

4. Circuit Description

(see circuit diagrams 41314 S Bl.1, Bl.2, Bl.3, 413141 S and level diagram).

4.1 Oscillator and Frequency Modulator (circuit diagram 41314 S Bl.1 and Fig. 4-7)

Two stators are electrodeposited on the ceramic segments of printed-circuit design which form the oscillators and frequency modulators BN 41314-2 (Fig. 4-7). All stators are tuned by a common rotor. Each segment consists of a complete oscillator with a frequency modulator. The outputs of all oscillators are combined via a star-connected resistance network (R801 to R806). The oscillator in use is fed with the DC voltage cut in via the associated switch (S16 to S22). The rotor is capacitively earthed via the ganged cylindrical capacitor C835. Electronic tuning and switching of the oscillators and optimum design of each individual oscillator are thus possible. The varactors G1360 to G1410 provide the frequency modulation. Frequency-dependent coupling of the varactors via the second stator coating C835I to C835XII of the oscillator enables a constant deviation independent of the frequency. Suitable stator coating in each frequency range ensures linear frequency variation and constant deviation. The varactors are fed via the feed-through capacitors C800 to C805 with the DC and AC voltages required for frequency modulation and synchronization with the Frequenzkontroller 100.4542.

4.2 FM Chokes (circuit diagram 41314 S Bl.1 and Fig. 4-1)

The modulation voltage is fed to the parallel-connected diodes G1360 to G1410 via the FM chokes 41311-2.95, 41311-2.96, 41311-2.97 and the emitter follower T42. The temperature coefficient of transistor T42 compensates for that of the varactors. The transistor is therefore located in the same cast housing as the oscillators.

4.3 Deviation Network (circuit diagram 41314 S Bl.1 and Fig. 4-5)

The circuit board of the deviation network 41314-2.100.25 also carries the switches I to VII for the selection of the appropriate oscillator and the transistors T47 and T48 forming a temperature-compensated amplifier. The SYNCHRONIZATION input Bu6 permits the synchronization voltage from the Frequenzkontroller. The control voltage is weighted according to the frequency range by the voltage divider R491 to R497 and R484 to R490 in order to keep the loop gain constant with range-dependent division ratios in the case of synchronization. Consequently, the sweep width also differs in the different ranges. The other input of the amplifier is controlled by the frequency modulation voltage of the modulation unit 413141. By connection of the corresponding voltage dividers R459 to R464 and R466 to R471, the modulation voltage has the same frequency deviation in all ranges.

4.4 Buffer (circuit diagram 41314 S Bl.2 and Fig. 4-1)

The buffer 41311-5.10 is composed of two stages. It reduces shifts of the oscillator frequency due to the AGC circuit and the amplitude modulator to a minimum. RC sections adequately flatten the amplitude/frequency response, like in many of the following stages.

4.5 AGC Circuit (circuit diagram 41313 S Bl.2 and Fig. 4-1)

The AGC circuit is combined with the buffer on circuit board 41311-5.10. The two parallel-connected PIN diodes G110 and G111 act as variable operating resistance of the transistor T3.

They are connected in parallel with the DC feed-in via R56, L30, the cathodes of the two diodes being connected to the collector of the transistor T3 via the disc capacitors C32 and C33 and the anodes directly to chassis. The AGC voltage is applied to the PIN diodes via T5, T6, L40, L50, R63 and R64. The Zener diodes G112 and G113 limit the transient response. The transistors T4 and T31 furnish the low-impedance reference level for T6 via R60.

4.6 Frequency Converter (circuit diagram 41314 S Bl.2)

The output frequency in range I is produced by frequency conversion; in the other ranges, the RF voltage is applied directly to the amplitude modulator and, in parallel via a buffer, to the second output.

4.7 Low-pass Filter Preceding the Mixer (circuit diagram 41314 S Bl.2 and Fig. 4-1)

The low-pass filter 41314-5.11/2 suppresses the harmonics of the oscillator so that together with the signal coming from the crystal oscillator an output frequency with low content of harmonics and non-harmonic spurious frequencies is produced. The two reed relays Rs1, Rs2 of the filter switch the mixer in the lowest frequency range.

4.8 Mixer (circuit diagram 41314 S Bl.2 and Fig. 4-1)

The mixer 41314-5.12 contains the diodes G180 and G181. Thanks to its balanced design, it suppresses a large part of the non-harmonic spurious waves. Maximum suppression of the crystal-oscillator voltage is adjusted with C89. In the frequency range 0.4 to 48 MHz, the mixer also serves as beat indicator at the output frequency "0" and is thus used for the calibration of the frequency scale. The amplifier T7 and T8 amplifies the beat voltage and the diodes G170 and G171 serve for rectification. The DC voltage is indicated on meter 29 (Fig. 2-1).

4.9 Low-pass Filter Following the Mixer (circuit diagram 41314 S Bl.2 and Fig. 4-1)

The low-pass filter 41314-5.14/2 suppresses harmonics and high-frequency non-harmonic spurious waves of the mixer. The filter contains a broadband amplifier (T50, T51), which adjusts the level of the mixer output voltage to that of the voltage driving the amplitude modulation stage in the other ranges directly without passing through the mixer. The two reed relays Rs3 and Rs4 switch the mixer in the lowest frequency range.

4.10 Crystal Stage (circuit diagram 41314 S Bl.2 and Figs. 4-3 and 4-4)

The crystal stage 41313-9.5 comprises the crystal-controlled oscillator (T43) and the tuned amplifier (T44). It is connected to the mixer with the solid-jacket cable K3. In the frequency ranges II to VII where the crystal stage is not used, it is disconnected by interruption of the operating voltage.

4.11 Second-output Amplifier (circuit diagram 41314 S Bl.2 and Fig. 4-1)

The amplifier for the second output is on the modulator circuit board 41314-5.15/2. It consists of transistor T10. A voltage independent of the output attenuator and having the

frequency adjusted on the SMDA is available at RF OUTPUT II at the rear of the set for the connection of the Frequenzkontroller. At RF OUTPUT II the externally applied voltage can also be measured (see section 3.2.4).

4.12 Modulator (circuit diagram 41314 S Bl.1 and Fig. 4-1)

The modulator 41314-5.15/2 operates with current distribution, the DC voltage produced in transistor T15 being impressed on the two modulation transistors T16 and T17 via R140. The RF energy amplified in transistor T11 is applied to the emitters of T16 and T17. It is according to the base control either taken to chassis via C141, C142, R151 or coupled out via C147. The signal is boosted by approximately 12 dB in transistors T18, T19. The AF voltage passes via cable K6, the AM filter and the transistor T9 to the differential amplifier T13, T14. It is pre-emphasized in the two diodes G150, G151 and controls the bases of the RF modulation transistors T16 and T17 in opposite phase. Furthermore, a feedback voltage corresponding to the VOR-ILS output voltage is applied to the collector of T9 via cable K5 and R149, which is derived from the rectified voltage of the AGC amplifier. This greatly reduces the AF modulation distortion.

4.13 Output Stage and Output Filter (circuit diagram 41314 S Bl.2, Fig. 4-1)

The output stage 41314-5.21/2 consists of two stages and delivers an output level of 0.5 V into 50 Ω . With the attenuator pad R210 the RF level can be adjusted within the amplifier chain such that the RF level at the collector of T11 is 60 to 70 mV and at the RF OUTPUT II 15 to 20 mV (at an attenuator position of approx. -20 dB), see also section 5.3.7. The output filters 41314-5.22 are switched for the different frequency ranges by the reed relay contacts of Rs5 to Rs14; they are designed as Cauer filters. The low-pass filters suppress harmonics in the output voltage. The resulting low distortion is important not only for the application of the SMDA but also for the correct rectification of the output voltage with G1260 (in the attenuator 41314-3). This ensures a flat frequency response of the AGC circuit and a constant feedback which effectively reduces the modulation distortion. By short-circuiting the sockets Bu14.4 and Bu14.5, the transistor T32 (on 41313-17.3) cuts off the operating voltage of the driver and of the output stage (carrier suppression). By short-circuiting the sockets Bu14.4 and Bu14.5, the transistor T32 (on 41313-17.3) cuts off the operating voltage of the output stage and the modulation generator (carrier suppression).

4.14 Attenuator (circuit diagram 41314 S Bl.2 and Figs. 4-1 and 4-2)

The attenuator 41314-3 has an exponential attenuation characteristic. It consists of potentiometer R260 whose resistance film is earthed at both broadsides by means of metallized strips. The wiper is moved by a spindle-controlled slider to which the pointer for level indication is fixed.

4.15 Overload Protector (circuit diagram 41311-7 S and Fig. 4-2)

The overload protector 41311-7 protects the output stage of the SMDA, the AGC amplifier and the attenuator from RF or DC voltages inadvertently fed to the RF OUTPUT 16. The overload protector interrupts the lead K9 between the output socket and the attenuator within a millisecond by means of the reed contact 1. The overload protector comprises a capacitive voltage divider C4, C5 whose output voltage is rectified by the temperature-

compensated diode G12 and then interrupts the current through the relay coil Rs1 via the amplifier T1 to T4. Thus the connection between the output socket and the attenuator is interrupted also when the SMDA is switched off (important for checking purposes). If DC voltages above about 1 V are applied to the output, the overload relay responds via R14, R9, G16 and G14. When the output is cut off, the multivibrator T7, T8 is put into operation. It controls the incandescent lamp, which blinks, via transistor T9 and cancels the effect of the positive feedback provided by T1, G15, G16, via transistor T5. As a result, the overload protector is connected through again when no RF or DC voltage is present. If RF power is fed to the RF OUTPUT 16, the pilot lamp lights or blinks.

4.16 AGC Amplifier (circuit diagram 41314 S Bl.2 and Fig. 4-1)

The AGC amplifier 41314-3.10.7 produces the rectified voltage for the automatic level control of the SMDA and the modulation feedback. G1260 in the attenuator 41314-3 serves as the rectifier diode; it is biased, for linearization of the characteristic and for temperature compensation, with the forward voltage at G1261 of the current through R274. The rectified voltage is amplified in the differential amplifier T261-II and DC coupled via R290, D15 to the AGC circuit 41311-5.10. The rectified voltage is derived at the emitters of the transistors T261-II and after multiplication by a factor of 10 in the high-impedance operational amplifier B1 is taken to the filters 41313-17.1 and 41313-17.2 by means of K18. It is then available at socket Bu14.1 for use in the VOR-ILS Unit as is the demodulated AF voltage in AM operation after having been multiplied by a factor of 10.

4.17 Modulation Unit (circuit diagrams 413141 S, 413141-5 S, 413141-6 S and 413141-7 S as well as Figs. 4-2 and 4-3)

The modulation unit consists of three printed circuit boards which are interconnected by means of plugs and sockets. On the basic circuit board the modulation voltage is processed. The other two circuit boards contain the modulation generator and the meter amplifier.

Modulation Voltage Processing (413141-5 S)

The desired type of modulation (phase, frequency or amplitude modulation) may be selected with the switches S100 or S200, respectively. The corresponding potentiometers R100 and R200 are used for adjusting the modulation index, frequency deviation or modulation depth. In the case of phase and frequency modulation, the AF signal passes via the FET T110 to the emitter follower B120. With frequency modulation, this signal is applied directly via the switch S200III to the frequency deviation network of the basic unit, to the maximum frequency deviation indication and to the meter amplifier. With phase modulation, the frequency-dependent voltage divider C130, L130, R130 and the amplifier B130 are interconnected. To minimize the noise voltage at the output of B130, the gain must be kept low which calls for an RC section with a low limit frequency and, consequently, low voltage attenuation. Since this RC section does not, however, supply a linearly increasing AF voltage, the inductance L130 has been provided for compensation.

When measuring the frequency deviation with the Frequenzkontroller, a positive voltage is applied to the base of the transistors T153 and T113 via Bu1.11. This cuts off the FET T110 whereas T111 becomes conductive via T112. In this way, any AF voltage which may effect the frequency deviation measurement is safely switched off. Moreover, transistor T152 is made conductive. As a result, a negative voltage tapped from the voltage divider R150, R151 and R152 is applied to the frequency deviation network of the basic unit a low impedance via the transistors T150 and T151 and Bu1.8 and Bu1.14 so that the oscillator is

about 110 kHz off-tune. With amplitude modulation, the AF voltage passes from the potentiometer R200 via R202 and Bu1.2 to the amplitude modulator. The rectified voltage supplied by the AGC diode G1260 in the attenuator 41314-3 is used for the indication of the AM. The two Zener diodes G1201 and G1202 protect the AM modulator against overvoltage in the case of external modulation.

Modulation Generator (413141-6 S)

The modulation generator is an RC oscillator. The 12 fixed frequencies are tapped from the resistor chain R101 to R111 and R121 to R131 of the Wien bridge by means of switch S1. To make the generator frequencies as independent of temperature as possible metal-film resistors have been used whereas the corresponding bridge capacitances are provided by mica capacitors. The fine tuning of the generator frequency is accomplished with the twin potentiometer R1 in 413141 S. The thermistor R12 which is connected into the feedback path of the generator keeps the amplitude constant. Since, however, this amplitude is temperature-dependent on account of the thermistor, the amplifier B2 is connected in series whose gain, in turn, is temperature-dependent through the thermistor R22, compensating for the amplitude temperature response. The connection from R11 to chassis is established via the type-of-modulation selectors (S100 and S200 in 413141-5 S). If both switches are in the position EXT., this connection is separated and the modulation generator stops operating. After amplification in B2, the modulation generator voltage is applied to the circuit board for modulation voltage processing. An emitter follower (T1) is connected in series to the generator output (Bu1 in 413141 S), whose output voltage can be adjusted with the potentiometer R26 (knob 7).

Meter Amplifier (413141-7 S)

On the meter panel the indication mode switch S1 is located, which in position MOD. GEN. switches off the charging capacitor (average-responsive rectification). These switch is followed by a precision voltage divider R10 to R14 from which a voltage is tapped by means of switch S2 according to the selected indicating range and applied to the amplifier B1. The rectification is effected by the diode G12 which is connected to the output of the high-speed operational amplifier B2. Since the feedback voltage is tapped after the diode, a completely linear rectification is ensured, the bend of the diode characteristic being less by the amplification factor ($> 10,000$). The voltage passes via the series resistor R33 and the type-of-indication selector S1111 through one of the trimmers R34, R35, R36 or R37, depending on the position of the type-of-indication selector, to the panel meter J1 in 413141 S. In order to achieve a small error of rectification even with frequencies of 30 Hz, the charging capacitor had to be selected such that the pointer of the meter would stabilize only after approx. 10 sec. To avoid this, a discharge circuit consisting of G13, R31, C33 and T1 has been incorporated which after a delay of $t \approx 40$ msec ($t > T_{30\text{Hz}}$) ensures a rapid discharge. The discharge time is considerably less than the response time of the panel meter.

4.18 Power Supply (circuit diagram 41314 S Bl.3 and Figs. 4-4 and 4-6)

The power supply consists of the circuit board 41311-4.5 comprising the transformer and the capacitors and of the circuit boards 41311-4.7 and 41314-4.9. The regulators of the "+" and "-" power supplies and the temperature-compensated reference Zener diodes are located on the lower circuit board 41311-4.7 because of the negligible heat development. The series transistors T57, T59 with the drivers T58, T60 and rectifiers G1570, G1590, which develop appreciable heat, are located on the upper circuit board 41314-4.9. The power supply is designed for extremely low hum voltages, high stability and small temperature effect.

4.19 Mechanical Construction

4.19.1 Removing the Operating Controls

Designation	Ref. No. in Fig. 2-1	Remarks
Coarse tuning drive	24	Hex socket-head screw SW 2
Fine tuning drive	23	Remove knob of coarse drive. Loosen the grub screw in the flange of the knob (parallel to the shaft). Remove knob by turning it anticlockwise
RF output attenuator	12, 13	Hex socket-head screw SW 2

Table 4 Removing the Operating controls

4.19.2 Withdrawing the Modulation Unit (Fig. 4.2)

After pulling out the cable plug St1 and loosening the four Phillips-type screws in the corners of the front panel of the modulation unit, the latter may be withdrawn from the SM DA.

4.19.3 Opening the Oscillator and Replacing the Oscillator Segments (Figs. 4-2, 4-3, 4-7 and 4-8)

Withdraw the signal generator from the cabinet as described in section 3.3.2. Remove the cover of the oscillator after loosening 12 screws (M 3 x 6 DIN 84). Find the location of the segment to be replaced according to the following drawing:

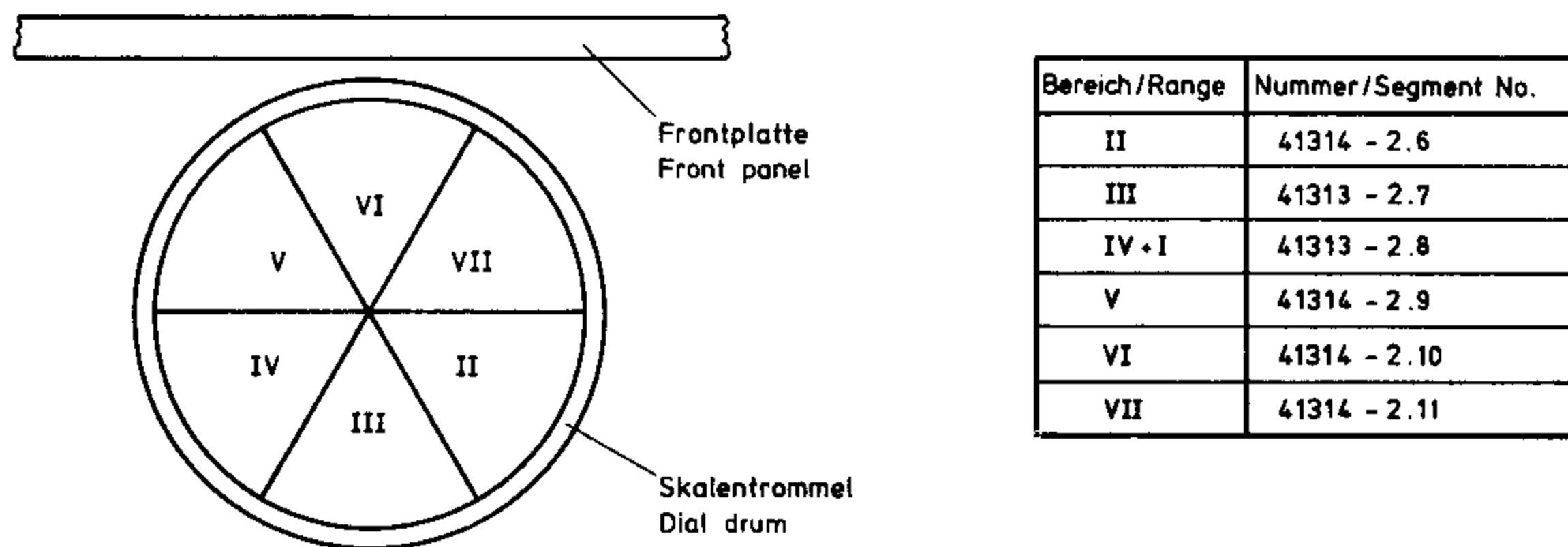


Fig. 4-8 Location of the segments

Remove the segment concerned by proceeding as follows: Adjust the tuning knobs so that the segment concerned is not covered by the rotor plate of the variable capacitor. Disconnect or unsolder the leads of the -18-V operating voltage, of the deviation voltage and of the RF output in range II. Loosen five screws (M 2 x 6 and M 2 x 8 DIN 84); take care that the washers do not drop into the oscillator. The oscillator segment can now be taken out. Remove also the guide sleeves from the segment. Inserting the new oscillator segment: Put both guide sleeves into the inner mounting holes of the segment. Before inserting the segment, its contact faces must be cleaned with trichlorethylene.

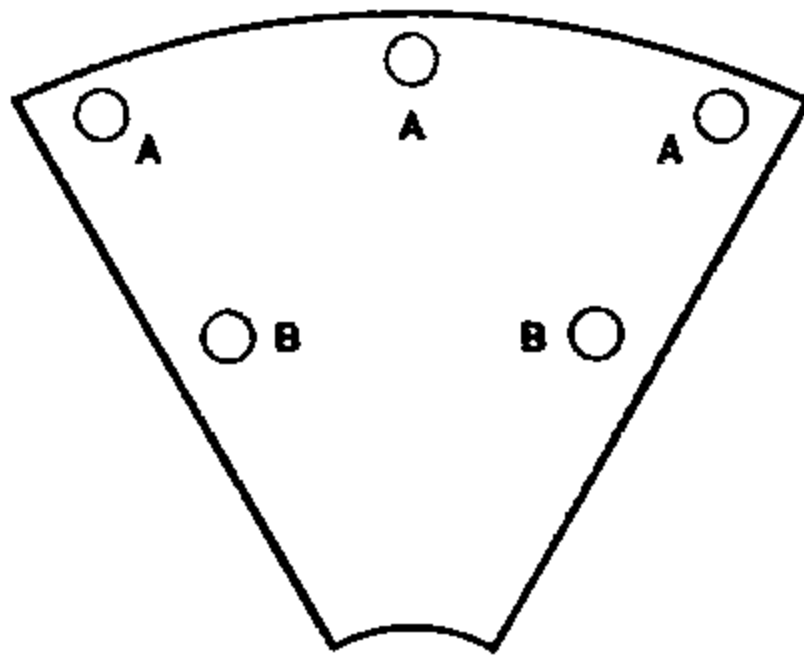


Fig. 4-9 Location of the Mounting holes

- A) Mounting holes
- B) Mounting holes with guide sleeves

Insert the oscillator segment in such a way that the two guide sleeves engage in the respective slots. To fix and connect the segment proceed in the reverse order as for withdrawing. Next adjust the corresponding oscillator range (see section 5.4.2). Before reassembling, clean the contact faces of the cover and of the case with trichlorethylene. Then place the cover on the oscillator. Make sure that the adjustment holes are in the proper position. The signal generator can now be put back into its cabinet. Check the performance in the range concerned according to section 5.3.2.

4.19.4 Withdrawing the RF Attenuator and the AGC Amplifier (Fig. 4-2)

Withdraw the signal generator from its cabinet as described in section 3.3.2. Remove the knob of the RF attenuator (see section 4.19.1). Disconnect or unsolder the leads K2, K5, K8, K9, K18 (in 41314 S Bl.2) and the +18-V and -18-V leads (in 41314 S Bl.3). Loosen retaining screws (2 accessible from the top, 2 from the bottom) and remove the attenuator from below. For replacing, proceed in the reverse order. Check the mechanical functioning (pointer movement) and the electrical performance of the attenuator according to section 5.3.12 and that of the AGC amplifier according to 5.3.13.

4.19.5 Withdrawing the Overload Protector (Fig. 4-2)

Withdraw the signal generator from its cabinet as described in section 3.3.2. Pull the modulation unit out as described in section 4.19.2. Disconnect or unsolder the leads K9, K10 (in 41314 Bl.2), the +18-V and -18-V leads and the lead of the incandescent lamp (in 41314 S Bl.3) Loosen the retaining screws and remove the overload protector from above. For replacing, proceed in the reverse order.

4.19.6 Withdrawing the Power Supply

Withdrawing the Stabilizing Circuits (Fig. 4-6)

Withdraw the signal generator from its cabinet as described in section 3.3.2. Both plug-in stabilizing circuits can be pulled out of the multipoint connectors after loosening the respective screws on the frame. For the electrical check, see section 5.3.1.

Withdrawing the Power Supply Frame and the Cable Harness (Fig. 4-4): Unsolder five AC voltage leads, four DC voltage leads (Bu8, Bu9, Bu10, Bu11 battery operation) and three operating-voltage leads. Loosen four screws on the frame. Push the power supply frame and cable harness back and pull out from above (Fig. 4-4). For replacing, proceed in the reverse order. Electrical check according to section 5.3.1.

4.19.7 Withdrawing the Crystal Stage (Fig. 4-3, 4-4)

Withdraw the signal generator from its cabinet as described in section 3.3.2. Remove the cover of the oscillator (6 screws); then the rear side of the circuit board is accessible for measurements. Disconnect the coaxial cable (K3) from the crystal stage and unsolder the operating-voltage lead. The oscillator can be withdrawn after loosening the 3 screws on the frame. For replacing, proceed in the reverse order.

4.19.8 Withdrawing the FM Chokes (Fig. 4-1)

Withdraw the signal generator from its cabinet as described in section 3.3.2 and the amplifier according to section 4.19.10. Remove both covers. Find the location of the sub-assembly to be exchanged according to Fig. 4-1. Unsolder the connections of the subassembly concerned and remove the subassembly (in the case of 41311-2.95, remove the partition also). For replacing, proceed in the reverse order. Electrical check according to 5.3.3.

4.19.9 Withdrawing the Pushbutton Assembly and the Deviation Network (Fig. 4-5)

Withdraw the signal generator from its cabinet as described in section 3.3.2. Unsolder the leads of the cable harness. Loosen the three retaining screws. Swing the pushbutton assembly with the panel out of the frame and pull out.

4.19.10 Withdrawing the Amplifier (Fig. 4-1)

Withdraw the signal generator from its cabinet as described in section 3.3.2. Unsolder the cable harness at the 6-pole soldering lug strip, disconnect cables K1 to K10, unsolder the +18-V and -18-V operating-voltage leads of the overload protector and loosen the screws on the frame. Remove the chassis from above. For replacing, proceed in the reverse order. Electrical check according to sections 5.2 and 5.3.

All these subassemblies are located on the same chassis and are accessible from below.

4.19.11 Withdrawing the Buffer, AGC Circuit, Mixer, Modulator, Output Stage (Fig. 4-1)

Withdraw the signal generator from its cabinet as described in section 3.3.2 and put the set upside down. Remove the two covers (17 and 14 screws, respectively). The location of the subassemblies to be exchanged can be found by referring to Fig. 4-10. Unsolder the leads of the subassembly concerned. Loosen the screws and take the subassembly out. For replacing, proceed in the reverse order. Electrical check according to sections 5.2 and 5.3.

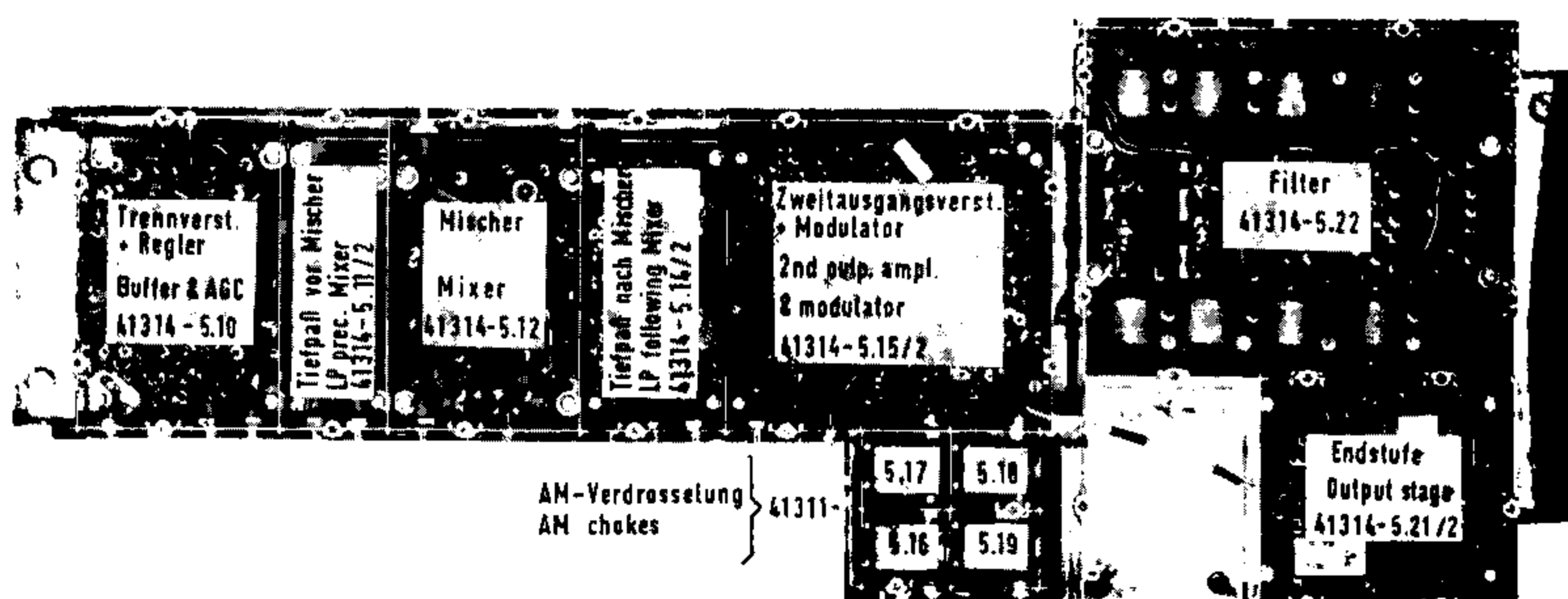


Fig. 4-10 Location of circuit boards on the chassis