwidth b = 6 kc/s:
drop at the band edges (27 and 33 kc/s) not more than 3 db, attenuation at 24 and 36 kc/s at least 30 db.

(e) For the single-sideband filter (with 370-kc/s filter):
peak-to-valley ratio between 370.8 and 373 kc/s not more than ±1 db as referred to the attenuation at 371.7 kc/s (31.7 kc/s).
Attenuation at 373 kc/s not more than 3 db as referred to the attenuation at 371.7 kc/s.
Attenuation at 370.3 kc/s not more than 6 db as referred to the attenuation at 371.7 kc/s.
Attenuation at 370.0 kc/s at least 30 db as referred to the attenuation at 371.7 kc/s.
Attenuation between 369.7 and 367 kc/s at least 60 db as referred to the attenuation at 371.7 kc/s.

12. Checking the Selectivity of the Circuit L14/C29

Connect the measuring oscillator (operating at 30 kc/s with a signal strength of 5 mv) to grid 1 of tube 6.
Connect the millivoltmeter via a 10-pf capacitor to the 30-kc/s output (jack 3).
The selectivity curve must meet the following demands (Fig. 11):
attenuation between 27 and 33 kc/s not to exceed 1 db,
attenuation at 25 and 35 kc/s about 2.5 db.

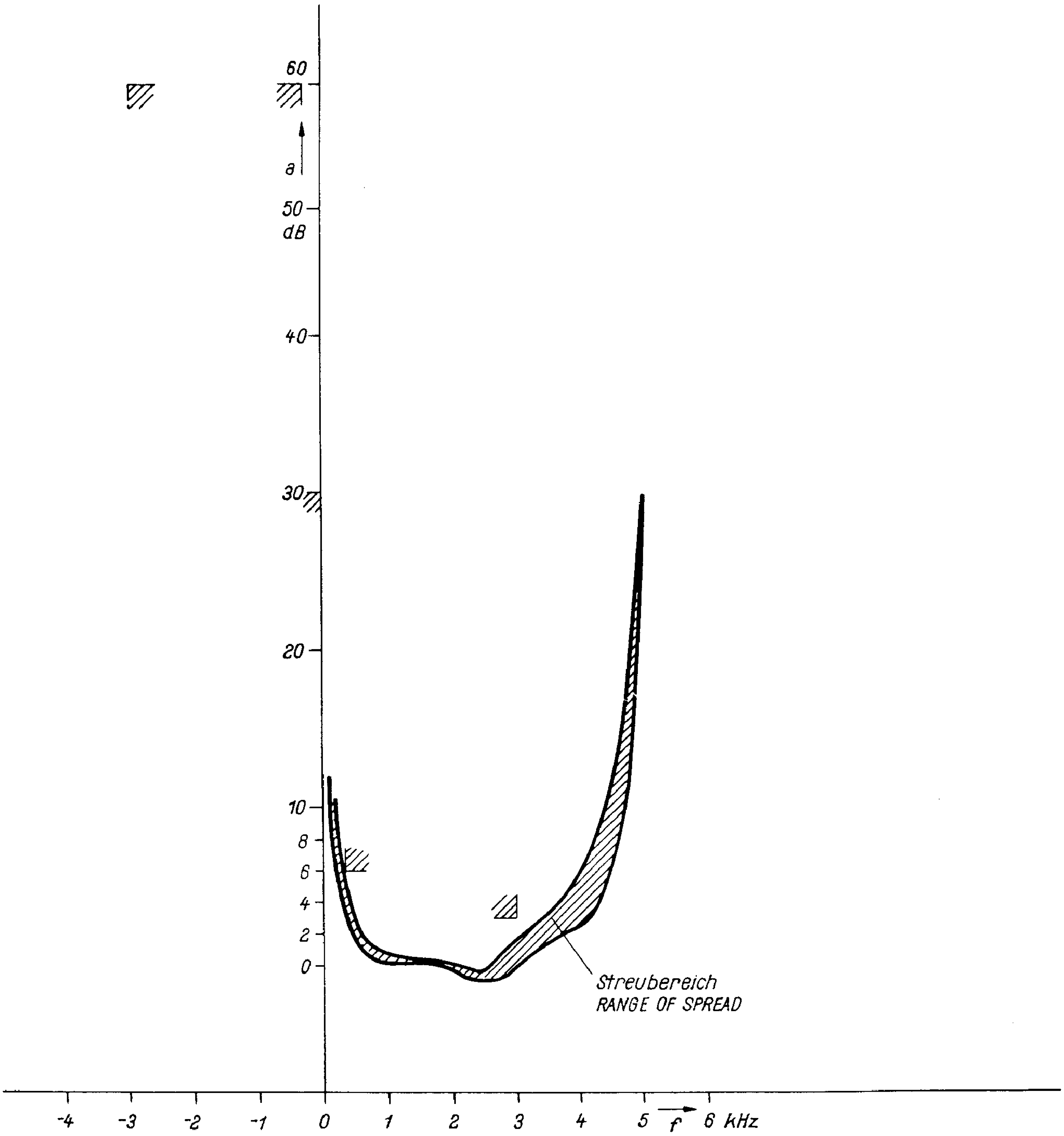


Bild 11 Gesamtselektion des Empfängers bei Einseitenband-Betrieb

Fig. 11 OVERALL SELECTIVITY OF THE RECEIVER WITH SINGLE-SIDEBAND OPERATION

D. Checking and Aligning the RF Amplifier (Rel str 455 V 311a or b En)

(For the measurement of the image-frequency rejection and the IF breakthrough selectivity see the FAULT LOCATING part, II.B.2 and 3).

Measuring Instruments

A-V-Ω Multizet meter

μA-Multizet meter

RF tube voltmeter for 1.5 to 30 mc/s, 3 mv to 1 v.
up to 30 mv C_{input} < 10 pf
over 30 mv C_{input} < 3 pf

Measuring oscillator for 1.45 to 32.6 mc/s (30.05 mc/s)

Variable attenuator Z = 60 Ω, 0 to 120 db (e.g. Type Rel 3 D 118b)

Adapter A according to Fig. 12
(connector Type Funk stv 63a with voltage divider 12 pf/100 pf)

1. Operational Voltages

In general the measurements at the terminals Ma1, Ma2, Ma3 on the incorporated RF amplifier will be sufficient. In the 60-mv measuring range an A-V-Ω Multizet meter should read 10 scale divisions in each case. If necessary, the electrode voltages must be measured at the tube prongs (see the FAULT LOCATING part II.C).

2. Overall Gain (can be measured without dismounting the RF amplifier)

For measuring the gain of the RF subassembly, connect the measuring oscillator to the antenna terminal. Also connect the terminals a1/a2 of adapter A to cable 2 (IF1 output) by reference to Fig. 12.

Set the frequency of the measuring oscillator to equal the receiving frequency of 7.45 mc/s in range 3.

At an EMF of the measuring oscillator of 1 mv and with optimum adjustment of the RF tuning correction, a voltage of about 1.7 mv should be measured at the output (b1/b2) of the adapter.

3. Stage Gain (can only be measured when the RF amplifier is dismounted)

(a) Disconnect the first IF filter from the anode of tube 3 and replace it by a 180-Ω resistor. Connect a high-impedance millivoltmeter to the anode of tube 3 (measuring point 5 in the following level chart) via a 1000-pf capacitor.

(b) Connect a measuring oscillator to the RF input (measuring point 1) of the RF amplifier and set it at an EMF of 1 mv at the frequencies listed in the table.

(c) Measure the AC voltages at:

control grid of tube 1	(measuring point 2)
control grid of tube 2	(measuring point 3)
control grid of tube 3	(measuring point 4)
1000-pf capacitor following anode of tube 3	(measuring point 5)

The measuring values should correspond approximately to the values listed in the table.

The levels at the measuring points 2, 3, and 4 can be measured at the grid prongs, if necessary, without dismounting the subassembly.

Level Table for the RF Section

Band	Frequency f in mc/s	Measuring Point 1 EMF in mv	2 EMF in mv	3 EMF in mv	4 EMF in mv	5 EMF in mv
1	1.45	1	5	14	24	17
1	3.45	1	9	32	91	60
2	3.35	1	3.8	17	25	17
2	7.55	1	4.8	33	53	33
3	7.45	1	2.7	17	23	15
3	15.05	1	3.2	47	105	69
4	14.95	1	2.7	14	29	17
4	22.55	1	3.0	29	72	50
5	22.45	1	2.5	13	22	12
5	30.05	1	2.9	26	67	32

4. Bandwidth

Use the same measuring setup as outlined in 3.

For the bandwith b of the RF amplifier (with a drop of 3 db at the band edges), the following nominal values apply:

Band	1	1	2	2	3	3	4	4	5	5
f in mc/s	1.45	3.45	3.35	7.55	7.45	15.05	14.95	22.55	22.45	30.05
b in kc/s	10.5	35	41	113	75	170	165	280	190	240

5. Aligning Instructions for the 1st IF Filter (1300 to 1400 kc/s)

(RF amplifier dismounted, soldering-lug strip at the rear connected to separate power supply unit or cableform)

(a) Dismount the 180-Ω resistor soldered in position instead of the filter for measuring the stage gain (II.D.3), and reconnect the filter. The grouping of the filter coils is shown in Fig. 13.

(b) Connect adapter A (capacitive voltage divider) to the IF output cable 2 to serve as filter termination.

(c) Apply a measuring oscillator signal of f = 1334 kc/s to jack 1 of the RF amplifier.

(d) Connect a high-impedance RF millivoltmeter to the anode of tube 3 via a capacitor of about 0.2 to 0.4 pf. The reading of this instrument is used as an alignment criterion.

(e) Short-circuit coil L2 (Type Rel 454 F 307a) (by connecting prong 3 to chassis, see top of Fig. 13).

(f) Align coil L1 (Type Rel 454 F 307a) for maximum deflection of the instrument.

(g) Cancel the short-circuit of coil L2 and short-circuit coil L1 (Type Rel 454 F 308a) (by connecting to chassis prong 1 in the 2nd filter section, see bottom of Fig. 13).

(h) Align coil L2 (Type Rel 454 F 307a) for minimum deflection of the instrument.

(i) Cancel the short-circuit of the coils L1 and L2 (Type Rel 454 F 308a) (by connecting prong 4 between C2 and C4 to chassis).

(k) Align coil L1 (Type Rel 454 F 308a) for maximum deflection.

(l) Cancel the short-circuit of coil L2 and short-circuit coil L3 (by connecting prong 5 between C4 and C6 to chassis).

(m) Align coil L2 for minimum deflection.

(n) Cancel the short-circuit of coil L3 and short-circuit coil L4 (by connecting prong 3 to chassis).

(o) Align coil L3 for maximum deflection.

(p) Cancel the short-circuit of L4.

(q) Align coil L4 for minimum deflection.
Tolerance values for the filter curve (Fig. 15):
At 1300 kc/s and 1400 kc/s, the attenuation must not exceed 1.5 db (measure at filter output via 0.2 pf).
Guiding value for the pass-band attenuation 6 db.

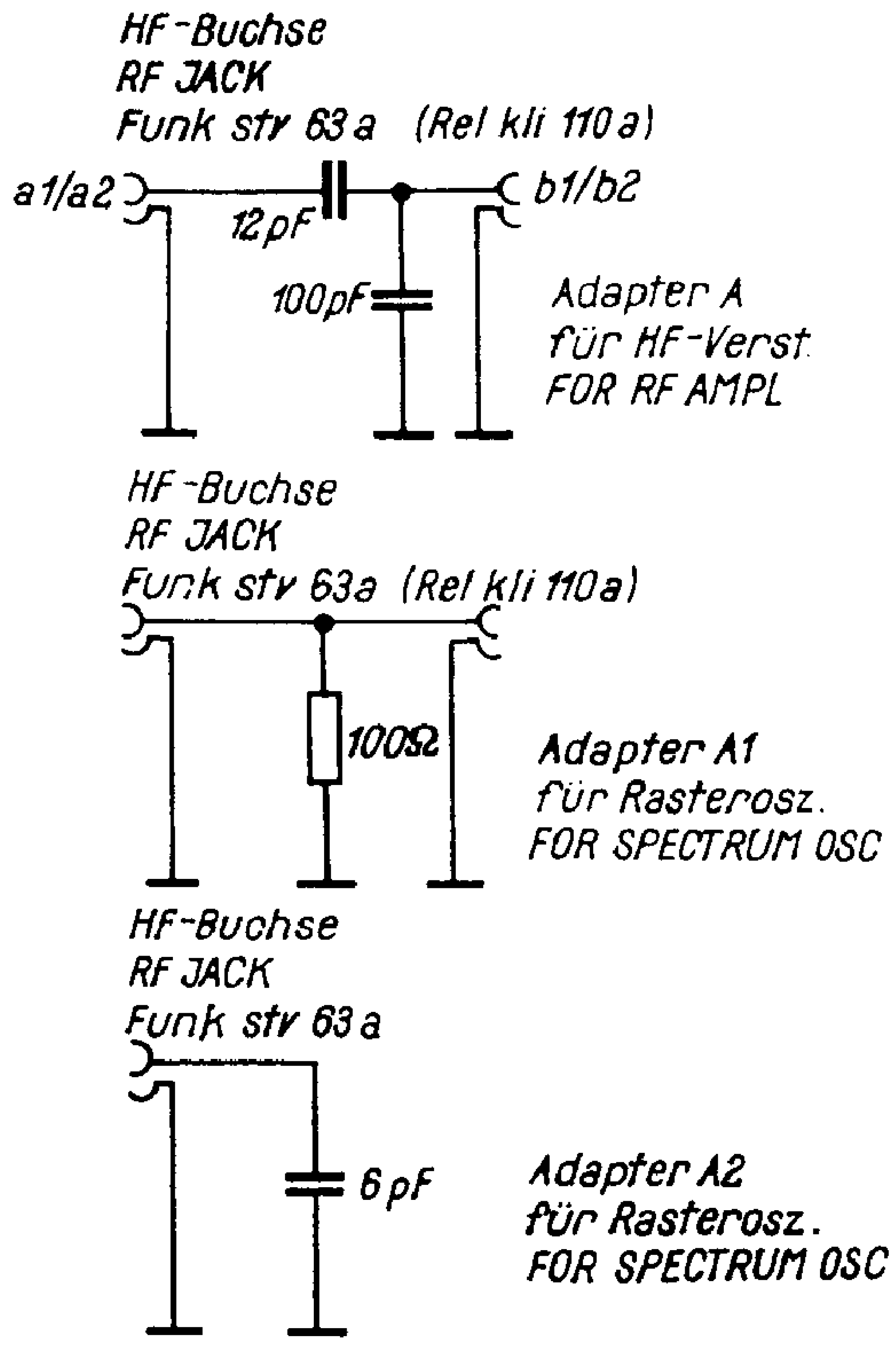


Bild 12 Adapter für HF-Verstärker und Rasteroszillator
Fig. 12 ADAPTER FOR RF AMPLIFIER AND SPECTRUM OSC

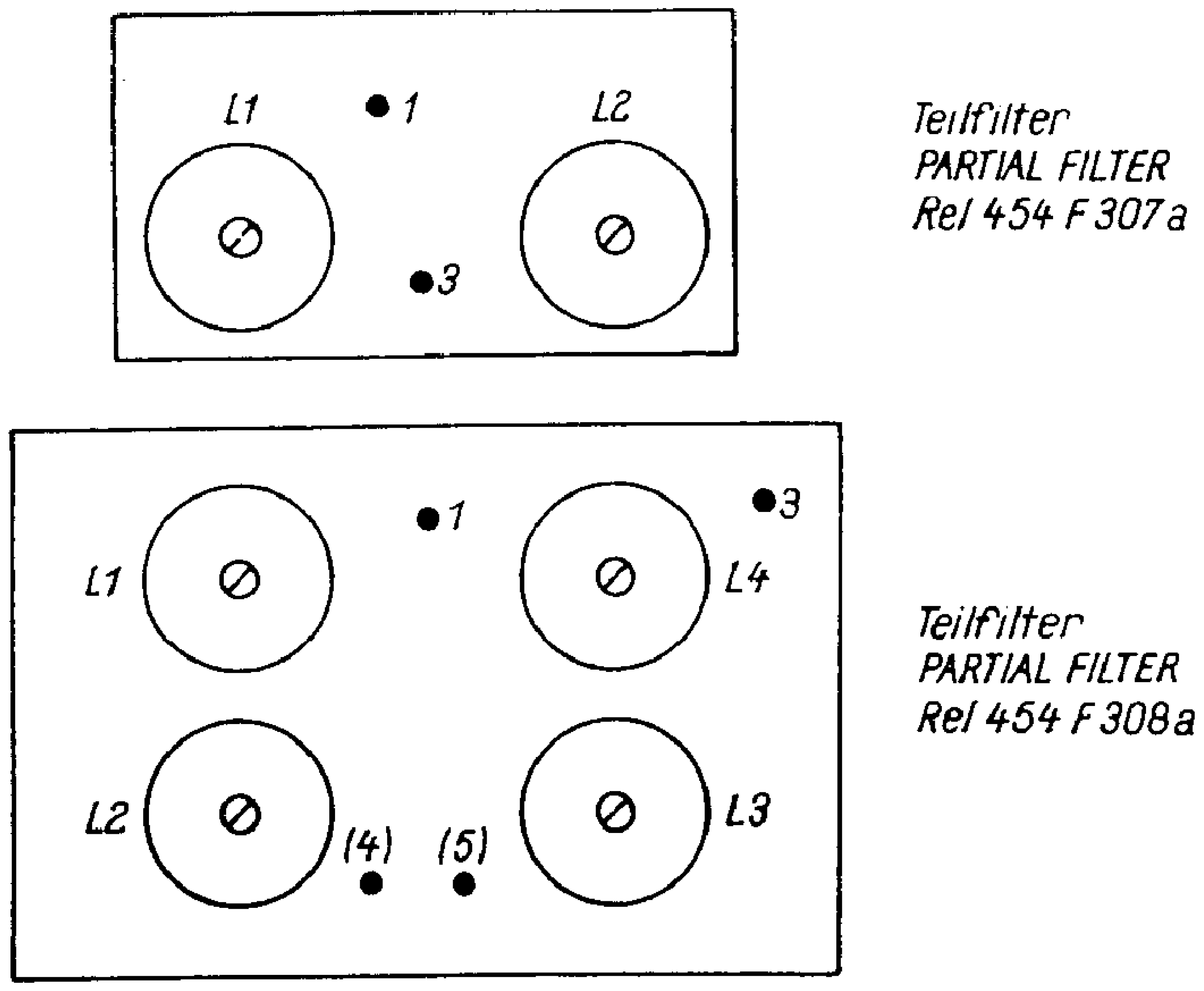


Bild 13 Anordnung der Spulen des 1. ZF-Filters an der Rückseite des HF-Verstärkers
Fig. 13 COIL ARRANGEMENT OF THE 1st IF FILTER ON THE REAR OF RF AMPL

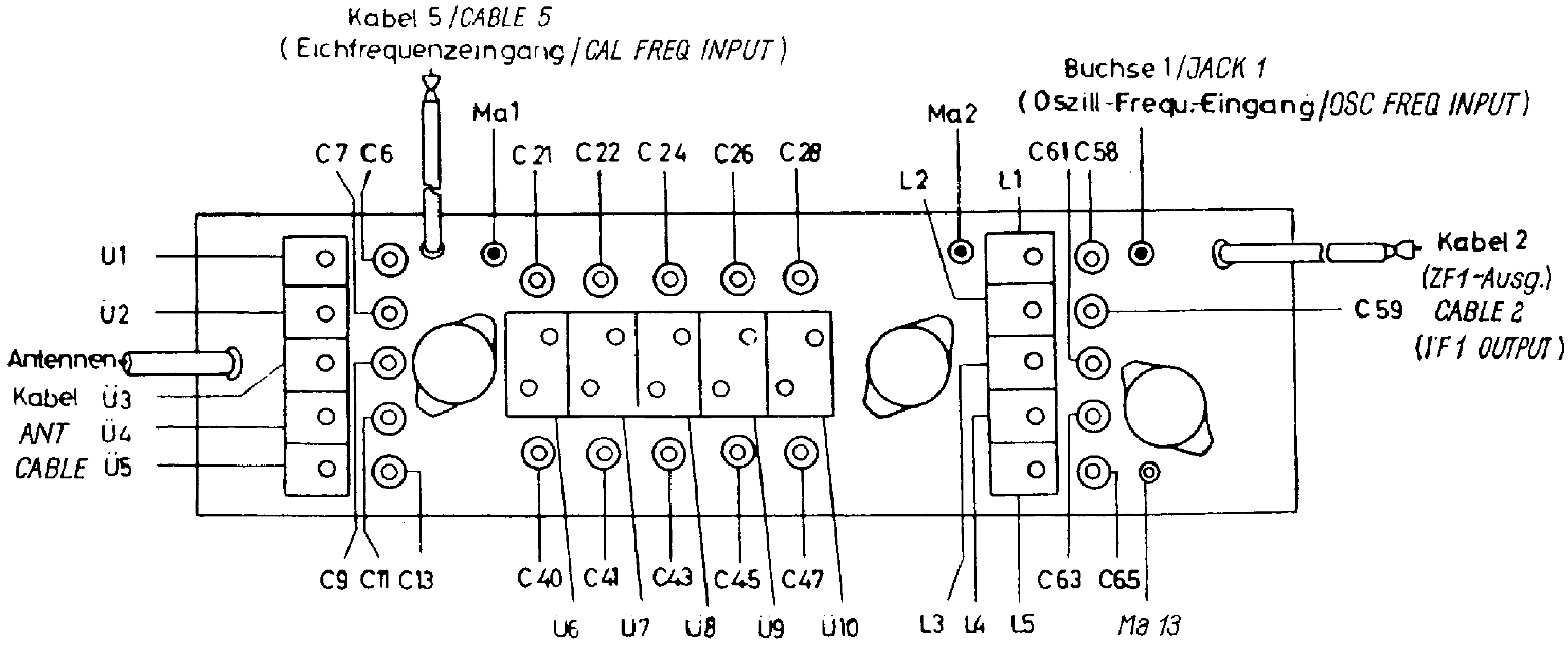


Bild 14 Abgleichstellen im HF-Verstärker
Fig. 14 ALIGNING POINTS IN THE RF AMPLIFIER

6. Aligning Instructions for the RF Circuits (in mounted condition)

Connect the IF cable 2 to the voltage divider adapter A (Fig. 12) and connect an RF millivoltmeter to its output.

Connect the measuring oscillator to the antenna jack. Set the RF tuning correction control to "0". The placement of the coils and trimmers is shown in Fig. 14.

Sequence to be Followed in the Preliminary Alignment (example for band 1)

(a) Set the coarse tuning control and the measuring oscillator to 1.45 mc/s.

(b) Align the coils Ü1 and L1 for maximum of the millivoltmeter.

(c) Detune the first circuit of Ü6 with 100 pf (across trimmer C21; be cautious, some trimmers are live with anode voltage) and align the second coil for maximum deflection.

(d) Detune the second circuit of Ü6 with 100 pf (across trimmer C40) and align the first coil for maximum deflection.

(e) Set the coarse tuning control and the measuring oscillator to 3.45 mc/s.

(f) Align the trimmers C6 and C58 for maximum deflection.

(g) Detune the first circuit of Ü6 with 100 pf across trimmer C21 and align the trimmer C40 for maximum deflection.

(h) Detune the second circuit of Ü6 with 100 pf across trimmer C40 and align the trimmer C21 for maximum deflection.

(i) As the procedures affect themselves mutually, the alignment must be repeated in this order until no further improvement is possible.

The circuits for the other bands are aligned in the same way. For the aligning frequencies see the following table:

Aligning Frequencies for the RF Amplifier

Band	Aligning Frequency mc/s	Maximum Voltage at:	Aligning Frequency mc/s	Maximum Voltage at:
1	1.45	Ü1, Ü6, L1	3.45	C6, C21, C40, C58
2	3.35	Ü2, Ü7, L2	7.55	C7, C22, C41, C59
3	7.45	Ü3, Ü8, L3	15.05	C9, C24, C43, C61
4	14.95	Ü4, Ü9, L4	22.55	C11, C26, C45, C63
5	22.45	Ü5, Ü10, L5	30.05	C13, C28, C47, C65

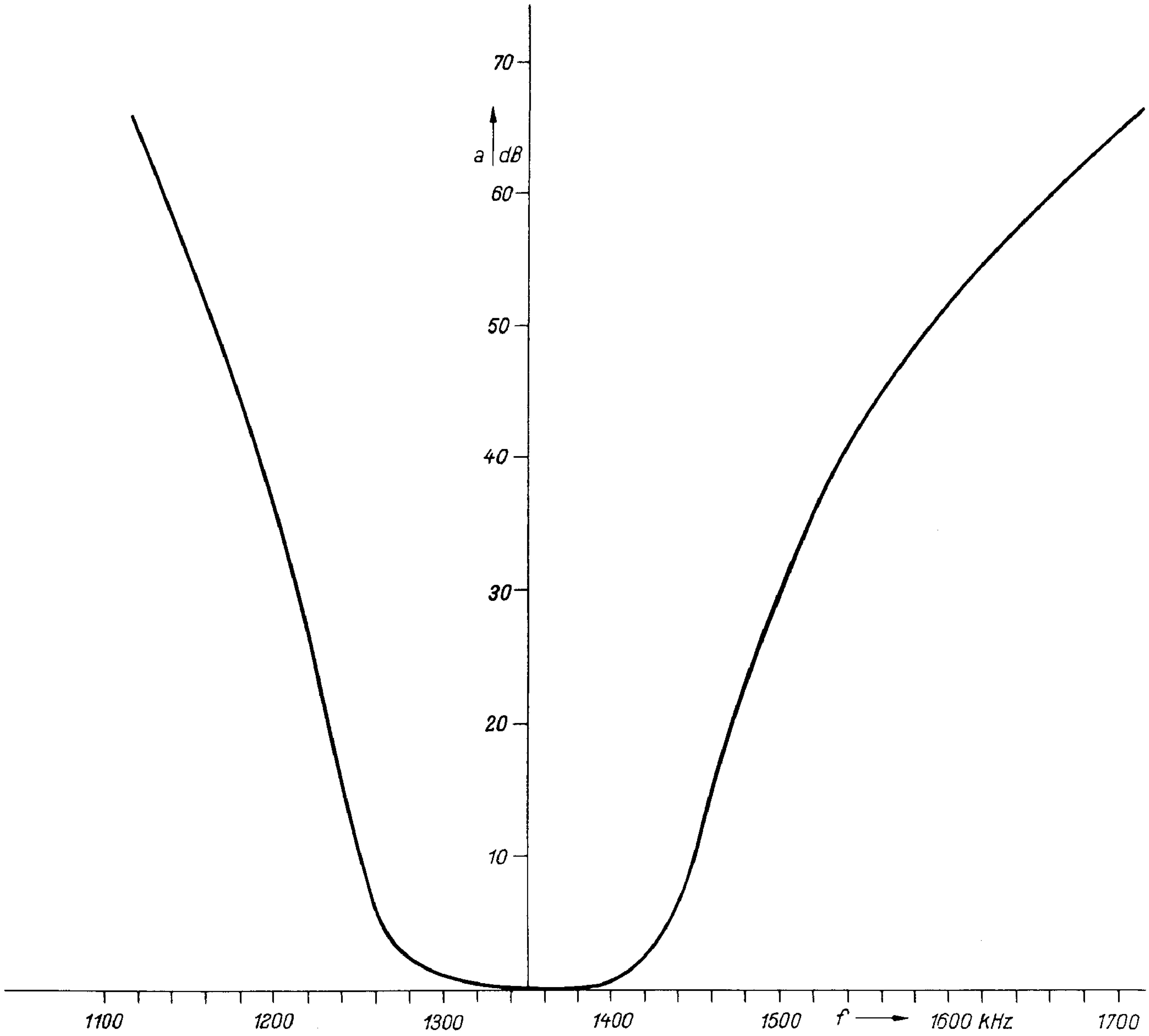


Bild 15 Durchlaßkurve des 1. ZF-Filters
Fig. 15 PASS-BAND CURVE OF 1st IF FILTER

E. Checking and Aligning the Spectrum Oscillator (Rel str 455 U 300a En)

Measuring Instruments

A-V-Ω Multizet meter
μA-Multizet meter
RF Multizet meter or RF millivoltmeter, measuring range 1 v
Frequency meter 2.85 to 31.55 mc/s or detector, setting error $\leqq \pm 1$ kc/s (e.g. a second receiver E 311 if alignment at top of band 5 is not necessary).
Adapter A1: Funk stv 63a, terminated into 100 Ω ±5%, in parallel to RF jack Rel kli 110a (Fig. 12)
Adapter A2: Funk stv 63a, terminated into 6 pf (Fig. 12)
Aligning tool B 63399-A2
Aligning tool Type Funk empf 138 Tz 48

1. Operational Voltages

In general the measurements at the terminals 11/I and 11/II of the incorporated spectrum oscillator will be sufficient. An A-V-Ω Multizet meter, in the voltage range 60 mv, should read 10 to 15 scale divisions at Ma 11/I (positive terminal connected to chassis). With relay H restored and cable 8 (gII) short-circuited, a value of 22 ±2 scale divisions should be measured (negative terminal connected to chassis).

2. Oscillator Voltage

(a) Connect adapter A1 to cable 7 and adapter A2 to cable 1.

(b) Connect an RF Multizet meter (measuring range 1 v) or an RF millivoltmeter to the output of adapter A1 and measure the voltages in all five frequency bands. The values should be between 0.4 and 0.65 v.

3. Fine Alignment of the Spectrum Oscillator

Minor irregular deviations between the 400-kc/s calibrating marks and the whistle points in calibration may occur after extended periods of time, e.g., due to aging. Compensation by means of the scale correction screw is not possible in such case. The remedy is to realign the respective coils and trimmers of the resonant circuits of the spectrum oscillator to the 400-kc/s marks of the scale, with the spectrum oscillator in mounted condition.

The coil and the trimmer of the oscillator circuit in operation at the time are accessible through openings in the front panel and corresponding openings in the gear wheel attached to the spectrum oscillator (Fig. 2). On older models the cover plate ahead of the front panel must be removed for this purpose (Fig. 3).

(a) Set the class-of-emission switch to CALIBRATION.

(b) The alignment must be made with the appropriate special tools (trimmers are live with anode voltage, danger of shock). At the lowermost calibrating mark of the frequency band in question the alignment is made with L, at the uppermost with C.

(c) Repeat these procedures several times until no greater change results any more.

(d) Now check the position of several 400-kc/s marks in between.

4. Preliminary Alignment of the Spectrum Oscillator

(a) The following procedure is only used in the case of major detuning of the oscillator circuits:
Connect adapter A1 to cable 7, and adapter A2 to cable 1.

(b) Connect to the output of adapter A1 a frequency meter or a detector covering the frequency range between 2.85 and 31.55 mc/s with an accuracy of ±1 kc/s.

(c) Set the coarse tuning to FREE (relay H energized).

(d) The alignment must be made with the appropriate special tools (hazard of shock). In each band set first the lower aligning frequency (see the following table) on the frequency meter and align the coil. Now carry out the C-alignment at the upper aligning frequency. Repeat these procedures several times until the aligning frequencies are achieved with an accuracy of about ±1 kc/s.

Band	Alignment Point	Lower Aligning Frequency in mc/s	Alignment Point	Upper Alignment Frequency in mc/s
1	L1	2.85	C1	4.85
2	L2	4.75	C5	8.95
3	L3	8.85	C9	16.45
4	L4	16.35	C13	23.95
5	L5	23.85	C17	31.55

(e) Finally carry out the fine alignment as outlined under G3.

F. Checking and Aligning the Spectrum Unit (Rel str 455 N 300a En)

Measuring Instruments

A-V-Ω Multizet meter
µA-Multizet meter
RF Multizet meter or RF tube voltmeter, measuring range 1 v.

1. Operational Voltages

For measuring the electrode voltages by reference to the table FAULT LOCATING II.C, withdraw the subassembly, open it and connect it via adapter cables to the respective clip contact strip in the slide-in chassis after removing the coaxial cables and loosening the four fastening screws (see Fig. 1). In many cases a tube check at the measuring terminals will be sufficient.

2. Relay K and Thermostat Relay

Measure the current flowing from the base contact 7 of the crystal oven to chassis with an A-V-Ω Multizet meter, measuring range 15 ma AC, immediately after energization of the unit. It must not exceed 13 ma. When the oven has warmed up (after about five to ten minutes) the thermostat relay short-circuits the instrument.

3. Lock-in Ranges and Lock-in Indication

In all frequency bands the lock-in ranges should be distributed about symmetrically about the respective 100-kc/s mark. (On the upper frequency bands an overlapping of the lock-in ranges may occur).

The symmetry is affected by potentiometer R9 in the crystal spectrum section. In general, it must be adjusted so that the lock-in ranges are symmetrical at about 23 mc/s (frequency band 5). Readjustment of this potentiometer can become necessary especially after the replacement of tube 13.

During the searching process, the lock-in lamp should flash at the rate of about 0.5 to 2 seconds.

4. Aligning the Coil L2

The coil L2 in the 100-kc/s wave trap (Type Rel 455 F 305a) is only accessible after removal of the cover cap, i.e. when the spectrum oscillator has been withdrawn. It must be aligned so that the RF voltage across the resistor R5 becomes a minimum (less than 0.25 v as measured with an

RF Multizet meter, range 1 v). The lock-in lamp must light. For this measurement the coil turret in the spectrum oscillator must be between two lock-in points to prevent the oscillator from oscillating.

5. Checking and Aligning the 100-kc/s Crystal

The steps required for this purpose have been outlined in the "Notes on Maintenance".

G. Checking and Aligning the Interpolation Oscillator (Rel str 454 U 302a or b En)

Measuring Instruments

A-V-Ω Multizet meter
RF Multizet meter or RF tube voltmeter, measuring range 10 v.

1. Operational Voltages

In general the measurements at the terminals Ma15/I and Ma15/II on the incorporated interpolation oscillator will be sufficient. In the measuring range 60 mv an A-V-Ω Multizet meter should indicate about 10 scale divisions between these points.

2. Oscillating Voltage of the Interpolation Oscillator

The oscillator voltage at cable 4 should be between 4 and 6 volts (as measured with an RF Multizet meter, voltage range 10 v AC) throughout the range 930 to 1030 kc/s.

3. Thermostatic Oven

(a) Insert the A-V-Ω Multizet meter (measuring range 1.5 amps AC) in circuit ahead of the soldering lug a4 or a5. The oven heater current should be 830 ma ±10%.

(b) At an ambient temperature of 20°C with quiescent air and with the oven closed, the current must not become zero before about 15 to 20 minutes. The green low-temperature indicating lamp must go out after about 20 to 25 minutes.

(c) For checking the high-temperature indication, connect the soldering pin a3 to chassis (only for this measurement). After about 25 minutes the red lamp must light up. Interrupt the chassis connection immediately after that.

4. Aligning the Interpolation Oscillator

The steps required for this purpose have been outlined in the NOTES ON MAINTENANCE.

III. TEST CIRCUIT DIAGRAM

The use of the test circuit diagram in connection with the individual circuit diagrams is often advisable when locating faults or carrying out repair work.

This circuit diagram, covering the whole receiver, also contains all resistance and capacitance values and the principal DC voltage values as measured with an µA-Multizet meter.

DC voltages that must be measured under specific operating conditions have not been entered. Like the signal voltage values for gain measurements listed in section II of the FAULT ELIMINATING part, they are stated in connection with the test data for the respective subassemblies.

The test circuit diagram is subdivided into three sheets, which can be easily joined.