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Instruction Book

DECADE EXCITER

0.1 – 30 MHz

Type NO 262

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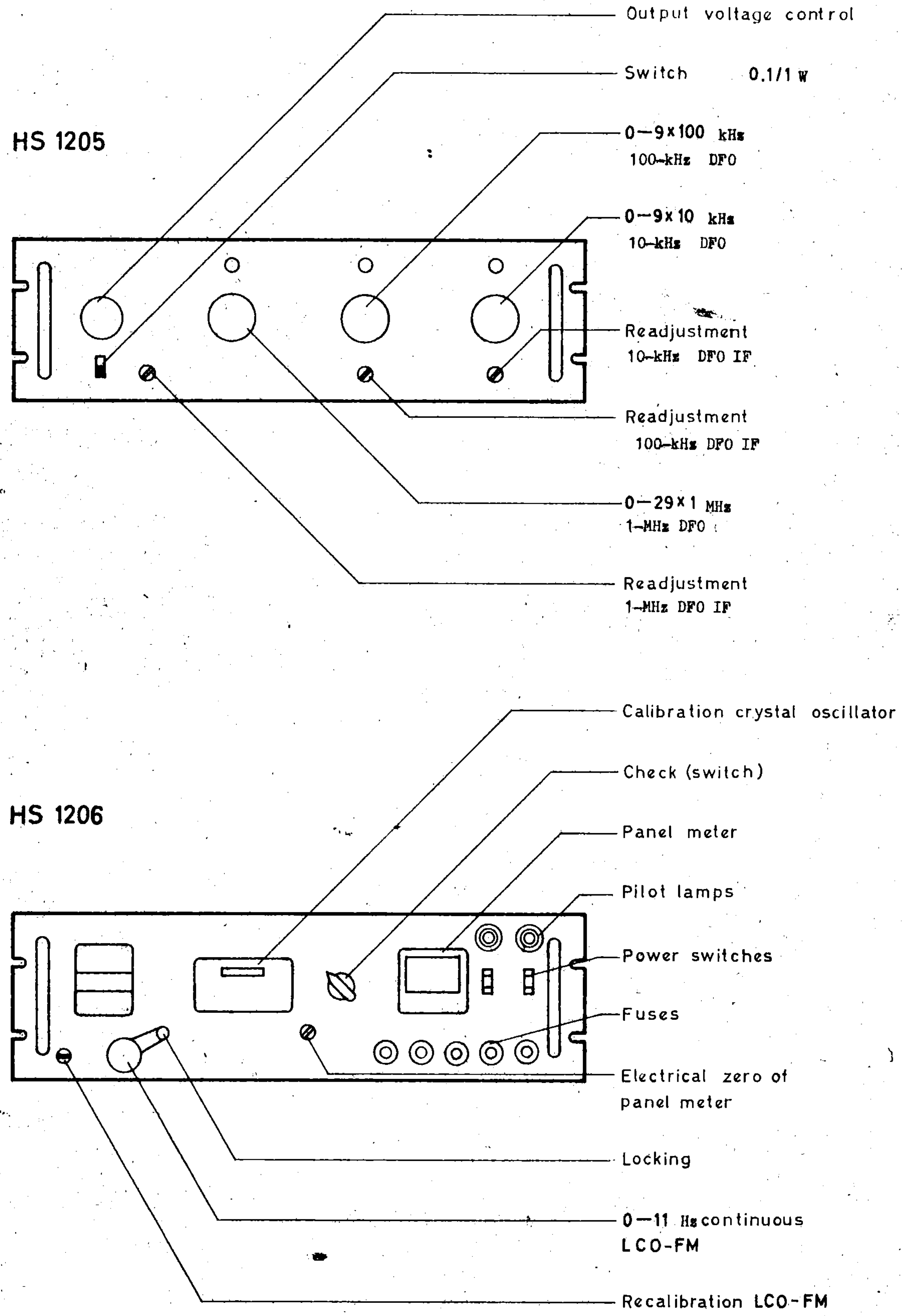

Fig. 1 Front view of the Decade Exciter
Type NO 262

1. Specifications

1.1	Frequency range	0.1 to 30 MHz
1.1.1	Frequency setting	
	by means of DFO's in the decade steps	0 to 29 x 1 MHz 0 to 9 x 100 kHz 0 to 9 x 10 kHz
	continuous with LCO-FM over the range	0 to 11 kHz
	Scale calibration of the LCO-FM	for direct reading; 10 Hz/scale division; scale length approx. 1.4 m
1.1.2	Output frequency follows frequency setting	without delay
1.1.3	Accuracy of the output frequency	specified for:
	temperature range	+15 to +40°C
	AC supply voltage range	115/125/220/235 V ±5%
	AC supply frequency range . . .	47 to 63 Hz
1.1.3.1	For decade setting of the DFO's	
	Control of the DFO's either by built-in crystal oscillator or by external standard frequency . .	switchover facility built-in
	with internal control	in accordance with accuracy of built-in crystal oscillator
	Error after tuning against external frequency standard . .	$< 5 \times 10^{-8}$
	Frequency variations during 24 hours	$< 5 \times 10^{-8}$
	Mean frequency drift (aging) after 10 days of uninterrupted operation	
	within 1 day	$< 1 \times 10^{-8}$
	within 1 month	$< 2 \times 10^{-7}$
	within 1 year	$< 5 \times 10^{-7}$
	Warm-up period for an error of less than 10^{-6} at an ambient temperature of +15°C	< 2 hours
	with external control	in accordance with accuracy of external standard frequency
	Input for external standard frequency	unbalanced, coaxial, series BNC, Amphenol Type UG 291 B/U

	Voltage requirement	0.5 V sinusoidal across 60 Ω	
	S/N ratio requirement for external standard frequency	> 100 dB	
1.1.3.2	For continuous setting of the LCO-FM after 10 days of uninterrupted operation		
	Error after recalibration against crystal oscillator	< ±5 Hz	
	Frequency variations during 12 hours	< ±5 Hz	
	Total error within 12 hours after recalibration against crystal oscillator	< ±10 Hz	
1.2	Output for adjustable frequency	unbalanced, coaxial, series BNC, Amphenol Type UG 291 B/U	
1.2.1	Output power into 60 Ω switchable		
	for sinusoidal signal	100 mW	1 W
	for amplitude modulation corresponding to	6.9 V_{pp}	
	continuously adjustable (without deterioration of performance)	approx. -10 dB	approx. -10 dB
1.2.2	RF distortion factor	< 2%	< 10%
1.2.3	Non-linear distortion (measured with a standard two-tone signal applied to the information input; see 1.4), referred to one of the two signals	< 46 dB	
1.2.4	Level of any other spurious signal more than 15 kHz off the useful signal, referred to the useful signal	< -70 dB	< -70 dB
1.2.5	RMS S/N ratio, unweighted	> 55 dB	> 55 dB
1.2.6	RMS S/N ratio, weighted according to CCIR 1949 (30 Hz to 15 kHz)	> 65 dB	> 65 dB
1.2.7	Spurious FM deviation	< 0.5 Hz	< 0.5 Hz

1.3	Output of the built-in crystal oscillator	unbalanced, coaxial, series BNC, Amphenol Type UG 290 A/U
1.3.1	Frequency	100 kHz
1.3.2	Open-circuit voltage	approx. 1.0 V sinusoidal
	Source impedance	approx. 60 Ω
1.3.3	RF distortion factor	< 10%
1.3.4	S/N ratio	> 80 dB
1.4	Information input	unbalanced, coaxial, series BNC, Amphenol Type UG 291 B/U
	A frequency- or amplitude-modulated 300-kHz carrier may be applied to this input. Its modulation reappears at the output of the Decade Exciter.	
1.4.1	Centre frequency	300 kHz
1.4.2	Bandwidth	±6 kHz
1.4.3	Input level	180 mV_{pp}, max; corresponding to 63 mV_{rms} on a sine wave
1.4.4	Input impedance	approx. 500 kΩ shunted by 50 pF
1.4.5	Linear distortion	< 1.5 dB
1.4.6	Unit suitable for A3B modulation	R&S A3B Modulator Type NA 60
1.5	FM inputs	two unbalanced, coaxial, series BNC, Amphenol Type UG 291 B/U (disconnectible)
	A voltage causing a proportional deviation of the output frequency may be applied to each of these inputs.	

		Input FM-A	Input FM-B
1.5.1	Centre-frequency voltage (deviation = 0)	approx. +50 V	approx. +50 V
1.5.2	Deviation/voltage ratio	+200 Hz/+1 V	-200 Hz/+1 V
1.5.3	Max. frequency deviation	±750 Hz	∓750 Hz
1.5.4	Modulation frequency	0 to 1.5 kHz	0 to 1.5 kHz
1.5.5	Input impedance	approx. 500 kΩ	approx. 500 kΩ
1.5.6	Variation of the deviation/ voltage ratio with the output frequency	< 2%	< 2%
1.5.7	Unit suitable for F1, F6 modulation	R&S Keyer Type NA 61	

1.6	Subdivision of the equipment	
	Rack-mounting unit Type HS 1205	DFO 1 MHz DFO 100 kHz DFO 10 kHz
	Rack-mounting unit Type HS 1206	LCO-FM crystal oscillator frequency divider power supply 1 (standby) power supply 2
1.7	Power connection	connector at the rear, R&S Type FS 320
	AC supply voltage	115/125/220/235 V, selectable
	permissible fluctuations	±5%; ±10% during short periods
	AC supply frequency	47 to 63 Hz
	Power consumption	
	Power supply 1 (standby) . . . . . LCO-FM crystal oscillator frequency divider	max. 85 VA
	Power supply 1 + 2 (operation). . .	max. 270 VA
1.8	Dimensions	see Fig. 2
1.9	Steel cabinet suitable for accommodation of the two rack-mounting units with cabling	

1.9.1	Outputs and inputs	unbalanced, coaxial, R&S Type FMU 90100
1.9.2	Dimensions	see Fig. 3
1.10	Weight	
	Type NO 262	
	Rack-mounting unit Type HS 1205 . .	approx. 19 kg
	Rack-mounting unit Type HS 1206 . .	approx. 25 kg
	Patch cords	approx. 1 kg
	Type NO 262/1	
	combined in a steel cabinet	approx. 63 kg
1.11	Colour (if not agreed otherwise)	grey RAL 7001
	Panel engravings (if not agreed otherwise)	German + English
1.12	Accessories supplied	Power cord LK 333 Patch cord Alignment tool CZ 906 Valve lifter RöZ 1 Valve lifter RöZ 2
1.13	Order Number	
	Rack-mounting unit Type HS 1205 and rack-mounting unit Type HS 1206 with patch cords	NO 262
	Rack-mounting unit Type HS 1205 and rack-mounting unit Type HS 1206 with patch cords	NO 262/1
1.14	Method	frequency synthesis with triple-mix method

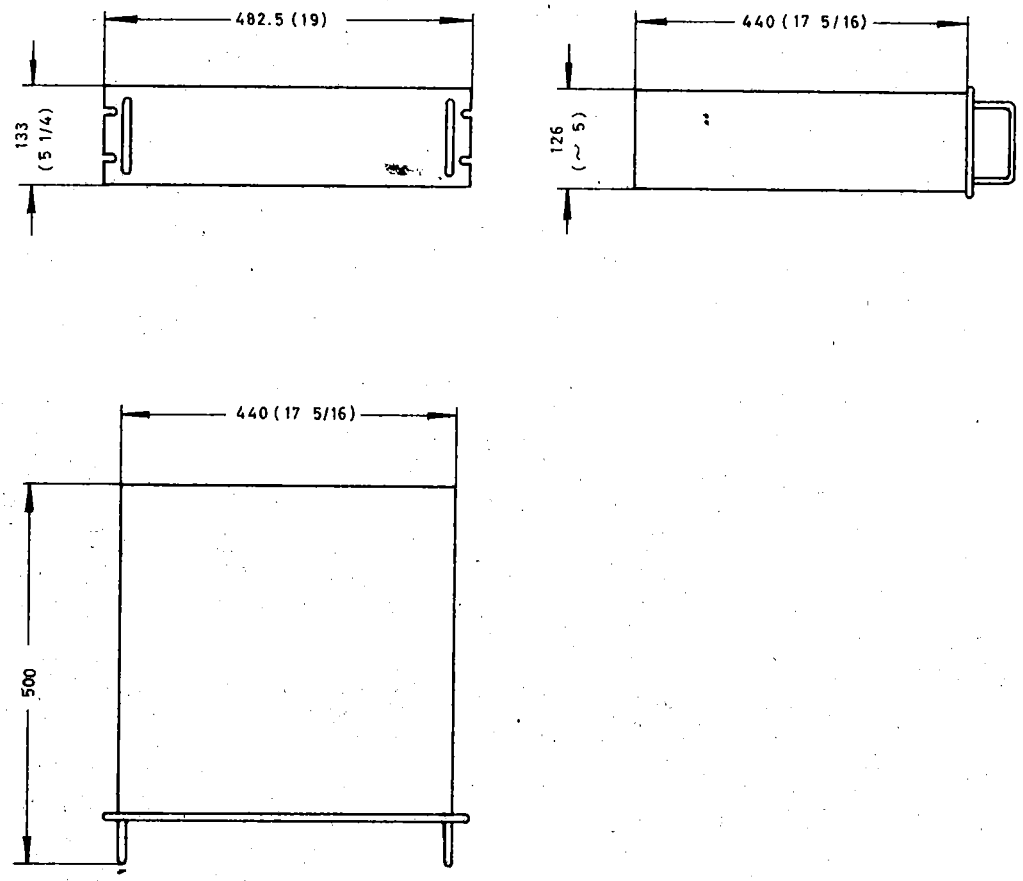

Fig. 2 Dimensions in mm (inch) of each rack-mounting unit

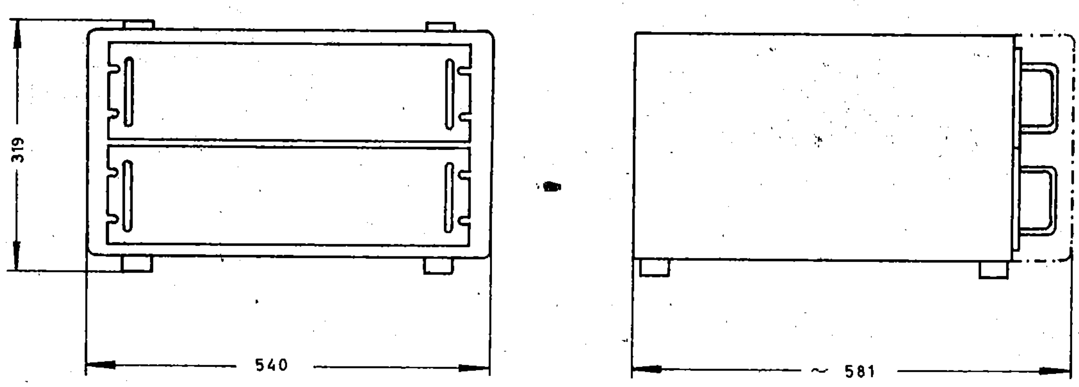

Fig. 3 Dimensions of the common cabinet, in mm

2. Operating Principle

The Decade Exciter Type NO 262 is a frequency-synthesizer type generator. Fundamental frequencies are derived from a frequency standard in decade steps. Harmonics of these fundamental frequencies are selected and mixed in decade frequency oscillators (DFO's). Their sum together with the frequency of a continuously variable oscillator determines the output frequency.

Hence, the output frequency combines two components: the component which is adjustable in decades and is of the accuracy of the frequency standard, and the component which is continuously variable with the accuracy of the free-running oscillator.

The overall accuracy of the Decade Exciter Type NO 262 in the range 0.1 to 30 MHz permits the unit to be used as the frequency-determining element of transmitters and receivers in radio communication.

To achieve the necessary accuracy below 10 MHz the first three decades and above 10 MHz the first four decades of the output frequency are derived from the frequency of a highly stable crystal oscillator (frequency standard), using three decade frequency oscillators, the 1-MHz DFO, 100-kHz DFO and 10-kHz DFO. These three DFO's form the heart of the Decade Exciter and are fundamentally of identical design. They operate on the frequency-synthesis method with triple mixing, described below in some detail.

2.1 Frequency Synthesis with Triple-mix Method

See Fig. 4.

A harmonic generator is used to produce a harmonic spectrum from the fundamental frequency f_0. The required harmonics are obtained with the aid of the bandpass filter BP1. Using a local oscillator, these harmonics are converted in the mixer M1 into the frequency range of the bandpass filter BP2. The selectivity of this bandpass filter permits only one of the converted harmonics to be passed through whereas all the others are attenuated to ensure the specified signal-to-noise ratio. The frequency of the local oscillator, f_1, determines which of the converted harmonics falls into the pass band of BP2.

The local oscillator which can be switched in steps of the fundamental frequency is the actual control element of the DFO. In the mixer M2, the frequency f_2 is mixed with the interpolation frequency f_i for frequency conversion into the pass band of the BP3. The variation of the interpolation frequency and the bandwidth of the BP3 are equal to the fundamental frequency and thus equal to the spacing between the harmonics.

The frequency f_3 is thus composed of the interpolation frequency and the harmonics converted with the aid of the local oscillator. In the third mixer M3 reconversion takes place again with the aid of the local oscillator so that the output frequency f_4 consists only of the selected harmonic of the fundamental frequency and of the interpolation frequency, i.e., the local oscillator serves only for the selection of the harmonic and does not affect the accuracy of the output frequency.

The three frequency conversions can be described by a simple system of linear equations:

Mixer M1: $f_2 = f_1 - n\,f_o$

M2: $f_3 = f_2 - f_i = (f_1 - n\,f_o) - f_i$

M3: $f_4 = f_1 - f_3 = f_1 - (f_1 - n\,f_o - f_i) = \underline{n\,f_o + f_i}$

As the above equations show, the local oscillator does not influence the accuracy of the output frequency, but rather its error limits are determined by the bandwidth of the bandpass filter BP2 only. A simple LC oscillator will thus be sufficient. Such DFO's are easy to build because all the bandpass filters are fixed-tuned.

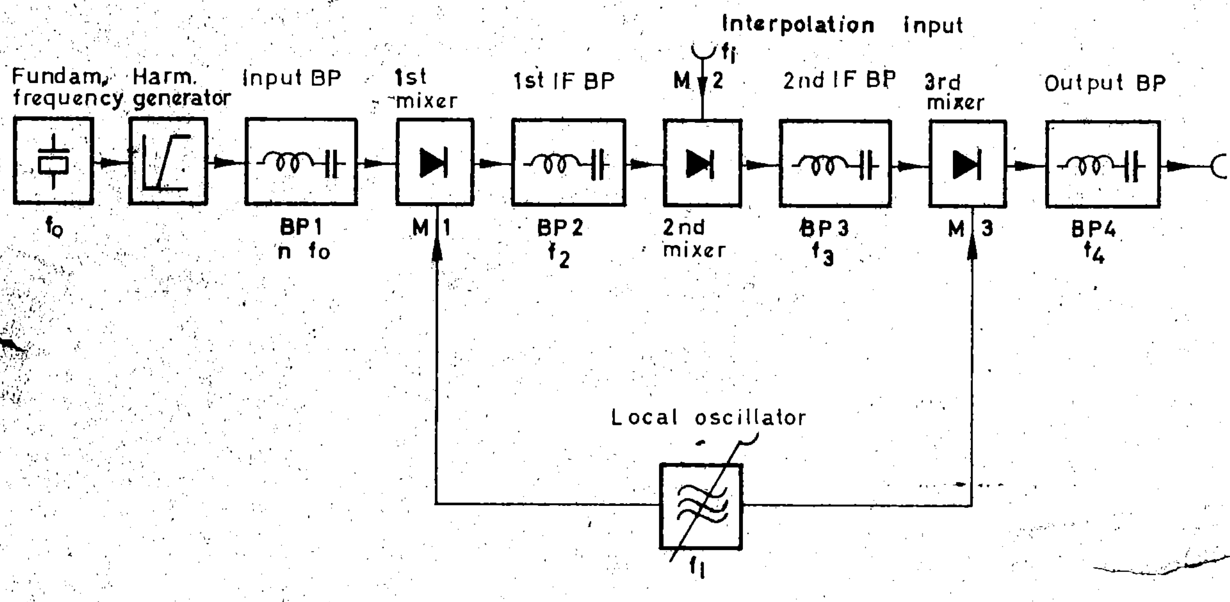

Fig. 4 Frequency synthesis with triple-mix system

2.2 Description

Reference is made to the block diagram of the Decade Exciter Type NO 262.

The Decade Exciter uses a decade system of fundamental frequencies, the output frequency of one decade being applied to the next higher decade as an interpolation frequency. Using the equations on page 13, the output frequency of the last decade can, therefore, be obtained in the following way:

DFO 10 kHz : $f_{40} = t\,f_{o1} + f_{LCO}$

DFO 100 kHz: $f_{500} = s\,f_{o2} + f_{40} - f_m = s\,f_{o2} + t\,f_{o1} + f_{LCO} - f_m$

DFO 1 MHz : $f_{4000} = r\,f_{o3} - f_{500} = r\,f_{o3} - s\,f_{o2} - t\,f_{o1} - f_{LCO} + f_m$

Furthermore, there is the decade relationship of the fundamental frequencies

$$f_{o1} = \frac{1}{100} f_{o3} \quad \text{and} \quad f_{o2} = \frac{1}{10} f_{o3}$$

and one obtains

$$f_{4000} = f_{o3} \left(r - \frac{s}{10} - \frac{t}{100}\right) - f_{LCO} + f_m$$

The fundamental frequency f_{o3} being the 1-MHz standard frequency produced by the crystal oscillator

$$f_{4000} = 1\ \text{MHz} \left(r - \frac{s}{10} - \frac{t}{100}\right) - f_{LCO} + f_m$$

f_{4000} = the output frequency of the Decade Exciter

r = the order of the selected harmonic in the 1-MHz DFO

s = the order of the selected harmonic in the 100-kHz DFO

t = the order of the selected harmonic in the 10-kHz DFO

f_m = the frequency applied to the information input

f_{LCO} = the output frequency of the LCO-FM.

The above result shows that the output frequency is composed of a decade component ($r - \frac{s}{10} - \frac{t}{100}$) and a continuously variable component (f_{LCO}) and that frequency changes at the information input (e.g. FM) affect the output frequency.

Basically, the three variable quantities r, s and t can be chosen at will. In practice, however, a number of points must be taken into consideration, such as the design of band-pass filters of sufficient selectivity and stability and the necessity to avoid annoying mixture products in the passband of the individual filters.

For the above reasons,

$r = 10$ to 39, $s = 84$ to 93, $t = 81$ to 90

was considered suitable for the Decade Exciter Type NO 262.

The switches of the individual local oscillators are not identified by the order numbers r, s and t. The output frequency corresponding to the switch inscriptions is available only after the difference $r - \frac{s}{10} - \frac{t}{100}$ has been obtained by frequency conversions.

The design of the Decade Exciter is illustrated in the block diagram which also clearly shows that it consists of three decade frequency oscillators:

a 10-kHz	DFO	with 10 positions of	(0 - 9)	x 10 kHz
a 100-kHz	DFO	with 10 positions of	(0 - 9)	x 100 kHz
a 1-MHz	DFO	with 30 positions of	(0 - 29)	x 1 MHz

The smallest decade step of 10 kHz is covered by the free-running LC oscillator.

The LCO-FM has a frequency range of 89 to 100 kHz. Its frequency is adjustable on a 1100-division scale calibrated from 0.00 to 11.00 kHz, that is, the coverage is 1 kHz more than a decade.

The LCO-FM is followed by the 10-kHz DFO which is basically designed according to the triple-mix arrangement shown in Fig. 4. The frequency regions are such that the disturbing products which occur in the mixers are suppressed by the bandpass filters until their level is below the value specified for spurious frequencies. The local oscillator is adjustable in 9 10-kHz steps with a switch bearing inscriptions from (0 - 9) x 10 kHz.

The output frequency of this decade is applied to the 100-kHz DFO as an interpolation frequency. In addition to the known components of the circuitry the decade contains a mixer laid out for an information with a centre frequency of 300 kHz. This information may be a 300-kHz carrier which is amplitude- or frequency-modulated and whose modulation is reproduced at the power output of the exciter. In unmodulated operation, a sinusoidal 300-kHz voltage derived from the frequency standard is applied to the input. The output signal of the 100-kHz DFO passes via a variable attenuator to the next decade. It is thus possible to adjust the output voltage of the entire exciter.

The output frequency of the exciter is produced in the last mixer of the 1-MHz DFO. Because of the wide range of the output frequency, the 1-MHz decade differs from the basic arrangement as follows:

a) The 1-MHz spectrum is limited by a low-pass filter since points of the spectrum below the utilized range, 10 to 39 MHz, do not give rise to spurious frequencies in the first mixer.

b) No spurious frequencies below the range of the output frequency, 0.1 to 30 MHz, are developed in the last mixer so that here also a low-pass filter characteristic is sufficient. It is achieved by an equalized wideband amplifier which produces the required output power.

The fundamental frequencies which must be applied to the three DFO's are taken from the built-in crystal oscillator. Its precision crystal is housed in an oven which eliminates the influence of the ambient temperature. The temperature in the oven is controlled by on-off switching through a contact thermometer. To keep the oscillator current of the crystal at a sufficiently low and stable level, the oscillator valve is controlled via a single-stage amplifier.

Crystal aging which leads to a continuous, gradual change in the driving frequency, can be compensated for by two variable capacitors (coarse and fine).

The built-in crystal oscillator can be switched out of circuit if operation from an external 1-MHz frequency standard is desired. The accuracy of the decade output frequency component referred to the frequency standard is then governed only by the external standard frequency.

The output frequency of the crystal oscillator is passed through a buffer amplifier and applied, as fundamental frequency, to the 1-MHz DFO. The frequency divider is then driven via a tuned coupling circuit.

A pulse shaper in this frequency divider feeds a combined 2:1 and 5:1 frequency divider. Their output frequency is used as the fundamental frequency for the 100-kHz DFO. Besides, a sinusoidal 100-kHz voltage is available at the output of a selective amplifier, the load not reflecting back into the circuit. This voltage can be utilized both for checking the accuracy of the frequency standard and, in other sets, for obtaining subcarriers which then exhibit the full accuracy of the frequency standard.

Another 2:1 and 5:1 frequency divider combination produces the 10-kHz fundamental frequency for the 10-kHz DFO.

In CW operation of the exciter, a sinusoidal 300-kHz signal for feeding the information input is obtained by frequency tripling.

The supply voltages for the entire exciter are delivered by two separate and mutually independent power supplies.

Power supply 1 has a power switch (STANDBY) of its own. This power source feeds all the subassemblies determining the accuracy, such as the crystal oscillator and the LCO-FM, and the divider section so that the 100-kHz output is available for checking and driving.

The decade frequency oscillators take their operating voltages from power supply 2 (OPERATION) which can be switched into circuit. Continuous operation is unnecessary since the DFO's are fully operative immediately after the warm-up period.

A panel valve voltmeter which can be connected to various level check points with the CHECK switch permits performance checking. This type of performance checking, i.e. measuring the level, has the advantage that trouble-shooting is simplified by signal tracking. The order of the check points is fixed accordingly.

The heater and anode voltages of both power supplies are indicated in the positions 2, 3, 4, 5, 6 of the CHECK switch. Position 7 permits the heater current of the oven to be monitored. The levels of the three fundamental frequencies are measured in the positions 8, 9, 10. The LCO-FM is checked in position 11. Each decade frequency oscillator has three check points which permit the indication of the level of the first intermediate frequency (12, 15, 18), of the local oscillator (13, 16, 19) and of the output (14, 17, 20). In the last position (21), the final frequency and the driving frequency are applied to a diode mixer for intercomparison. The panel meter indicates the difference frequency as a beat frequency when the final frequency is adjusted for 1000.000 kHz (LCO-FM in the scale position 0.00) and the recalibration of the LCO-FM deviates from the nominal value 0.00 for some reason or other. In the same manner, the scale end (10.00) of the LCO-FM can be checked by also adjusting a final frequency of 1000.000 kHz for this scale position.

3. Subassemblies of the Decade Exciter

The individual subassemblies are housed in two separate rack-mounting units. Rack-mounting unit 1, Type HS 1205, contains the three decade frequency oscillators (DFO's). Rack-mounting unit 2, Type HS 1206, incorporates the power supplies, the crystal oscillator, the frequency divider and the shift oscillator. Both plug-in units are interconnected by patch cords. All subassemblies are self-contained units.

3.1 Rack-mounting Unit Type HS 1205

3.1.1 10-kHz Decade Frequency Oscillator (DFO)

See circuit diagram HS 1205-1S

3.1.1.1 Spectrum Generation

The fundamental frequency f_{o1} arriving from the frequency divider is applied to socket 3 and passed on to the first section of Rö1. The amplified squarewave pulses are then differentiated by the network C97, R4. The voltage divider R57, R58 provides so much negative bias at the grid of section II of Rö1 that only the positive peaks of the differentiated fundamental frequency produce anode current pulses. These pulses contain far more harmonics than necessary. For this reason, the four-section bandpass filter BP10 is employed to narrow down the spectrum to the harmonics 81 to 90, that is, to the frequencies 810, 820, 830, and so on to 900 kHz. L4 couples these frequencies to the first mixer, Rö2.

3.1.1.2 Local Oscillator

Section II of Rö7 functions as a Hartley circuit with grid-leak detection/limiting. The frequency of the local oscillator is adjusted in steps of 10 kHz with switch S1 and covers the range 1485 to 1575 kHz. As indicated in the block diagram, the frequency of 1575 kHz corresponds to the position 0 of the 10-kHz DFO.

The signal from the local oscillator passes at the same time through the buffer Rö7I to the first mixer Rö2 and through the capacitive voltage divider C86/C44 to the third mixer, Rö5.

For checking, the voltage delivered to the first mixer is rectified by C61, Gl 2, R38, R52 and C60 and measured with the CHECK switch in position DFO 10 kHz 0.

3.1.1.3 First IF Amplifier

The first IF amplifier consists of the two four-section filters BP20a and BP20b and the amplifier Rö3. The selectivity of this amplifier is such that from the spectrum frequencies converted in the mixer Rö2 with the aid of the local oscillator only those are passed through which are within its bandwidth of ±1.5 kHz. Hence this bandwidth is also the admissible frequency tolerance of the local oscillator.

Using the equations in the paragraphs 2.1 and 2.2 this frequency conversion is also given by

$$f_{20} = f_1 - t\, f_{01};$$

consequently, in position

0: $f_{20} = 1575 - (810, 820 \text{ to } 890, \underline{900}) = 765, 755 \text{ to } 685, \underline{675}$

1: $f_{20} = 1565 - (810 \text{ to } 880, \underline{890}, 900) = 755 \text{ to } 685, \underline{675}, 665$

etc.

At the last parallel-resonant circuit of the BP20b, the check voltage 10-kHz DFO IF is obtained from the rectifier Gl 1. The first intermediate frequency f_{20} is applied to the second mixer Rö4 via the secondary coil of the tuned transformer.

3.1.1.4 Second Intermediate Frequency f_{30}

The second intermediate frequency is produced in the mixer Rö4 from f_{20} and the shift oscillator frequency applied via socket 4 .
The six-section bandpass filter BP30 must, therefore, have the pass band

$$f_{30} = f_{20} - f_{LCO} = 675 - (90 \text{ to } 100) = 575 \text{ to } 585 \text{ kHz}$$

Because of the extended range of the LCO-FM and because of the permissible deviation of the local oscillator, the actual pass band is wider by about 4 kHz.

3.1.1.5 Third Intermediate Frequency f_{40}

The third intermediate frequency is produced in the mixer Rö5 to which the frequency of the local oscillator f_e and, via potentiometer R28, the frequency f_{30} are applied. This potentiometer permits factory adjustment of the insertion loss of the filters which somewhat differs from set to set. The four-section bandpass filter BP40a at the output of mixer Rö5 and the two-section bandpass filter BP40b following amplifier Rö6 reject all spurious frequencies from the wanted frequency f_{40} (90 to 100 kHz). At the partial capacitance C58 of the last parallel-resonant circuit the useful frequency is brought out via socket 5 and applied to the 100-kHz DFO as interpolation frequency. The circuit elements R54, Gl 3, R50, C59 and R55 are employed for performance checking in the position DFO 10 kHz A.

3.1.2 100-kHz Decade Frequency Oscillator (DFO)

See circuit diagram HS 1205-2S

3.1.2.1 Spectrum Generation

The squarewave leaving the frequency divider with the fundamental frequency of 100 kHz passes via socket 6 to the 100-kHz DFO. The rise time of these squarewaves, which is too long to produce the required spectrum, is shortened by the duotriode Rö9 connected in a Schmitt trigger circuit. The squarewave is differentiated at the inductance L134. Rectifier Gl 4 suppresses the positive-going pulses and rectifier Gl 5 applies the negative-going pulses to the first bandpass filter, BP100. As in the 10-kHz DFO, a four-section filter is used which confines the spectrum to 10 frequencies in the range 8.4 to 9.3 MHz. The spectrum is displaced by 300 kHz from the 81st to 90th harmonic of the 10-kHz decade. This is due to the information with a centre frequency of 300 kHz, which is impressed in the course of the subsequent frequency conversions.

3.1.2.2 Local Oscillator

Like the local oscillator in the 10-kHz DFO (see section 3.1.1.2) this oscillator is a free-running LC type with grid-leak detection/limiting (Rö18II). The signal is also brought out via a buffer, Rö18I, and a capacitive voltage divider, C222/C162. The voltage for checking the operation is likewise taken from the AC anode voltage of the buffer valve. However, because of the 300-kHz spectrum shift the frequency range of this local oscillator is not ten times higher than that of the local oscillator in the 10-kHz DFO. Switch S1 permits adjustment in 100-kHz steps from 10.95 MHz to 11.85 MHz.

3.1.2.3 First IF Amplifier

The first IF amplifier follows the mixer Rö10 and consists of the four-section filters BP200a and BP200b and the interconnected amplifier Rö11. It has a midband frequency of 2.55 MHz, a bandwidth of ±15 kHz and provides more than 70 dB attenuation at more than 100 kHz off-tune. As set forth in section 3.1.1.3 only one of the converted spectrum frequencies is filtered out. The first intermediate frequency, f_{200}, and the output frequency f_{40} of the 10-kHz decade are applied to the subsequent mixer Rö12 via the socket 7 . The second intermediate frequency, f_{300}, appears at the anode of this mixer.

3.1.2.4 Second Intermediate Frequency f_{300}

The second intermediate frequency is coupled out via the six-section filter BP300. Corresponding to the variation of the interpolation frequency f_{40} the theoretical range of the intermediate frequency is

$$f_{300} = f_{200} - f_{40} = 2.55 - (0.9 \text{ to } 1.0) = (1.55 \text{ to } 1.65) \text{ MHz}$$

The actual range is wider by the tolerable deviation of the local oscillator (±15 kHz).

The IF signal coming from the coupling transformer of the last parallel-resonant circuit of the BP300 and the information signal of 300 kHz centre frequency applied via socket 8 are both fed to the control grid of mixer Rö13, where the third intermediate frequency, f_{400}, is produced.

3.1.2.5 Third Intermediate Frequency f_{400}

The third intermediate frequency is produced according to the equation

$$f_{400} = f_{300} + f_m$$

Since f_m, the frequency at the information input, may have a bandwidth of ± 6 kHz, the bandwidth of this intermediate frequency is increased by another ± 6 kHz. Thus the linear distortion at the information input is kept low in the range ± 6 kHz. The two four-section bandpass filters BP400a and BP400b filter out all spurious frequencies which occur during mixing.

Potentiometer R148 permits the gain of amplifier Rö14 connected between the filters to be varied. Thereby it is possible to compensate for the spread between the individual subassemblies. The output signals from the second four-section filter, BP400b, and from the local oscillator are applied to the next mixer, Rö15, where the output frequency f_{500} of the 100-kHz decade is produced.

3.1.2.6 Output Frequency f_{500}

The output frequency f_{500} is applied to the four-section bandpass filter BP500a whence it passes to valve Rö16, to the four-circuit band-pass filter BP500b and to the output amplifier Rö17. The performance check in the position DFO 100 kHz A of the CHECK switch is made at the anode of this valve.

All amplifier valves, Rö14, Rö16, Rö17, operate with heavy DC feedback for stabilization of the output voltage. The single-section output filter, TP500c, functions as a tuned transformer. Providing about 60 Ω it couples the output signal of the DFO to socket 9 whence the signal passes to socket 13 (see circuit diagram HS 1205 S). Here, the front panel control R193 together with R192 permits the output level of the 100-kHz DFO, and thus of the entire Decade Exciter, to be varied. The signal is then applied to sockets 14 and 11 and fed into the 1-MHz DFO.

3.1.3 1-MHz Decade Frequency Oscillator (DFO)

See circuit diagram HS 1205-3S

3.1.3.1 Spectrum Generation

The following two differences from the other two DFO's have made a different layout for the generation of the spectrum necessary:

a) The fundamental frequency present at socket 12 is taken from the crystal oscillator without any frequency division and is, therefore, sinusoidal.

b) The used spectrum does not cover a range of 10 but of 30 harmonics.

The first difference has necessitated a somewhat more intricate circuitry to obtain a pulse from the sinusoidal voltage. The voltage is first amplified in a tuned amplifier, Rö19. The low-impedance secondary of L201 feeds L202 and the variable-capacitance diode Gl 10, which are connected in series. During the transition of the current from the forward to the reverse direction Gl 10 causes voltage peaks which are used for controlling Rö20. From there, the pulses are applied to the filter TP1000.

Unlike the bandpass filters in the other DFO's, TP1000 is a low-pass filter because of the second difference from the other DFO's, the wide range of the spectrum. Since spurious frequencies can occur only with harmonics above the highest used, i.e. 39 MHz, limitation of the spectrum below the lowest harmonic, 10 MHz, is unnecessary.

3.1.3.2 Local Oscillator

Because of the relatively high frequencies (105.5 to 134.5 MHz) on which this oscillator operates and because of the large number of steps (30) in which it is adjustable, it was not possible to use a conventional switch, but rather a precision variable capacitor, C426, was chosen. It is operated via a 30-step drive. The straight-line frequency-capacitance characteristic of the plates of the variable capacitor, which can be corrected in the test department by means of the 30 trimmers associated with the respective steps, and the drive provide a setting accuracy which fully satisfies the requirements. The correction of the initial capacitance of the oscillator, sometimes necessary after valve replacement, is possible from the front panel with the aid of trimmer C423. The Colpitts type oscillator circuit with grid-leak detection/limiting is excited by section I of the valve Rö33. The two buffers Rö32 and Rö34 are coupled to it by C421 and C428. Both buffers have tuned load impedances. The load impedance of Rö32, a parallel-resonant circuit made up of anode capacitance and L232, applies the signal with the proper impedance to the cathode of the first mixer, Rö21. The third mixer, Rö28 and Rö29 connected in push-pull, is driven from the buffer Rö32 via the two-section bandpass filter C435/L235-L236/C436. Gl 17, C430, R297 and R303 serve for rectifying the check voltage DFO 1 MHz O.

3.1.3.3 First IF Amplifier

Five identical bandpass filters, BP2000a to BP2000e, and the four amplifier valves Rö22 to Rö25 constitute the first IF amplifier. This cascade arrangement of four identical amplifiers, each consisting of a valve and a two-circuit filter, ensures the necessary selectivity and gain at the high centre frequency of 95.5 MHz. Valve Rö25 also functions as a limiter so that the subsequent mixer operates always at the same level obtained from the secondary coil of L215.

In the DFO 1 MHz IF position of the CHECK switch the voltage at the last parallel-resonant circuit, C361/L215, is measured in a rectifier circuit.

3.1.3.4 Second Intermediate Frequency

The output frequency of the 100-kHz DFO, f_{500}, passes to the mixer Rö26 via socket 11 together with the first intermediate frequency. The sum frequency is coupled out via the four-section filter BP3000a and amplified by the following valve, Rö27. The gain of this valve is stabilized by a large amount of DC feedback. The last mixer, Rö28 and Rö29, operates in push-pull, the signal being applied to it in phase opposition via the delay networks C387/L223I and C388, C389, C390, C415, C391, C392/L223II. The oscillator signal is applied in phase via R257, R258. The balanced-to-earth output signal f_{4000} is thus produced at the anodes of the two mixers.

3.1.3.5 Output Signal f_{4000}

The spurious frequencies which occur in the last mixer are all above the highest output frequency of the exciter. Besides the attenuation of these spurious frequencies the low-pass filters TP4000a ensure equalization of the frequency response.

The output capacitances of valves Rö28 and Rö29 and the input capacitances of the output valves form part of the low-pass filter TP4000a. The subsequent push-pull stage Rö30 and Rö31 operates with DC feedback. Its output signal is applied to the broadband transformer Tr4 which with the valve capacitances, with L229, L230 and with the capacitances C408, C409 and C410 forms the low-pass filter TP4000b. The terminating impedance for this low-pass filter is the load impedance to be connected to socket 10 .

The output voltage is measured in the position DFO 1 MHz A of the CHECK switch, with the aid of the rectifier Gl 16 and the associated circuit components.

In the diode mixer Gl 13 a portion of the output voltage applied via R282/R283 and a portion of the standard frequency voltage, 1 MHz, fed in via C313 are combined. The difference-frequency signal obtained is applied via resistor R233 to the check point LCO-FM RECALIBRATION selected by means of the CHECK switch.

3.2 Rack-mounting Unit Type HS 1206

See circuit diagram HS 1206 S

3.2.1 Crystal Oscillator

The entire crystal oscillator is operated from an anode supply voltage stabilized with R48 and Rö5, AC supply fluctuations thus being eliminated. This stabilized supply voltage also feeds the shift oscillator and the screen grid of the valve Rö17.

3.2.1.1 Temperature Control

The anode current of Rö1 passes through the heater resistance R8 (heater winding). This valve is a DC amplifier which delivers a constant current when the contact-thermometer operated switch S1 is open. S1 closes when the oven has reached its rated temperature and cuts off Rö1 by applying a negative voltage to the control grid. This voltage is obtained by rectifying the heater voltage in a voltage-doubler circuit and by filtering it through C2, R6 and C1. This nearly wattless control ensures low-level loading of the thermometer contact and, consequently, a long life.

The voltage for the check point THERM. is tapped from the cathode resistor R2.

3.2.1.2 Oscillator Circuit and Amplitude Control

The vacuum-mounted crystal Q1 operates in a Colpitts circuit whose main capacitances, C4 and C5, are housed in the oven together with the crystal. The partial capacitances C6 and C8 can be adjusted from the front panel and serve for the coarse and fine adjustment of the frequency. The oscillator valve Rö2 excites the crystal-controlled circuit while C17 drives amplifier Rö3 whose load resistance is constituted by the parallel-resonant circuit L1, C27, C29 tuned to 1 MHz. The negative control voltage which is produced at diode Gl 3 via C24 is delayed by the anode supply voltage reduced by the voltage divider R33, R34. This control voltage is smoothed by the RC network R31 - C14 and applied to the oscillator valve Rö2 via the grid leak resistor R11.

To prevent the control action from breaking down, when no cathode current is present, and thus the crystal from oscillating with too large an amplitude, the control voltage is referred to the cathode potential of the valve Rö3, via R30. For this reason, also the cathode of Rö2 is at a fixed positive voltage. If no cathode current is present at Rö3, the control voltage decreases to earth potential, and the oscillator valve Rö2 is cut off by its cathode bias.

3.2.1.3 Buffer Amplifier

A portion of the AC anode voltage of the amplifier Rö3 is impressed on the control grid of the buffer Rö4. Rö4 operates with DC feedback and has a cathode output which supplies the fundamental frequency of the 1 MHz DFO via socket 4 . The standard-frequency signal leaving the anode passes through the selective circuit L2, C34, C35 to socket 5 whence it is passed on to the frequency divider. This voltage is rectified by diode Gl 4 and can be measured in position 8 of the CHECK switch.

3.2.1.4 Valve Voltmeter for Performance Checking

The duotriode Rö6 operates as differential DC amplifier in grounded anode connection. The control grid of section II is taken to chassis while the control grid of section I can be connected via the CHECK switch S9 to the voltage to be measured. The voltage is then indicated on meter I1 which is connected between the cathodes of the two valve sections. Potentiometer R54 permits the electrical zero to be adjusted.

3.2.1.5 External Drive

If the Decade Exciter is to be driven from an external standard frequency the crystal oscillator is disabled by interrupting the anode supply voltage of the oscillator valve Rö2 with switch S7. The external standard frequency is applied to the cathode of Rö3 via socket 3 .

3.2.2 Shift Oscillator

The shift or reactance valve oscillator operates in a Colpitts circuit with grid-leak detection/limiting. Rö9 functions as a triode (cathode, control grid, screen grid), The essential, frequency-determining elements of the oscillator circuit are air-tight and moisture-proof. The frequency is adjustable with the precision variable capacitor C64.

Changes in the calibration of the oscillator are mainly due to aging of the tank-circuit inductance L8. The inductive trimmer L7 which is in series with L8 permits the overall inductance to be front-panel controlled in the switch position RECALIBRATION LCO-FM. Changes in the initial capacitance will occur much less frequently; if any, they can be compensated for with the capacitive trimmer C65.

The oscillator is carefully temperature-compensated over the entire frequency range; compensation of the initial capacitance is rendered possible by C60. This trimmer must not be used to correct capacitance variations.

The two reactance valves, Rö7 and Rö8, are in parallel to the tank circuit; they derive their control voltage from the capacitive voltage divider C70, C71 via the phase-inverting circuit elements R74, C55 and R72, C53, L5 or R75, C56 and R73, C54, L6. Using R76 and R77 it is possible to adjust this control voltage and thus the deviation voltage ratio. Both valves deliver inductive currents fed to the oscillator circuit in a push-pull arrangement. In CW operation, both currents are equal in value and cancel; hence the oscillator circuit is not detuned.

In FM operation, the modulation signal passes via sockets 6 , 7 and the resistors R68, R69 to the control grids of the reactance valves, shifting their operating points in step with the modulation. Since the cathodes are coupled, the modulation signal applied to one valve will also shift the operating point of the other, but in the opposite direction. This shift of the operating point changes the amplification factor and, consequently, the two reactive anode currents. They do no longer cancel, but rather their resultant component detunes the oscillator circuit.

The two equally favoured modulation inputs FM-A and FM-B have the same sensitivity, but different polarity. A voltage increase at the input FM-A raises, a voltage increase at the input FM-B lowers the output frequency of the entire Decade Exciter. Both inputs are DC coupled and require a bias of about +50 V. This bias can be provided by the R&S Keyer Type NA 61. In operation without this keyer or with a DC-free modulation, a stabilized bias is applied in the position FM-OFF of switch S8.

The screen grids are operated with a stabilized DC voltage and the heater voltage is kept stable by the barretter R56 and the Zener diodes Gl 6, Gl 7, to prevent the operation of the reactance valves from being affected by voltage fluctuations. The interpolation-frequency signal for the 10-kHz DFO passes from the anode of the oscillator valve Rö9 to the low-pass filter C77, L9, C78, L10, C79 and is brought out at socket 8. For checking in the position LCO-FM of the CHECK switch the AC anode voltage is rectified and filtered by the arrangement C75, Gl 8, R88, C76, R89.

3.2.3 Frequency Divider

The 1-MHz standard frequency signal is applied to socket 9 whence it travels to the frequency divider. The first stage, Rö10, is a pulse former of the Schmitt trigger circuit type and produces a squarewave signal from the sinusoidal input voltage. The squarewave voltage obtained is coupled out at the anode of the second section of Rö10 and fed into the 2:1 frequency divider Rö11 via C89.

3.2.3.1 1 MHz : 100 kHz Frequency Divider

The valve Rö11 functions as a bistable multivibrator. Both grids are simultaneously driven by a squarewave signal applied via R115 and R114. The two triode sections are alternately conductive in step with the applied squarewave signal. The pulse repetition frequency of each individual anode current is, therefore, only half the frequency of the driving voltage.

The 500-kHz squarewave voltage present across R123 has a mark-to-space ratio of 1:1 and is differentiated with the RC network C95, R126 so that positive- and negative-going pulses which drive the second section of valve Rö12 appear at R126.

The period during which the above triode section is conductive is equal to the spacing between the positive and negative trigger pulses, the positive pulse making the triode section conductive, the following negative pulse cutting it off.

The first section of Rö12 provides monostable multivibrator action, the time constant of the network C99, R132, R133 being of such a value that only every fifth pair of pulses is utilized for control.

Potentiometer R133 permits the time constant and hence also the division ratio to be adjusted. Thus the squarewave voltage across R137 and R138 has a mark-to-space ratio of 9:1. This 100-kHz squarewave voltage is the fundamental-frequency signal applied via C104 to the 100-kHz DFO.

The circuit components C103, C105, Gl 10, R141, R142 serve for the level measurement in the position 100 kHz of the CHECK switch. The 100-kHz squarewave voltage present across R138 passes via C106 to the grounded-grid stage Rö11 where it is amplified. The grounded-grid circuit was chosen, because the period during which the valve conducts is then only 10%.

3.2.3.2 100 kHz : 10 kHz Frequency Divider

Valves Rö14 and Rö15 operate on the same principle as do valves Rö11 and Rö12; they divide the 100-kHz fundamental frequency by 10. The 10-kHz squarewave voltage is the fundamental-frequency signal fed via C126 into the 10-kHz DFO. Its mark-to-space ratio is also 9:1.

The voltage for the check point 10 kHz is taken from R173.

3.2.3.3 100-kHz Final Amplifier

The 100-kHz standard-frequency signal is coupled out as a sine-wave by the tuned amplifier Rö16. The squarewave signal passes via R178 to a two-section bandpass filter which attenuates the harmonic content of the squarewave so that a sine wave is applied to the control grid of valve Rö16.

The load impedance of valve Rö16 is constituted by the parallel-resonant circuit made up of L15 and C141. L15 has a low-impedance secondary coil from which the signal passes via R182 to the 100-kHz output. The Q, transformation ratio and R182 are such that an open-circuit voltage of 1 V and a source impedance of 60 Ω are obtained.

3.2.3.4 300-kHz Final Amplifier

The 300-kHz voltage necessary for CW operation is also derived from the 100-kHz squarewave voltage. To this end, the latter is applied to Rö17 via C143. The following three-section bandpass filter has a centre frequency of 300 kHz, thus only the third harmonic of the 100-kHz squarewave will pass through. All the other harmonics and the fundamental frequency are attenuated to obtain the required signal-to-noise ratio.

Since the output voltage of the entire Decade Exciter is directly proportional to the voltage of the 300-kHz frequency, the level of the latter is stabilized by gain control of valve Rö17 with the aid of Gl 12, Gl 13, R187, C138. This stable voltage is applied to the voltage divider R193, R194 where contact rs1I of the RF relay Rs1 derives a level corresponding to the output power, 0.1 W or 1 W, of the entire set. The relay is operated with a front-panel switch.

3.2.4 Power Supply

For reasons of compact design, the Decade Exciter has been laid out such that all of its subassemblies can be fed with unregulated operating voltages to meet the specified data. This makes for a relatively economical and efficient power supply.

The two power supplies of the set are provided with the fine-wire fuses Si1, Si3 and Si5 on the primary side and with fuses Si2 and Si4 on the secondary side. Operation from the AC supply voltages 235 V, 220 V, 125 V and 115 V is possible by appropriate adjustment.

Power supply 1, which feeds the unit Type HS 1206, i.e. the crystal oscillator, shift oscillator and frequency divider, can be directly switched on with S2. Glow lamp Rl1 is its voltage indicator. Power supply 2, which feeds the three DFO's incorporated in unit Type HS 1205, can be switched on with S3 only after power supply 1 is on. Together with power supply 1 the blower incorporated in Type HS 1205 is switched on. Glow lamp Rl 2 is the voltage indicator for power supply 2. Both power supplies use for rectification modern silicon rectifiers in a bridge circuit with L input.

As against peak-responsive rectification with a capacitor input, the inductance input has the advantage that the current at the AC voltage end is sinusoidal. This means that the set can also be powered from an rms value stabilizer. Moreover, the DC voltage is much less dependent on the load in the case of an inductance input.

To prevent hum pickup, the three DFO's have separate heater windings which are earthed only to the respective chassis.

4. Preparation for Use

The Decade Exciter Type NO 262 consists of the two rack-mounting units Type HS 1205 and HS 1206. Before putting the set into operation interconnect the units on the rear as follows (see Fig. 5). The connections refer to CW operation.

Cable No.	Length	R&S Ord. No.	Connector (HS 1205)	Connector (HS 1206)
1	-	NO 261-2	1	1
2	-	NO 261-2	2	2
3	24 cm	NO 261-3/24	100 kHz ⎍	100 kHz ⎍
4	30 cm	NO 261-3/30	10 kHz ⎍	10 kHz ⎍
5	35 cm	NO 261-3/35 or NO 261-1.11/... for operation in steel cabinet	Information	300 kHz ~ "
6	24 cm	NO 261-3/24	1 MHz ~	1 MHz ~
7	24 cm	NO 261-3/24	89 to 100 kHz	89 to 100 kHz

All cables are part of the accessories supplied with the set.

Put the FM ON/OFF button in the position FM OFF and the INT/EXT button for the driving frequency to 1 MHz INT.

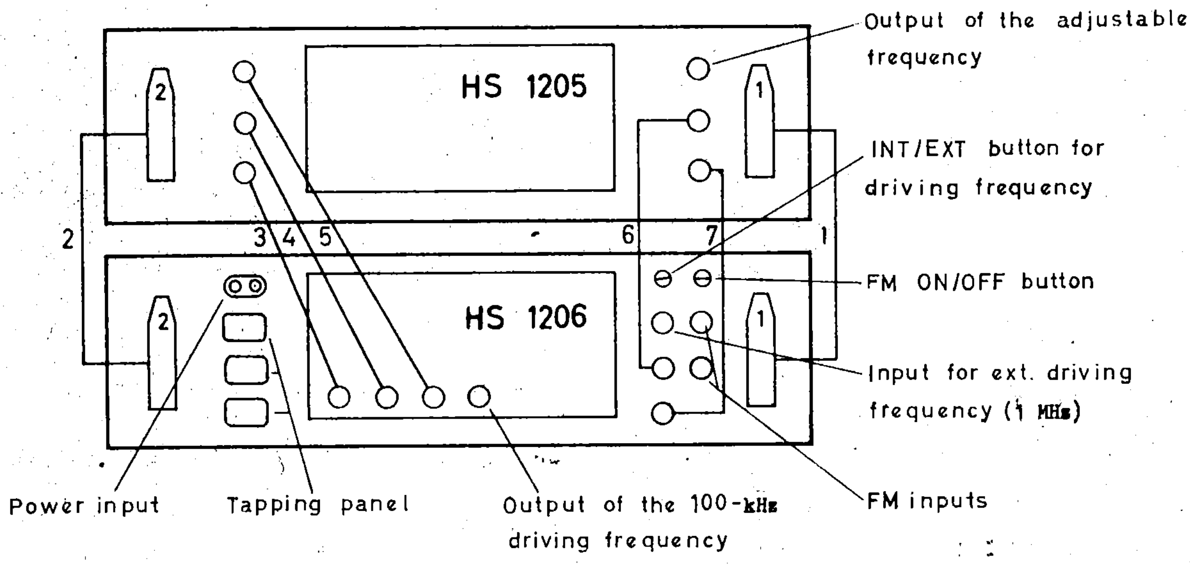

Fig.5 Cable connections on the rear of the rack-mounting units and connections of the power cord

4.1 Putting into Operation

The power inputs are on the rear of Type HS 1206 (see Fig. 5). Connect the set by means of the supplied power cord LK 333 to an earthing contact type wall outlet. Prior to doing this, adjust the tapping panels for the local AC supply.

The Decade Exciter Type NO 262 can be operated from the following AC supply voltage:

115, 125, 220 or 235 V ±5% (for a short time ±10%)
47 to 63 Hz

The adjustment for the local AC supply must be made on the three tapping panels on the rear of Type HS 1206. Make sure that the rating of the fuses accessible from the front panel agrees with the selected AC voltage:

	115/125 V	220/235 V
Si1	slow-blow 1.25 A	slow-blow 0.6 A
Si2	0.2 A	0.2 A
Si3	slow-blow 1.6 A	slow-blow 0.8 A
Si4	0.6 A	0.6 A
Si5	slow-blow 0.5 A	slow-blow 0.25 A

(See also Parts List)

The Decade Exciter has two separate power supplies. The associated power switches are located on the front panel of Type HS 1206.

Power supply 1 (standby) feeds Type HS 1206, i.e., crystal oscillator, frequency divider and LCO-FM.

Power supply 2 (operation) can be switched on only after power supply 1 has been switched on and feeds Type HS 1205, i.e., the 1-MHz DFO, the 100-kHz DFO, the 10-kHz DFO and the blower.

A glow lamp is associated with each power switch; it lights when the switch is up for on.

Power supply 1, which feeds all the oscillators determining the frequency accuracy, should operate continuously (standby) or be switched on at least a few hours before the set is put into operation. The specified frequency accuracy (see 1. Specifications) is then reached about 5 mintes after power supply 2 has been switched on.

4.2 Performance Checking

The CHECK switch and the panel meter beside it serve for checking the proper functioning of the Decade Exciter Type NO 262. During operation, the deflection of the pointer should be within the black scale range, with the exception of the following positions:

Switch Position	Explanation
EL. 0	Serves for adjusting the electrical zero of the panel valve voltmeter. The associated potentiometer can be screw-driver adjusted from the front panel.
THERMOSTAT	Serves for indicating the heater current of the oven. The pointer of the meter should be at about the 75th scale division until the oven has reached its rated temperature of +65°C. At the rated temperature, the contact thermometer switches the heater current on and off at intervals of approx. 60 sec. This corresponds to an indication of about 5 and 75 scale divisions, respectively.
DFO 100 kHz A	Series for indicating the output voltage of the 100-kHz DFO which should correspond to about 75 scale divisions at an output power of 1 W of the Decade Exciter. At an output power of 0.1 W the level is too low for useful indication.
DFO 1 MHz A	Serves for indicating the output voltage of the Decade Exciter. The 0.1/1 W switch permits the measurement range of this indication to be changed over.

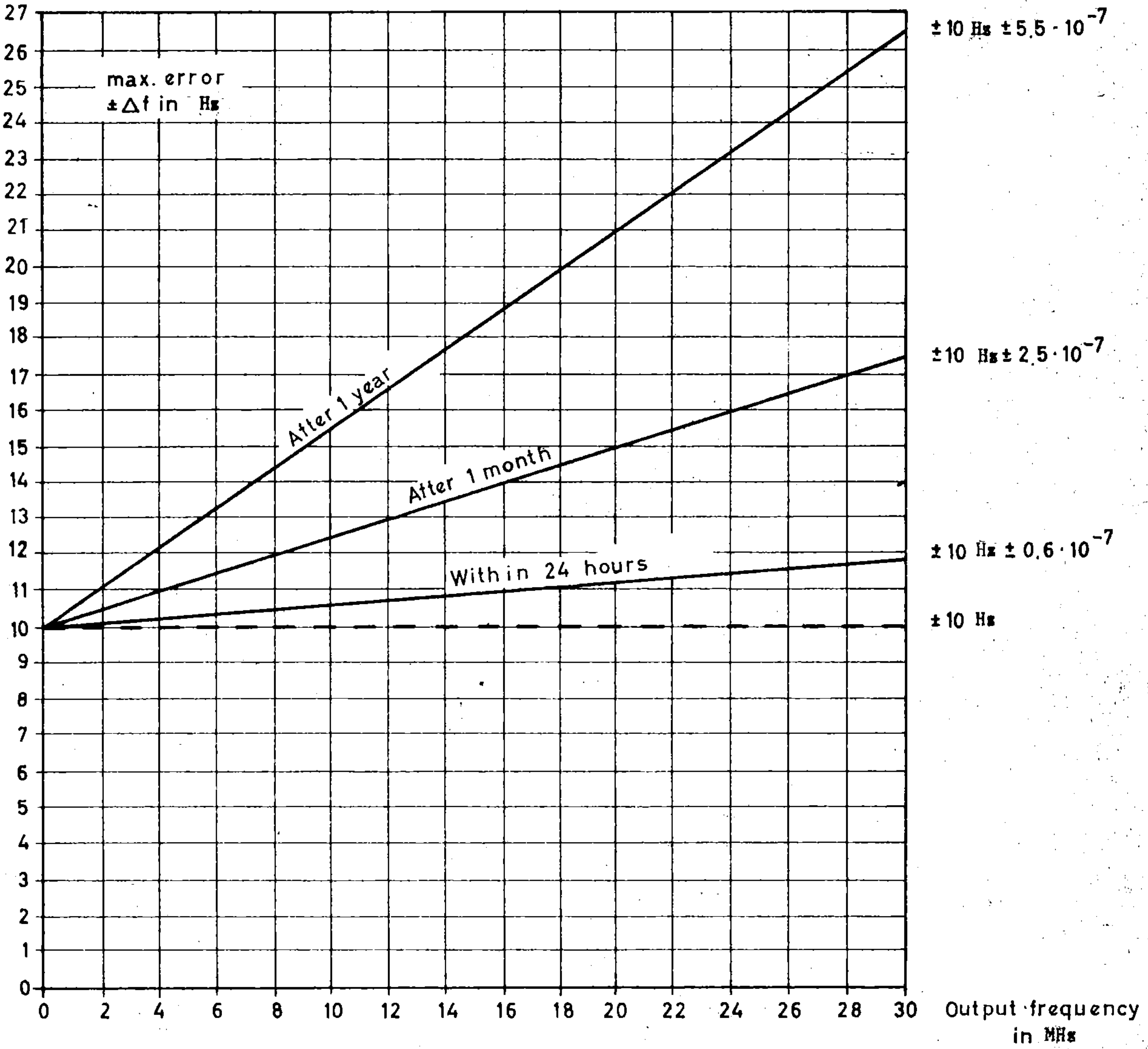

Fig.6 Error limits of the output frequency

RECALIBRATION LCO-FM

Serves for beating the adjustable output frequency at 1000.000 kHz and 999.999 kHz with the frequency of the crystal oscillator, 1000 kHz. This permits checking the frequency of the LCO-FM.

5. Operation

5.1 Adjusting the Output Frequency

The DFO's enable the adjustment of multiples of the fundamental frequencies of 1 MHz, 100 kHz and 10 kHz derived from the built-in crystal oscillator. The smallest fundamental-frequency interval, 10 kHz, is covered by the continuously variable LCO-FM.

The output frequency of the Decade Exciter is the sum of the adjustments, e.g.:

```
14 729.36  kHz
|  ||└┬┘
|  || └──LCO-FM at 9.36 kHz
|  |└────10-kHz DFO in position 2
|  └─────100-kHz DFO in position 7
└─────────1-MHz DFO in position 14
```

Other adjustments or checks are not necessary. The output frequency follows the adjustments without delay.

5.2 Error Limits of the Output Frequency

The absolute error plotted in Fig. 6 results after adjustment of the crystal oscillator and with daily calibration of the LCO-FM.

5.3 Modulating the Output Frequency

5.3.1 Frequency Modulation

Frequency modulation is achieved using the two reactance valves, Rö7 and Rö8, of the LCO-FM in Type HS 1206. The modulation signal is fed into the two sockets FM-A and FM-B with the FM ON/OFF button put to ON. For details regarding the input signal refer to 1. Specifications.

Frequency-shift keying with single- or two-channel operation, F1 or F6, is best made with the R&S Keyer Type NA 61, specially developed for operation in conjunction with the Decade Exciter. It is then only necessary to connect the two above-mentioned sockets FM-A and FM-B to the identically labelled output sockets of the keyer. Naturally, the FM ON/OFF button must be at ON.

Detailed operating instructions are given in the instruction book on the Keyer Type NA 61.

The technical data for frequency modulation are not affected by the position of the 0.1/1-W switch.

5.3.2 Amplitude Modulation

The modulation of an amplitude- or frequency-modulated 300-kHz voltage applied to the information input on the rear of Type HS 1205 reappears at the output of the Decade Exciter.

The level of the signal to the high-impedance input may be 180 mV_{pp}, maximum, or 63 mV_{rms} in the case of a sinusoidal voltage. This level corresponds to the peak input voltage in CW operation for 0.1-W output power. An output power of 1 W is obtainable by feeding 0.2 V_{rms} to this input. In this case, it is disadvantageous to use amplitude modulation because the amplitude will be heavily distorted. Sidebands within the specified bandwidth ($\pm$6 kHz) will not be changed more than 1.5 dB in their amplitude.

Single-sideband modulation is best carried out by means of the R&S A3B Modulator Type NA 60 which is built for use with the Decade Exciter.

5.4 Connecting to a Load

Use a match-terminated coaxial 60-Ω patch cord to connect the Decade Exciter to the load.

5.5 Driving with an External Standard Frequency

For external control, the DFO's derive their output frequencies from the external standard frequency.

The required input signal is a sine wave of about 1 V_{rms}, the input impedance being 60 Ω. For external drive put the INT/EXT. button on the rear of Type HS 1206 to EXT.

Each spurious voltage causes an incidental phase or amplitude modulation of the voltage at the output of the Decade Exciter. The signal-to-noise ratio should, therefore, lie between 80 and 100 dB dependent upon the frequency.

For internal control no voltage must be applied to the 1-MHz EXT. socket.

6. Maintenance and Trouble-shooting

6.1 Blower

The blower incorporated in Type HS 1205 should always be in perfect working condition when the power switch OPERATION is up for on since cooling by air convection is not sufficient with regard to the maximum operating temperature. Check the blower regularly about every month, cleaning and lubricating the bearings, if necessary.

6.2 Calibrating the Crystal Oscillator

Allow the set to operate for at least 5 hours before calibrating it, as may be necessary after replacement of valves Rö2 and Rö3. Proceed in one of the following two ways:

Compare the driving frequency 1 MHz ≈ or 100 kHz ≈ at the sockets in the rear of Type HS 1206 with a standard frequency. If necessary, correct with the coarse and fine trimmers of the crystal oscillator. These trimmers are accessible from the front panel of Type HS 1206. The coarse trimmer covers a frequency variation of approximately 5×10^{-6}, the fine trimmer of approximately 1×10^{-6}, which is equal to 1×10^{-8} per scale division.

The second possibility permits readjustment at any frequency, but the LCO-FM must have been calibrated as described in section 6.3. Use the output frequency of the Decade Exciter for the comparison against a standard frequency. However, the residual error of the LCO-FM, max. ±5 Hz, will be introduced when this procedure is chosen.

6.3 Checking and Recalibrating the LCO-FM

6.3.1 Scale Beginning (0.00) and Scale End (10.00)

Adjust for the output frequency 1000.000 kHz and 999.999 kHz; put the CHECK switch to RECALIBRATION LCO-FM. The beat indicated on the panel meter represents the error of the scale beginning or scale end, respectively. Naturally, the LCO-FM must be operated without frequency modulation; that is, in operation without the keyer the FM ON/OFF button must be at OFF, in operation with the keyer the latter must be switched on and the frequency shift switched off. If recalibration is necessary, correct at 999.999 kHz using the inductive trimmer accessible behind the covering screw RECALIBRATION LCO-FM.

If, after the above correction has been made, the scale beginning is in error by more than 5 Hz readjustment is also possible . The associated capacitive trimmer is accessible through a hole in the bottom of the LCO-FM. It is, however, necessary to withdraw the two units from the cabinet. Repeat the adjustment with the inductive and capacitive trimmers several times.

6.3.2 Deviation/Voltage Ratio

Check the deviation/voltage ratio above all after replacement of the reactance valves Rö7 and Rö8.

First calibrate the LCO-FM as set forth in section 6.3.1 and adjust for an output frequency of 1000.400 kHz. Slowly advance the control of the keyer for a negative deviation. The panel meter of the Decade Exciter should then indicate a beat and the keyer -400 Hz. If this value exceeds the tolerance specified for the keyer, the deviation/voltage ratio can be corrected as follows:

a) Remove the barretter R56, thus interrupting the heater supply for the reactance valves. Allow about 2 minutes for the cathodes to cool off and calibrate the scale beginning as set forth in setion 6.3.1.

Put R56 back and allow about 2 minutes for the two reactance valves to warm up. If the calibration carried out without heating the reactance valves is displaced (beat indication on the meter signals a displacement by more than 1 Hz),

b) adjust potentiometer R76 (for Rö7) or R77 (for Rö8) for zero beat. These two potentiometers are accessible from above beside the associated reactance valve.

The above adjustment ensures balance of the two reactance valves.

c) Check the deviation/voltage ratio once again and correct with potentiometer R76 or R77. Using the other potentiometer restore balance as set forth under a) and b).

6.4 Readjusting the Local Oscillators of the DFO's

The permissible frequency departure of these oscillators is such that readjustment is necessary only in particular cases, such as replacement of valves.

Check for frequency departure in the IF position of the corresponding DFO. If necessary, correct by adjusting the trimmers accessible behind the associated covering screws (see Fig. 1) for maximum. In the case of the 10-kHz DFO and 100-kHz DFO this is possible only in position 5. After readjustment of a local oscillator measure the output frequency of the Decade Exciter using a simple frequency meter with a frequency accuracy better than 2 kHz. Check whether the adjustment was made at the spectrum point corresponding with the scale of the DFO.

The adjustment of the local oscillator is correct if the IF level remains within the black range when the control of the oscillator is rotated through its range of variation.

6.5 Adjusting the Division Ratio of the Frequency Dividers

Type HS 1206 incorporates the facilities for deriving the fundamental frequencies 100 kHz and 10 kHz from the 1-MHz driving frequency by frequency division. Valve Rö11 divides the driving frequency by 2 down to 500 kHz. Rö12 is a monostable multivibrator which divides the 500-kHz frequency by 5 down to 100 kHz. Replacement of this valve may necessitate the readjustment of the division ratio. For this readjustment, use R113 located between Rö10 and Rö13 in Type HS 1206. Check the DFO 100-kHz IF level with the 100-kHz DFO switch in position 5. Turn R133 until the DFO 100 kHz IF level has reached its rated value. Turn R133 clockwise and anticlockwise to determine the two range limits and set it to the middle of this range. The IF level will be in the black range in all positions of the 100-kHz DFO switch if the limits have been correctly determined.

The 10-kHz DFO obtains its fundamental frequency by further frequency division down to 50 kHz and 10 kHz with the aid of Rö14 and Rö15. The adjustment of this frequency divider is made, in the same manner as described above, by means of R159 located beside Rö15 in Type HS 1206, with the 10-kHz DFO switch in position 7.

6.6 Checking the Thermostat-controlled Oven Circuit

Checking the switching valve and thermometer is necessary when the switching cycles mentioned in section 4.2 occur irregularly.

The thermometer is accessible after removing the cover from the oven and can then be withdrawn. The heater current measured with the panel meter should reach its full value when the thermometer is withdrawn. Shorting the bronze contact spring of the thermometer to chassis should cause the pointer to fall back to five scale divisions. If the pointer does not deflect back, a component in the driving circuit of valve Rö1 is defective. If the switching valve is in perfect working order, check that the mercury column visible through the longitudinal slot of the contact thermometer is uninterrupted. An interrupted column can be remedied by careful heating. The mercury will then collect in the upper bulb of the capillary tube and return as an uniterrupted column upon gradual cooling. The contact-making of the thermometer within the cartridge can be checked by a continuity meter.

Turn the set off if the checking of the thermometer takes a long time to avoid overheating the oven.

6.7 Trouble-shooting with the CHECK Switch

Check for the drop or failure of the levels at one or several check points. In the following check point tables, "1" denotes satisfactory functioning, "0" a level drop below the marked range. In the latter case, check the valves under "Cause" and the circuit components determining their performance. If the Decade Exciter fails, always start checking in the position EL. 0.

Rack-mounting Unit Type HS 1205

10-kHz DFO			100-kHz DFO			1-MHz DFO			Cause
IF	O	A	IF	O	A	IF	O	A	
0	1	0	1	1	0	1	1	0	Rö1, 2, 3
0	0	0	1	1	0	1	1	0	Rö7
1	1	0	1	1	0	1	1	0	Rö4, 5, 6
1	1	1	0	1	0	1	1	0	Rö9, 10, 11
1	1	1	0	0	0	1	1	0	Rö18
1	1	1	1	1	0	1	1	0	Rö17 (HS 1206), Rö12, 13, 14, 15, 16, 17
1	1	1	1	1	1	0	1	0	Rö19, 20, 21, 22, 23, 24, 25, 32
1	1	1	1	1	1	0	0	0	Rö33
1	1	1	1	1	1	1	1	0	Rö26, 27, 28, 29, 30, 31, 34

Raok-mounting Unit Type HS 1206

Tr1 Si1	250 V Si1	Tr2 Si3	150 V Si4	Tr3 Si5	Therm.	1 MHz	100 kHz	10 kHz	LCO FM	Cause
0	0	0	0	0	0	0	0	0	0	Si1, Si2, Rö6
1	1	0	0	1	1	1	1	1	1	Si3
1	1	1	0	1	1	1	1	1	1	Si4
1	1	1	1	0	1	1	1	1	1	Si5
1	1	1	1	1	0	1	1	1	1	Rö1
1	1	1	1	1	1	0	0	0	1	Rö2, 3, 4
1	1	1	1	1	1	1	0	0	1	Rö10, 11, 12
1	1	1	1	1	1	1	1	0	1	Rö13, 14, 15
1	1	1	1	1	1	1	1	1	0	Rö7, 8, 9

6.8 Valve Replacement

The valves used in the set are mainly of the long-life type, the guaranteed life being 10 000 hours if the AC supply voltage is maintained to within $\pm 5\%$. Exceptions are Types EF 94 and EL 83. Readjustments after replacement of valves are generally not necessary apart from the following cases:

<u>Rack-mounting Unit Type HS 1205</u>

Valve	Adjustment	Remarks
Rö7	see section 6.4	10-kHz DFO, position 5
Rö18	see section 6.4	100-kHz DFO, position 5
Rö21	L206 1-MHz DFO IF level for maximum	For adjusting L206 to L215, vary L213 until the 1-MHz DFO IF indication decreases to 50 scale divisions. Subsequently readjust for maximum.
Rö22	L207 and L208 1-MHz DFO IF level for maximum	
Rö23	L209 and L210 1-MHz DFO IF level for maximum	
Rö24	L211 and L212 1-MHz DFO IF level for maximum	
Rö25	L213 and L214 1-MHz DFO IF level for maximum	
Rö26	L215 1-MHz DFO IF level for maximum	
Rö33	see section 6.4	DFO 1 MHz

Valve	Adjustment	Remarks
Rö2	see section 6.2	Frequency error due to valve replacement < 5×10^{-8}
Rö3	see section 6.2	Frequency error due to valve replacement < 2×10^{-8}
Rö6	zero adjustment accord. to section 4.2	
Rö7, 8	see section 6.3.2	Deviation/voltage ratio due to valve replacement less than 20%
Rö9	see section 6.3.1	Frequency error due to valve replacement on the average < 10 Hz
Rö10	see section 6.5	Generally, it is sufficient to check the 100-kHz DFO IF level
Rö13	see section 6.5	Generally, it is sufficient to check the 10-kHz DFO IF level