Instruction Book

Z-g DIAGRAPH

Type ZDU

BN 35610/50 BN 35610/60 BN 35610/75

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Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (FNr.) of the set when asking for technical information and, in particular, when ordering replacements.

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1.1 Use as Impedance-Admittance Meter and Reflectometer

Frequency range . . . . 30 to 420 MHz

Characteristic impedance Z_o
(source impedance of Type ZDU)

- model BN 35610/50 . . . . . 50 Ω
- model BN 35610/60 . . . . . 60 Ω
- model BN 35610/75 . . . . . 75 Ω

Indication . . . . direct visual indication by light spot; optional on
a) Smith chart (resistive and reactive component)
b) Carter chart (magnitude and phase)
c) reflection-coefficient chart (magnitude and phase)

Measurement range for resistance and reactances . . . . $Z_o/50$ to $Z_o/50 \times Z_o$

Radius ϱ of error circle after amplitude and phase adjustment at the measurement frequency

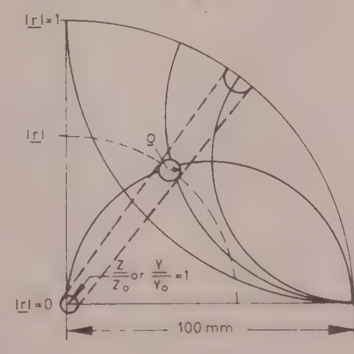
- normal . . . . $\frac{\varrho}{mm} = 100\,(0.01 + 0.015\,r)$
- spread . . . . $\frac{\varrho}{mm} = 300\,(0.01 + 0.015\,r)$

Near the matched condition ($Z \approx Z_o$)

the impedance error is $\frac{\Delta Z}{Z_o} \leqq 3\%$

the admittance error is $\frac{\Delta Y}{Y_o} \leqq 3\%$

the reflection-coefficient error $\Delta r \leqq 1.0\%$



(Section of diagram of Fig. 24)

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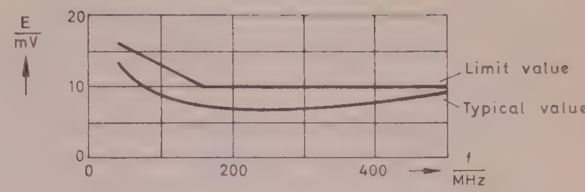
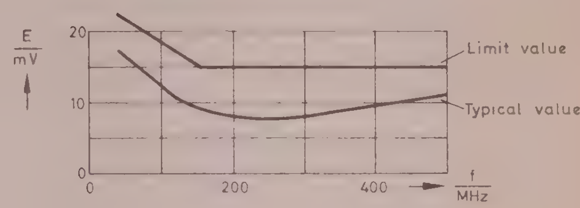
Voltage across test item under matched conditions

model BN 35610/50 . . . .

model BN 35610/60



model BN 35610/75 . . . .



Required generator voltage . . . < 2 V

Connector for test item and generator . . . . R&S connector Dezifix B, suitable for adaptation to other plug or socket systems, see section 3.9

1.2 Use as Test Set for the Determination of the Transmission Characteristics of 4- and Multi-terminal Networks

Frequency range . . . . 30 to 420 MHz

Indication . . . . direct visual indication by light spot on a polar diagram (transfer constant with respect to magnitude and phase in dB and °)

Measurement range

attenuation . . . . 0 to 30 dB

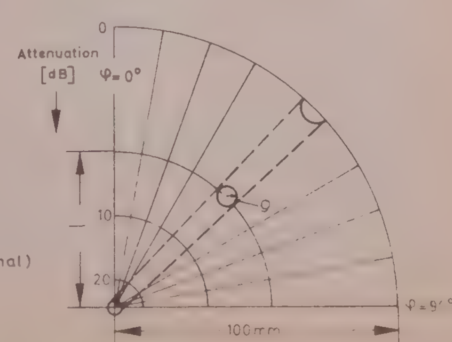
phase . . . . 0 to 360°

Radius ϱ of error circle after amplitude and phase adjustment at the measurement frequency

normal . . . . $\frac{\varrho}{mm} = 1.0 + 0.015 \times \frac{1}{mm}$

spread . . . . $\frac{\varrho}{mm} = 3\,(1.0 + 0.015 \times \frac{1}{mm})$

e.g. at an attenuation of 10 dB
max. attenuation error ±0.6 dB
max. phase error ±3.5°



(Section of diagram of Fig. 30
l = amplitude of the transmitted signal)

Connection between network and test set	two cables of equal electrical length with connectors mating with those of test set *), a T-section and two 20-dB attenuator pads. Under certain conditions a 4-terminal feed unit is used instead of the T-section and the attenuator pads.
Source impedance of attenuator pads or 4-terminal feed unit . .	Z_o ±5%
Load impedance of the network (without cable)	Z_o ±6%
Voltage across input of passive networks under matched conditions	< 20 mV (see frequency response curves, section 1.1)
Voltage across input of active networks under matched conditions	$< \frac{20\ \text{mV}}{\text{transmission gain}}$ (see frequency response curves, section 1.1)
Connectors	as in section 1.1

1.3 Use as Test Set for the Determination of the Phase Angle between two Voltages of Identical Frequencies

Frequency range	30 to 420 MHz
Measurement range	0 to ±180°
Error limits	±1.5°
Indication	direct visual indication by light spot on a polar diagram
Minimum voltage requirement for phase measurement	approx. 2 mV
Maximum permissible voltage .	approx. 15 mV

*) Cable pairs adjusted for equal electrical length may be ordered from ROHDE & SCHWARZ; see section 3.2.

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Input impedance of coaxial test line and coaxial reference line	
model BN 35610/50	50 Ω ±1%
model BN 35610/60	60 Ω ±1%
model BN 35610/75	75 Ω ±1%
Connectors	as in section 1.1

1.4 Use as a Tuned Linear Test Receiver

Frequency range	30 to 420 MHz
Input requirement for full-scale deflection on reference meter. .	approx. 20 mV
Threshold sensitivity	approx. 0.5 mV
Bandwidth	approx. 70 kHz increases to approx. 500 kHz by automatic tuning
Input impedance and connector .	see section 1.1

1.5 Other Data

Power supply	115/125/220/235 V ±10% 47 to 63 Hz and 400 Hz
Power consumption	approx. 180 VA
Valves, etc.	2 valves EA 50 1 valve EC 81 14 valves EF 80 2 valves EF 800 1 valve EL 84 2 valves EZ 80 2 valves PL 81 1 reference tube 85 A 2 2 crystal diodes R&S Stock No. GK 1011 C 1 crystal diode R&S Stock No. GK 1111 7 crystal diodes R&S Stock No. GK/OA95

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	1 incandescent lamp R&S Stock No. RL 93015 1 projector lamp R&S Stock No. RL 301 1 miniature glow lamp R&S Stock No. RL 210 2 scale lamps R&S Stock No. RL 165 S 1 1.6-A fuse 1,6 D DIN 41571 (for 220/235 V) 1 0.25-A fuse 0,25 C DIN 41571
Dimensions	560 x 340 x 480 mm
Weight	approx. 55 kg

2. Accessories Supplied

1	Connecting cable, 2 m, with female connector and earthing-contact type plug for connection of Type ZDU to the power supply	R&S Stock No. LK 333
2	R&S short-circuit connectors Dezifix	R&S Stock No. FZ 434
20	Transmission-line charts impedance-admittance chart for resistive and reactive components . . .	BN 35611/1709 (Fig. 24, p.
20	Transmission-line charts impedance-admittance chart for resistive and reactive components, three times enlarged	BN 35611/2692 (Fig. 25, p.
20	Transmission-line charts impedance-admittance chart for magnitude and phase	BN 35611/1659 (Fig. 26, p.
20	Transmission-line charts impedance-admittance chart for magnitude and phase, three times enlarged	BN 35611/1895 (Fig. 27, p.
20	Transmission-line charts reflection-coefficient chart	BN 35611/1657 (Fig. 28, p.
20	Transmission-line charts reflection-coefficient chart, three times enlarged	BN 35611/12394 (Fig. 29, p.
20	Transmission-line charts transfer-constant chart	BN 35611/1658 (Fig. 30, p.
1	Chart case, for storage of the charts	BN 3561 - 46

3. Recommended Accessories for Extending the Scope of Measurements

(to be ordered separately)

3.1 Feed Cable

1 m long, with Dezifix B connectors at both ends for connecting Type ZDU to the signal generator . . . . BN 9111105/100

3.2 Pair of 2-terminal Measuring Cables

For Type ZDU	Connector	Length	Order Number
BN 35610/50	Dezifix B	1 m	BN 35613/50/1
		2 m	BN 35613/50/2
		5 m	BN 35613/50/5
	Series N UG-21 D/U	1 m	BN 35613/11/1
		2 m	BN 35613/11/2
		5 m	BN 35613/11/5
BN 35610/60	Dezifix B	1 m	BN 35612/1
		2 m	BN 35612/2
		5 m	BN 35612/5
BN 35610/75	Dezifix B	1 m	BN 35613/80/1
		2 m	BN 35613/80/2
		5 m	BN 35613/80/5

The two cables of a pair are of equal electrical length; they are used in measuring test items which cannot be directly connected to the Type ZDU. Moreover, they are used for 4-terminal network measurements.

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Difference in electrical length between the two cables of a pair, on delivery	≦ 0.002 x 1 + 2 mm
Tolerance of mechanical length of a pair of cables	-60 to +90 mm
Permissible strain Bending radius	≧ 30 cm
Tensile strength	< 2 kg_f
Weight	1 to 4 kg depending on BN
VSWR	see Fig. 1

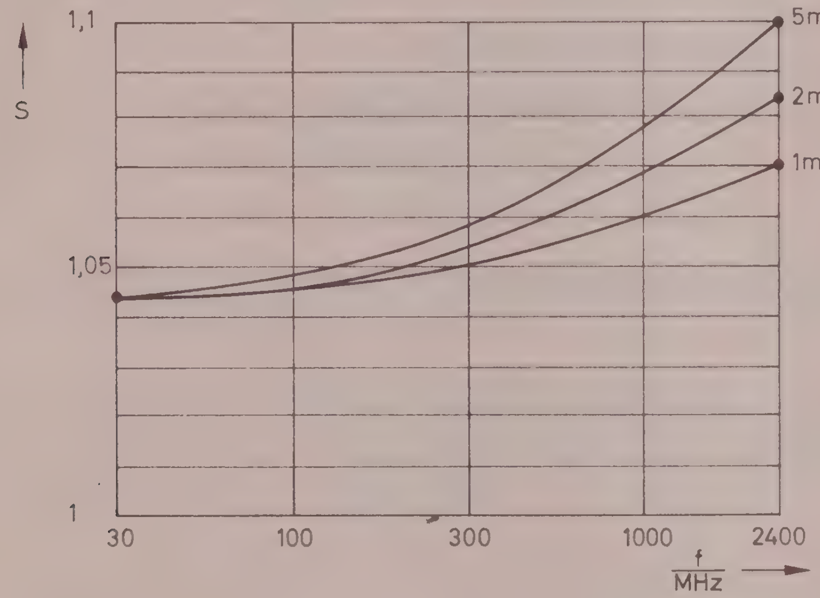

Fig. 1 VSWR of a single cable 1 m, 2 m and 5 m in length

Instructions on how to maintain the high electrical quality of the cables are given in the "Technical Information R 7352".

3.3 Accessories for Measuring Transmission Characteristics

3.3.1 4-terminal Feed Unit for Nearly Matched Networks

For Type ZDU BN 35610/50	BN 35615/2/550
For Type ZDU BN 35610/60	BN 35614/2/660
For Type ZDU BN 35610/75	BN 35615/2/880

Generator impedance	1.5 kΩ
Reflection within the coaxial line section	< 5%
Insertion loss from generator end to output end	approx. 30 dB

The 4-terminal feed unit is fitted with Dezifix connectors which can be adapted to suit other connectos systems.

3.3.2 T-section and UHF Attenuators for Feeding Networks of any Input Impedances

For measurements on networks of any input impedances, a T-section as specified in section 3.3.2.1 and two UHF Attenuators as specified in section 3.3.2.2 are required for feeding in.

3.3.2.1 T-section

T-sections are supplied in three models with the following Order Nos.:

Characteristic impedance	Z = 50 Ω	FS 532/50
	Z = 60 Ω	FS 532
	Z = 75 Ω	FS 532/75

The T-sections are fitted with precision Dezifix B connectors which can be adapted to suit other connector systems.

3.3.2.2 UHF Attenuators Type DPF

Model	Z_o	Attenuation	Frequency range	Power-handling capacity
BN 18060/50	50 Ω	5 dB	0 to 4000 MHz	0.5 W
BN 18060/60	60 Ω	5 dB	0 to 4000 MHz	0.5 W
BN 18061/50	50 Ω	10 dB	0 to 4000 MHz	0.5 W
BN 18061/60	60 Ω	10 dB	0 to 4000 MHz	0.5 W
BN 18062/50	50 Ω	20 dB	0 to 4000 MHz	0.5 W
BN 18062/60	60 Ω	20 dB	0 to 4000 MHz	0.5 W

These attenuators have adaptable R&S Dezifix B connectors with a power handling capacity of 0.5 W.

3.4 Matching Pads Type DAF

Model	Impedance transformation	Attenuation	Frequency
BN 18083	60 Ω to 75 Ω	4 dB	0 to 1000 MHz
BN 18083	75 Ω to 60 Ω	6 dB	0 to 1000 MHz
BN 18084	50 Ω to 75 Ω	4.2 dB	0 to 1000 MHz
BN 18084	75 Ω to 50 Ω	7.8 dB	0 to 1000 MHz
BN 18085	50 Ω to 60 Ω	4.2 dB	0 to 1000 MHz
BN 18085	60 Ω to 50 Ω	5.8 dB	0 to 1000 MHz

These matching pads are fitted with adaptable R&S connectors Dezifix B. They are an excellent and mostly indispensable accessory if two instruments or cables with varying impedance characteristics must be matched. They

are also usable as attenuators. If, for example, two pads BN 18083 are connected by their 75-Ω ends, they form an attenuator with Z = 60 Ω and an attenuation of 4 + 6 = 10 dB. If the 60-Ω ends are connected together, Z = 75 Ω and again 4 + 6 = 10 dB attenuation are obtained. The power handling capacity is 0.5 W.

<u>3.5 Calibrated Adjustable Shorts</u> . BN 39591/50, BN 39592/50, Z_o = 50 Ω
BN 39591/60, BN 39592/60, Z_o = 60 Ω
BN 39591/75, BN 39592/75, Z_o = 75 Ω

Generally speaking, adjustable shorts serve to obtain accurately-known reactances. Because of their perfect homogeneity and close tolerances they can be regarded as reactance standards. The Adjustable Short BN 39591 has a maximum usable length of 130 mm; the setting accuracy is ±0.05 mm with vernier and ±0.005 mm with the accompanying gauge blocks 2, 5, 10, 20, 30 and 40 mm. Adjustable Short BN 39592 has a maximum usable length of 500 mm and the same setting accuracy as mentioned above. In conjunction with Type ZDU, the adjustable short can be used for compensation, for example, when a test item must be connected via a short length of cable or air line and the result must be referred to the test item at the end of the cable or air line. Of course, the electrical length of the cable or line must not exceed the maximum electrical length (maximum usable length) of the adjustable short.

<u>3.6 Transistor Adapter</u> . . . . . BN 35616/50, Z_o = 50 Ω
BN 35616/60, Z_o = 60 Ω
with accessories for DC supply

Transistors cannot simply be connected to the Type ZDU because of their small dimensions. Thus a transistor adapter is required. The transistor adapter prolongs two coaxial lines, maintaining their characteristic impedance while changing the dimensions. Thus the input impedance or admittance of transistors with three or more electrodes can be measured along with their transmission characteristics in both directions, the terminating loads being selectable. For details see the relevant instruction book.

3.7 Impedance Transformer Type BSI

The different models of the Impedance Transformer Type BSI serve to match measuring instruments of 50, 60 or 75 Ω unbalanced input to balanced test items of 200, 240 or 300 Ω. The following models are used in conjunction with Type ZDU:

Model	Characteristic impedance unbal./bal.	Frequency range
BN 90634/200	50 Ω : 200 Ω	10 to 100 MHz
BN 90635/200		100 to 420 MHz
BN 90634/240	60 Ω : 240 Ω	10 to 100 MHz
BN 90635/240		100 to 420 MHz
BN 90634/300	75 Ω : 300 Ω	10 to 100 MHz
BN 90635/300		100 to 420 MHz

These impedance transformers have an adjustable Dezifix B connector on the unbalanced side and two sockets for 1.3 mm plug pins 12.6 mm apart on the balanced side. Thus a two-pin plug, BN E 454/4 - 30, is required for connecting a balanced twin lead, together with an adaptor, BN E 454/4 - 28, for a two-pin plug with 3 mm pins 12 mm apart. All these impedance transformers have a transformation ratio of 1:4, and by their use Type ZDU is made available for measuring balanced test objects. Moreover, high-valued impedances can be measured more accurately, since the impedance value indicated by Type ZDU is four times smaller. Care must be taken that the unbalanced characteristic impedance value of the Impedance Transformer Type BSI used corresponds with that of Type ZDU. Thus with a Type ZDU of which Z_o = 60 Ω, an Impedance Transformer Type BSI for 60/240 Ω must always be used, even if it is desired to measure an impedance of, say, 300 Ω.

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3.8 Broadband Baluns Type BSU

The Broadband Baluns Type BSU provide a low-reflection transition between a balanced and an unbalanced coaxial line of identical characteristic impedance. In conjunction with Type ZDU, the test input of which is unbalanced, they enable measurements of balanced test items, such as the input impedance of a balanced antenna to be made, without any transformation of the impedance taking place. The following table shows the characteristic impedances and frequency ranges of the different BSU models.

Model	unbalanced/balanced	Frequency range
BN 90610/50		10 to 90 MHz
BN 90611/50	50 Ω : 50 Ω	30 to 180 MHz
BN 90612/50		85 to 300 MHz
BN 90610/60		10 to 90 MHz
BN 90611/60		30 to 180 MHz
BN 90612/60	60 Ω : 60 Ω	85 to 300 MHz
BN 90610/D		10 to 90 MHz
BN 90611/D		30 to 180 MHz
BN 90612/D		85 to 300 MHz

All models possess an adaptable Dezifix B connector on the unbalanced side. On the balanced side, the models BN 90610/D, BN 90611/D and BN 90612/D have a shielded twin-pole socket for connection. All other models have two knurled terminals.

3.9 Screw-in Assemblies

The screw-in assemblies listed in the following table are available to adapt the Dezifix connectors of Type ZDU to other connector systems. A screw-in assembly consists of an outer and an inner conductor. The connector systems for which screw-in assemblies are available are listed in the left column and the corresponding order numbers in the two other columns.

Desired type of connector			Order Number of Screw-in Assemblies for ZDU input	Order Number of Screw-in Assemblies for coaxial test line and coaxial reference line
UHF socket	(Small Single) (MIL)	50 Ω	FHD 10910/50	FHD 10900/50
UHF plug	(Small Single) (MIL)	50 Ω	FHS 10910/50	FHS 10900/50
N socket	(MIL)	50 Ω	FHD 20910/50	FHD 20900/50
N plug	(MIL)	50 Ω	FHS 20910/50	FHS 20900/50
N socket	(MIL)	75 Ω	——	FHD 20900/75
N plug	(MIL)	75 Ω	——	FHS 20900/75
C socket	(MIL)	50 Ω	FHD 30910/50	FHD 30900/50
C plug	(MIL)	50 Ω	FHS 30910/50	FHS 30900/50
BNC socket	(MIL)	50 Ω	FHD 40910/50	FHD 40900/50
BNC plug	(MIL)	50 Ω	FHS 40910/50	FHS 40900/50
RF socket	4.1/9.5	50 Ω	FID 20910/50	FID 20900/50
RF plug	4.1/9.5	50 Ω	FIS 20910/50	FIS 20900/50
RF socket	7/16	50 Ω	FID 40910/50	FID 40900/50
RF plug	7/16	50 Ω	FIS 40910/50	FIS 40900/50
RF socket	3.5/9.5 DIN 47281	60 Ω	FID 20910/60	FID 20900/60
RF plug	3.5/9.5 DIN 47281	60 Ω	FIS 20910/60	FIS 20900/60
RF socket	6/16 DIN 47282	60 Ω	FID 40910/60	FID 40900/60
RF plug	6/16 DIN 47282	60 Ω	FIS 40910/60	FIS 40900/60
General Radio connector 874		50 Ω	FLA 20910/50	FLA 20900/50
Marconi connector H 4		50 Ω	FLB 20910/50	FLB 20900/50

The screw-in assemblies are easily attached: unscrew the outer conductor of the Dezifix connector with the special wrench FZM 10900 and the inner conductor with a (4 mm) screwdriver. The inner and outer conductors of the desired screw-in assembly can then be screwed in. Dezifix connectors and screw-in assemblies should be treated with care and stored in a safe place, since their electrical properties can be adversely affected by even slight mechanical damage.

4. Uses

As far as the measuring of complex impedances and transmission parameters is concerned, the frequency range of the Z-g Diagraph Type ZDU represents a boundary region distinguished by the use of test methods employing distributed constants instead of lumped constants. Nevertheless, a uniform procedure of great and consistent accuracy is also possible for this frequency range.

Z-g Diagraph Type ZDU employs the principle of the coaxial directional coupler. This principle is used especially for decimetre and centimetre waves but is equally suitable for the short-wave and ultra-short-wave ranges. By means of two built-in coaxial directional couplers the Z-g Diagraph measures the complex reflection coefficient originated by a test item connected to the coaxial test line. Although it is basically a reflection-coefficient meter, the Z-g Diagraph is not confined to measuring reflection coefficients, since impedance and admittance as well as a number of other quantities - which are dealt with further on - can be determined from a reflection-coefficient measurement. Thus the field of application is extremely varied, all the more since other quantities of interest can be derived from impedance or admittance. For example, the investigation of cables for their characteristic
0357 impedance and homogeneity, and the determination of material character-
24 istics are based on impedance measurements. The measurement of negative resistance is also an impedance measurement.

Sometimes it is necessary to measure the impedance of an item of difficult access, which cannot be connected directly to the Z-g Diagraph. An example is a high antenna. In these cases it is always found to be annoying that the impedance measured at the input of a connecting cable must first be changed by the phase angle of this cable to determine the true antenna input impedance, and that this phase shift varies with frequency. Thanks to the special design of the Z-g Diagraph Type ZDD, it is possible to indicate the true impedance of the test item on the screen by connecting a second cable, having the same electrical length as the test cable, to a test output provided on the set for this purpose. The phase shift thus being eliminated, there is no need for any conversion or graphic evaluation, provided the characteristic impedance of the cable employed is sufficiently uniform; errors with respect to Z will fully enter into the test result.

The measuring method employed permits the transmission parameters of 4- and multi-terminal networks to be measured in addition to the reflection coefficient, impedance and admittance. The effective transmission factor for the condition $Z_s = Z_l = Z_o$ can be measured with the help of two RF cables of equal electrical length and characteristic impedance Z_o. If Z_s and Z_l are not equal to Z_o, measurements are possible in conjunction with suitable matching elements, e.g. the Matching Pads Type DAF.

The 4-terminal parameters of transistors can be determined by means of impedance or admittance measurements or from transmission parameters. However, on account of the small dimensions of transistors, the transistor adapter mentioned in section 3.6 is required for this purpose.

Within the frequency range 30 to 420 MHz the phase angle between two voltages of equal frequency can be directly read between +180° and -180° from a polar-coordinate chart. In this case, the voltages to be compared need not be of the same value, the only condition being that they lie within the specified voltage range.

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Between about 0.2 and 20 mV, the built-in superheterodyne receiver may also be used as a linear test receiver. This may be of interest in spite of the fact that the sensitivity is reduced by the directional couplers, since the input impedance of the receiver is Z_0 within 1% over the entire frequency range.

Depending on the measurement problem, the result can be read directly on a Smith chart or on a special polar-coordinate chart without any arithmetical or graphical evaluation. This is of particular importance in studying test items over a broad frequency band since these measurements are tedious when using standing wave detectors. The Z-g Diagraph permits broad-band impedance or admittance diagrams of any apparatus, such as antennas, transformers, absorbers, filters to be plotted within a few minutes. Exchangeable charts make the procedure particularly easy.

Finally attention is called to the fact that the coaxial test and reference lines and the directional couplers proper do not include moving parts. This is of particular importance for the reproducibility of the results and for the operating stability of the equipment.

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5. Description

There is a directional coupler in a coaxial test line and another in a coaxial reference line. The one mounted in the coaxial test line furnishes a voltage proportional to the reflection coefficient $\underline{p}_x$ of the test item, while the one mounted in the coaxial reference line supplies a reference voltage proportional to unity reflection coefficient. The reflection coefficient is obtained from the comparison of the two voltages. The phase angle between these two voltages equals the phase angle of the reflection coefficient of the test item plus a constant angle which depends on the termination of the reference line.

The two quantities p_x and φ_x of the complex reflection coefficient $\underline{p}_x$ are represented linearly on the Smith chart (Fig. 24) used for direct visual indication. p_x is a vector whose length, for $\underline{Z}/Z_o = 1$, equals zero and, for any reactances, is equal to the radius of the diagram. φ_x is the angle of this vector in relation to the real axis between $R/Z_o = 1$ and $R/Z_o = \infty$ and, for $\underline{Z}/Z_o = 0$, reaches the value $\pm 180^o$. In order to determine this phase angle, the two directional-coupler voltages are first converted to a constant intermediate frequency and impressed on both ends of an artificial line after amplification and limitation. If the amplitudes of these two IF voltages are of equal level, distinct minima are created on this line, the distance of these minima from the ends of the line being a linear function of φ_x. In order to co-ordinate the linear characteristic of the phase angle on the chart and on the artifical line, the latter has been wound round the chart and the chart has been made rotatable about $\underline{Z}/Z_o = 1$ and mechanically coupled with the probe of the artificial line. For indication of the magnitude of the reflection coefficient p_x, use has been made of a sturdy mirror galvanometer which furnishes a light spot travelling along a constant base between $\underline{Z}/Z_o = 1$ and the reactance circle. After the probe minimum has been found, the position of this light spot immediately yields $\underline{Z}/Z_o$ if the reference voltage is set to a red mark, i.e., its rated value.

A special automatic frequency control makes the local oscillator follow any variations of the signal-generator frequency so that errors due to this reason are largely eliminated.

In order to enable measurements to be made on radiating test items, the coaxial test and reference lines have been provided at the side of the cabinet so that shieldings that are possibly set up do not bother the operator when measuring.

6. Operating Instructions

Note:

Before moving the set, even if only from one place to another within the laboratory, the indication and power switch (18) (Fig. 23) should be turned to OFF in order to avoid any damage to the built-in galvanometer.

6.1 Adapting the Set to the Local AC Supply Voltage and Frequency

The Z-g Diagraph has been designed for operation from an AC power supply and factory-adjusted to 220 V and 47 to 63 Hz. For a voltage other than 220 V, the set must be adapted correspondingly. To this end, it is necessary to loosen the four cylinder-head bolts at the corners of the front panel; it is then possible to remove the set from its cabinet. With the power cut off, the fuse must be inserted in the clips in the power supply (Fig. 31), identified by the required voltage rating. The fuse provided for an AC supply voltage of 220 V or 235 V is rated for 1.6 A (1,6 DIN 41571) and is to be replaced by a 2.5-A fuse (2,5 DIN 41571) in the case of a 115-V or 125-V AC supply. The set is connected to the AC supply through
0357 the power cable supplied.

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For an AC supply frequency of 400 Hz, the AC supply frequency selector (Fig. 31) located near the AC supply tapping panel must be adjusted correspondingly. For this purpose it is necessary to loosen the two screws, to change over the link, so that the connection between the two screws is interrupted, and then to tighten the screws again.

6.2 Preparation for Use

Place the set on a practically horizontal base. Take the long coaxial test line from the lid of the set, where it is kept for transport, and screw it clockwise as far as it will go into the hole in the right-hand wall of the cabinet.

Throw INDICATION switch (18) to NORMAL; the set is then switched on. After a short warm-up period, the pointer of the discriminator meter (4) moves to the right stop. This is a normal reaction which does not mean any danger for the instrument. The pointer remains at the stop until an input voltage is applied to the Z-g Diagraph and the Z-g Diagraph is tuned to the frequency of this voltage, i.e., until a signal reaches the discriminator.

The signal generator used for the measurement should be capable of delivering 2 V open circuit at a source impedance of 50 Ω, 60 Ω or 75 Ω, resp., so as to fully drive the Z-g Diagraph at every frequency. The maximum permissible RF input voltage is 5 V.

We recommend the use of the following Power Signal Generators included in our production programme: Type SMLM (30 to 300 MHz), Type SDR (300 to 1000 MHz), Type SLRD (275 to 2750 MHz), Type SLSV (25 to 470 MHz). Connect the signal generator to the INPUT socket (14). Allow a warm-up period of about 15 minutes before measuring.

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6.3 Handling the Chart Holder

The following charts are used for indication of the measured values:

(a) Impedance-admittance chart (for resistive and reactive components, Figs. 24 and 25);

(b) impedance-admittance chart (for magnitude and phase, Figs. 26 and 27);

(c) reflection-coefficient chart (for magnitude and phase, Figs. 28 and 29);

(d) transfer-constant chart (attenuation constant and phase constant, Fig. 30).

For inserting the chart, remove the bezel (17) and put the chart, fitted with two guide holes, on the plexiglass screen. Replace the bezel, thus pressing the chart against the plexiglass screen. The impedance-admittance charts (Figs. 24 and 26) can be inserted in such a way that either 0 or ∞ (with the charts of Figs. 25 and 27 either 0.5 or 2, because of the extended scale) is above the black line of the plexiglass screen. In the first case, the results represented on the chart are impedances, in the second case, they are admittances. Insert the charts shown in Figs. 28 and 29 so that 180° is above the black line and that of Fig. 30 so that 0° is above the black line.

6.4 Adjustments

6.4.1 Zero Setting of the Light-spot Galvanometer

With zero voltage applied to the light-spot galvanometer (reduce amplitude of the signal generator to 0 or disconnect the patch cord from the signal generator or switch to another range), set the crosslines of the light spot

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of the galvanometer precisely to the centre of the chart (mechanical zero) using a screwdriver. In the impedance-admittance chart the centre of the chart is the point $Z/Z_0 = 1$. The two slotted screws (15) and (16) serve for the VERTICAL and HORIZONTAL adjustments (Fig. 23).

6.4.2 Amplitude and Phase Adjustment for 2-terminal Network Measurement

Before starting the measurement, adjust the instrument with respect to amplitude and phase. If impedances, admittances or reflection coefficients are to be measured, short the coaxial reference line and the coaxial test line using short-circuit Dezifix connectors FZ 434. If, however, the effective transmission factor of a 4-terminal network is to be measured, proceed as described in section 7.6.2 or 7.6.3.

Make the amplitude and phase adjustment each time the frequency range is changed to maintain the accuracy specified under 1.1. For a long series of measurements check the two adjustments several times, especially during the first hour after the set has been switched on. When making the adjustment, use the measuring frequency which will be employed afterwards for carrying out the measurements, or a frequency in the middle of the range in which it lies.

6.4.2.1 Amplitude Adjustment

After tuning the Z-g Diagraph to the signal-generator frequency, adjust the amplitude of the signal-generator frequency until the centre of the cross-lines of the light spot comes to a standstill at the outermost circle of the chart. When this output of the signal generator is reached, the reference meter (6) should deflect to 100 (red line). If this is not the case, adjust the knob marked REFERENCE VOLTAGE COR. (5) for a deflection to this value. If the signal generator has changed its frequency while the amplitude was adjusted, retune the signal generator.

6.4.2.2 Phase Adjustment

Small phase variations caused by minor differences in the reactances of the two mixers or by aging and the slight temperature response of the IF amplifiers result in an error of the phase angle of the reflection coefficient. These variations can be compensated for with the knob PHASE COR. (7).

For this purpose, insert a chart, preferably the one used later on for the measurement. With the aid of the PHASE ADJ. knob (13), turn the chart until the crosslines of the light spot, which after amplitude adjustment is on the greatest chart circle, appear at $Z_0 = 0$ (impedance measurement) or ∞ (admittance measurement), depending on the chart used. The chart holder should be in such a position that the black line of the plexiglass screen is at that side to which the light spot deflects. After having pressed the button *) (3) below the small meter, turn the PHASE COR. knob (7) so that the meter (4) shows maximum deflection. To check this adjustment, find the maximum once again by rotating the chart. The Z-g Diagraph is ready for measuring if, at maximum deflection of the meter, the crosslines appear at the same place as before.

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*) If this button is pressed, it remains down until it is released by being pressed anew.

7. Measuring

7.1 Frequency Adjustment

After the desired measuring frequency has been adjusted on the signal generator, throw the FREQUENCY RANGE switch (12) (Fig. 23) to the corresponding range. Now tune the built-in oscillator by means of the coarse-fine drive marked FREQUENCY (10). Do not press the button (3). During tuning, the pointer of the discriminator meter (4) moves from the right to the left stop and then back again. The tuning is completed when the pointer, coming from the right stop, is at the red mark. Unambiguous tuning is ensured since the incorporated automatic frequency control will always shift the oscillator away from the resonance point if the adjustment is made to the image frequency.

To find the correct adjustment easily, turn the tuning knob counterclockwise; the first large pointer deflection of the discriminator meter is the correct one. When turning the tuning knob, further deflections of the pointer will occur, due to mixing of signal-generator harmonics with harmonics of the oscillator of the Type ZDU. However, on account of their much smaller amplitude, these deflections are easily distinguished from the deflection caused by mixing with the fundamental.

The fine adjustment of the frequency is made using the larger one of the two knobs mounted on the same shaft (10).

7.2 Impedance Measurement

Insert the chart shown in Fig. 24 or Fig. 26 as an impedance chart, i.e., $\underline{Z}/Z_o = 0$ should be above the black line of the plexiglass screen. The chart is chosen according to whether the result is to be represented by its
0357 resistive and reactive components or by magnitude and phase. Connect the
33 test item to the coaxial test line (9) while the coaxial reference line (11)

remains short-circuited. After adjustment for the desired measuring frequency, increase the input voltage until the pointer of the reference meter (6) deflects to 100 (red line). Once again check on the discriminator meter (4) that its pointer is still in the red range; if this is no longer the case retune the signal generator to the proper frequency. Press the button (3) and turn the PHASE ADJ. knob (13) until the pointer of the meter (4) is at maximum. Read the result on the chart or mark the point of intersection of the crosslines in pencil.

If, in the entire frequency range of interest, the crosslines of the light spot do not leave a circle around the centre with the values $\underline{Z}/Z_o = 0.5$ or $\underline{Z}/Z_o = 2$, insert a spread chart (Fig. 25 or 27) and switch (18) to INDICATION SPREAD. This means x3 magnification of the chart. The reference meter should be at full deflection, 100, (red mark) also for measurements in the spread range.

7.3 Admittance Measurement

Admittances are measured in the same way as impedances. The charts of Figs. 24 and 26, however, are inserted as admittance charts, i.e., so that $\underline{Z}/Z_o = \infty$ is above the black line.

When using the spread range and the associated chart according to Fig. 25 or 27, insert this chart so that $\underline{Z}/Z_o = 2$ is above the black line.

7.4 Investigating the Impedance or Admittance of Hard-to-get-at Items

Connect the test item to the coaxial test line (9) using a 50-Ω or 60-Ω or 75-Ω cable, respectively. Replace the short-circuit connector by a second cable of equal Z_o and identical electrical length connected to the coaxial reference line (11). Insert the short-circuit Dezifix into the free end of this cable. Fig. 2 shows an example of such a test assembly. To check whether

the electrical lengths of the two cables are actually equal, short-circuit also the coaxial test line at its end, select the input voltage so high that the pointer of the reference meter deflects up to the red mark, press the button (3) and turn the chart until the meter (4) shows maximum deflection. The crosslines of the light spot should then again by on $\underline{Z}/Z_o = 0$ or $\underline{Z}/Z_o = \infty$, depending upon whether the chart has been inserted for impedance or admittance measurement. If the phase adjustment was carried out before this measurement, it immediately shows the difference in the electrical lengths of the cables.

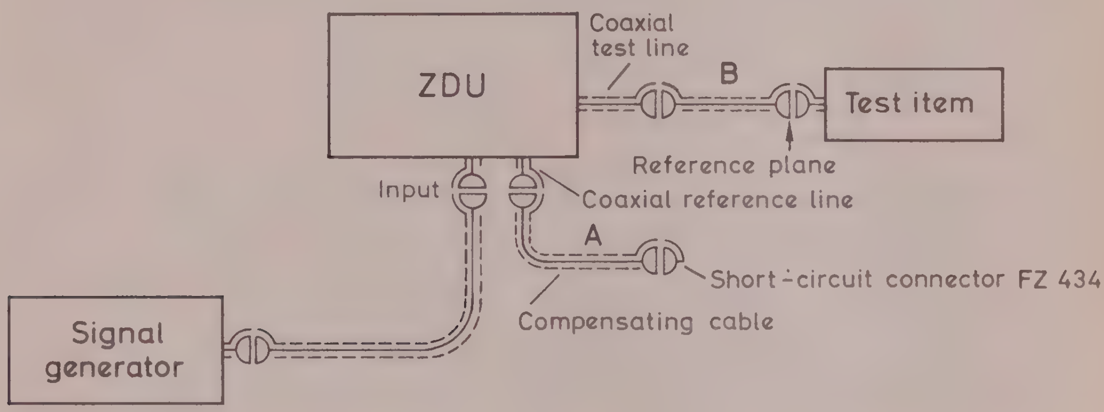

Fig. 2 Setup for impedance measurement on an item which is accessible only by means of a cable (A and B are a pair of 2-terminal measuring cables)

After the check has been completed, remove the short-circuit Dezifix connector from the measuring cable and connect the test item. Make the measurement as set forth under 7.2 or 7.3. The measured values read from the chart do not refer to the junction plane of the Dezifix connector at the Z-g Diagraph, but to the junction plane of the Dezifix connector at the end of the cable connected to the test item.

As mentioned before, it is important for the accuracy of the measurement that the electrical lengths of the cables are equal and that their characteristic impedances are equal to that of the Z-g Diagraph. Suitable cables,

i. e. pairs of 2-terminal measuring cables (see section 3. 2), may be ordered from ROHDE & SCHWARZ.

Measurements with cables, of which the electrical lengths are not exactly equal, can be made if the phase shift is eliminated by adjusting the PHASE COR. knob (7). This adjustment must be made after each change of frequency.

7. 5 Determination of the Complex Reflection Coefficient

Measure the complex reflection coefficient $\underline{p}_x$, defined by the equation

$$\underline{p}_x = \frac{\underline{Z} - Z_o}{\underline{Z} + Z_o}$$

with the coaxial test line terminated by a test item of the input impedance $\underline{Z}_x$, and proceed as in the impedance or admittance measurement set forth under 7. 2 or 7. 3. However, instead of the impedance chart, insert a chart bearing the inscription "Complex Reflection Coefficient Chart" (Fig. 28) in such a way that the angle of 180^o is over the black line of the plexiglass screen.

If the reflection coefficient is not greater than 0. 33 within the frequency range being investigated, the enlarged chart (Fig. 29) can be used. The measuring procedure remains the same. Switch (18) must be set to SPREAD.

7. 6 Measurement of Transmission Characteristics of 4-terminal Networks

7. 6. 1 Definition of the Effective Transmission Factor

The effective transmission factor is the complex quantity

$$g_B = \log_e \frac{E_o}{2\underline{E}_2} = a_B + jb_B,$$

the real component a_B [Np] being the effective attenuation and the imaginary

component b_B [radian] being the effective phase angle (cf R. Feldtkeller: Einführung in die Vierpoltheorie der elektrischen Nachrichtentechnik). The quantities E_o and E_2 are defined according to Fig. 3.

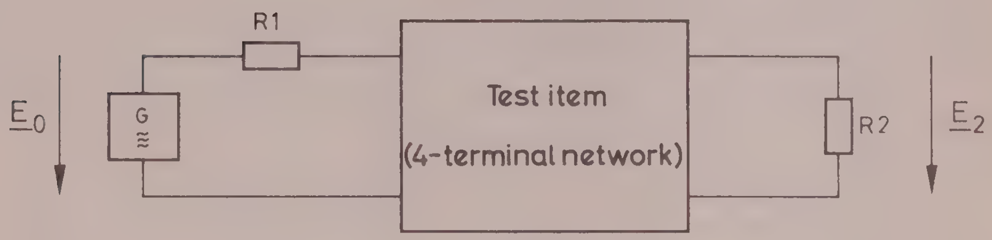

Fig. 3 Simplified diagram for the definition of the effective transmission factor

In the general case all the quantities, including R1 and R2, may be complex. The following instructions, however, are restricted to the case that $R_1 = R_2 = Z_o$, i.e. equal to the characteristic impedance of the Z-g Diagraph and of the coaxial lines used in the test setup, since only under this condition can accurate results be obtained. Matching Pads Type DAF (section 3.4) can be used for measuring the effective transmission factor in test assemblies that contain source and load resistances differing from the characteristic impedance of the Z-g Diagraph.

The transfer-constant chart (Fig. 30) is best used for measuring the effective transmission factor g_B or the effective attenuation a_B.

7.6.2 Measurement of Effective Attenuation Using the 4-terminal Feed Unit

Whereas the measurement of the effective transmission factor according to section 7.6.3 necessitates a T-section and two attenuator pads for feeding in the signal, the 4-terminal feed unit (section 3.3.1), which is less expensive, is sufficient when only the real component, i.e. the effective attenuation a_B is to be measured. Fig. 4 is the modified diagram of Fig. 3 depicting the measurement of effective attenuation with the help of the 4-terminal feed unit and Fig. 5 schematically shows the test setup.

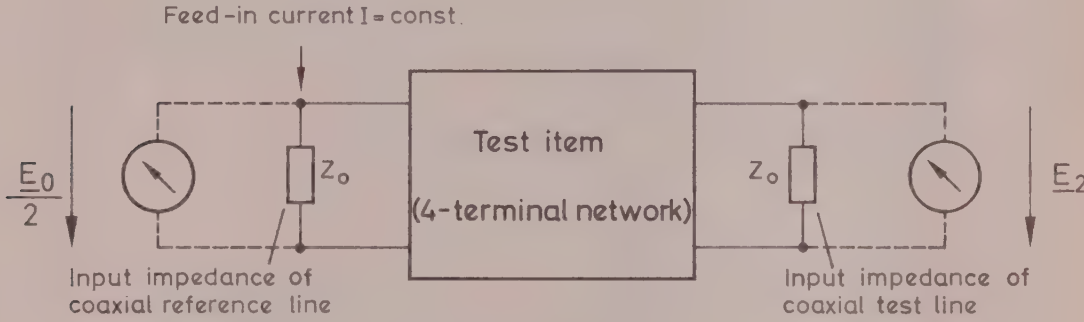

Fig. 4 Modified diagram of Fig. 3 depicting the measurement of effective attenuation with the help of the 4-terminal feed unit (section 3.3.1)

If the measurement is made according to Figs. 4 and 5, the source of the impedance Z_0 is represented by an impressed current in the input impedance of the coaxial reference line, which is transformed, without being changed, to the branching point via a matched cable.

Set up the test assembly according to Fig. 5 but without the 4-terminal network, i.e. connect the test cable B directly to the coaxial test line (9) (Fig. 23). Leave the input (14) of the Z-g Diagraph open. Adjust the signal generator to the desired frequency and tune the Z-g Diagraph. Then adjust the signal-generator voltage so that the light spot of the Z-g Diagraph goes to the outer circle of the chart (0 dB). If the 4-terminal network is

now inserted in the test assembly the effective attenuation can be read directly on the transfer-constant chart (Fig. 30). The correct result is obtained only if the signal-generator voltage is not readjusted after insertion of the 4-terminal network when the indication of the reference meter has changed. Since the input impedance of the 4-terminal network may differ from Z_o the voltage conditions at the branching point may be changed.

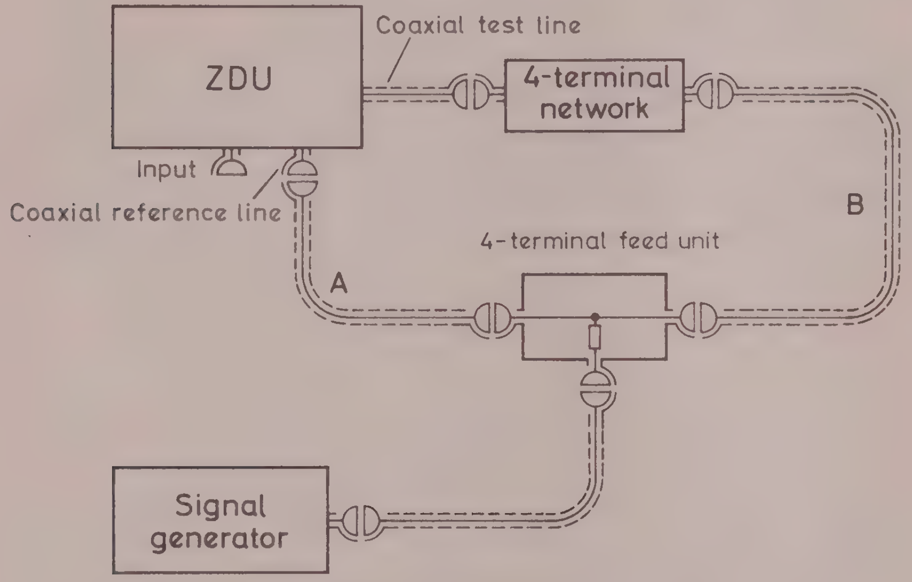

Fig. 5 Setup for the measurement of the effective attenuation a_B with the help of the 4-terminal feed unit (section 3.3.1) according to the simplified diagram of Fig. 4 (A and B are a pair of 2-terminal measuring cables according to section 3.2).

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7.6.3 Measurement of Effective Transmission Factor Using Two Attenuator Pads and a T-section

Only if the input impedance of the 4-terminal network is not very different from Z_o can the 4-terminal feed unit (section 3.3.1) be used for measuring the effective phase angle. Otherwise an error will occur which increases roughly linearly with the reflection of the 4-terminal network. If the input of the 4-terminal network presents a VSWR of, say, 1.4 the maximum error is 10^o.

The setup shown in Fig. 6, which is a modification of Fig. 3, permits the exact measurement of effective attenuation and effective phase angle regardless of the input reflection of the 4-terminal network being measured. E_o and E_2 can be read simultaneously on the Z-g Diagraph.

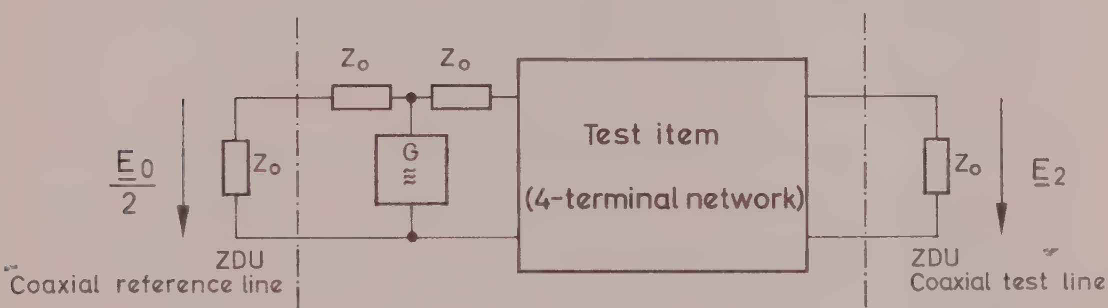

Fig. 6 Modified diagram of Fig. 3 depicting the measurement of the effective transmission factor with the help of two separate circuits

In the test setup of Fig. 7, the generator of Fig. 6, with the internal impedance $R_i = 0$ and the source impedance Z_o connected ahead, is replaced by a generator of arbitrary internal impedance (preferably $R_i = Z_o$) and two equal attenuator pads of $\geqq$ 20 dB (section 3.3.2.2).

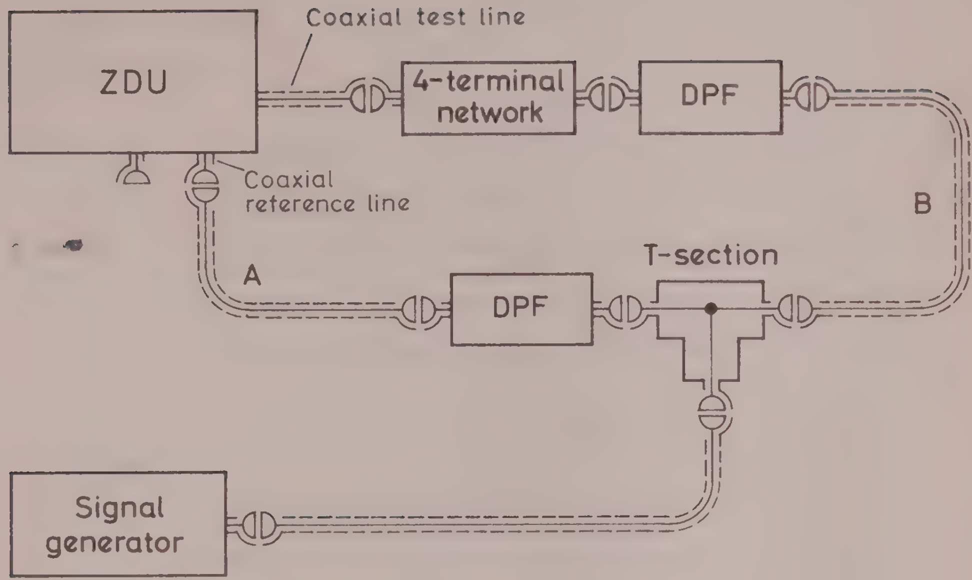

Fig. 7 Setup for the measurement of the effective transmission factor g_B with the help of a T-section and two 20-dB attenuator pads according to Fig. 6 (A and B are a pair of 2-terminal measuring cables according to section 3.2)

It is obvious that now the waves coming towards the inputs of the Z-g Diagraph are equal in amplitude and phase. Also the condition that the source impedance must equal Z_o is fulfilled with sufficient accuracy through the use of attenuator pads of $\geqq$ 20 dB; even a short circuit at the generator would result in a source-impedance error of less than 2%.

The voltage E_o present at the branching point of the T-section is measured in the coaxial reference line via a 20-dB attenuator pad and a cable of correct characteristic impedance and defined length. To compensate for the phase rotation caused by the cable and the attenuator pad and to make $R_i = Z_o$, a cable of equal electrical length and a similar attenuator pad must be connected into the test branch. The attenuator pad is best con-
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1. 41 cable errors. Since the inputs of the coaxial lines of the Z-g Diagraph

present very accurate impedances, E_o/E_2 is measured at the coaxial reference line and E_2 at the coaxial test line. The quantities E_o and E_2 are defined in Fig. 6.

The signal-generator voltage must be adjusted before the measurement. A correction of magnitude and phase on the Z-g Diagraph may also be necessary. It is therefore best to set up the test assembly of Fig. 7 without inserting the test item, i. e. to connect the attenuator pad directly to the coaxial test line. Then insert the transfer constant chart and adjust the signal-generator voltage so that the light spot is on the 0-dB circle. Correct for magnitude and phase as described in sections 6.4.2.1 and 6.4.2.2. Insert the 4-terminal network into the test branch, adjust the phase of the Z-g Diagraph and read the result in dB and degrees of angle on the chart. If the zero adjustment of the Z-g Diagraph is valid over a whole frequency range the 4-terminal network need not be removed for calibration after every frequency change. It is in this case sufficient to adjust the signal-generator voltage so as to obtain the reading of 100 on the reference meter and to make the phase adjustment. The result can then be directly read on the chart.

7.6.4 Measurement of Effective Transmission Factor on Amplifying Test Items

The foregoing sections deal with the measurement on passive 4-terminal networks such as filters, attenuators, etc. Often the effective transmission factor of amplifying, i. e. active 4-terminal networks such as tunnel-diode amplifiers and travelling-wave tubes is also interesting. If an amplifying network is connected into the test assembly according to section 7.6.2 or 7.6.3 after the Z-g Diagraph has been adjusted to 0^o and 0 dB the light spot goes beyond the boundary of the chart. The test setup must therefore be modified according to section 7.6.4.1 or 7.6.4.2.

7.6.4.1 Measurement Using Attenuator Pad and Compensating Line

An attenuator pad which has an attenuation greater than the gain of the 4-terminal network being tested is to be connected in series. The attenuation and phase rotation of the attenuator pad can be determined by a separate measurement and entered into the final result by calculation.

If the electrical length of the attenuator pad is known a compensating line of correct characteristic impedance and equal electrical length can be connected ahead of the coaxial reference line. In this case only the attenuation but not the phase rotation of the attenuator pad enters into the result.

Compensating lines of 10 cm and 20 cm electrical length are available from R&S. An electrical length of 30 cm is obtained by series connection. Compensating lines of other length can be made according to the sets of drawings (LNB 023/L/50, LNB 023/L/60 and LNB 023/L/75) attached to this instruction book. R&S supply the necessary tubular line and the corresponding inner conductor in 50-cm sections for the characteristic impedandes of 50, 60 and 75 Ω under the order designations LNB 05/50, LNB 050/60 and LNB 05/75, respectively. The designation LNB 05/75, for example, refers to a 75-Ω line (outer conductor 21 mm dia.) of 50 cm length, R&S also supply the necessary Dezifix elements; the corresponding R&S stock numbers can be found in the relevant parts lists.

Instead of the mentioned attenuator pad the Standard Attenuator Type DPU BN 18043 can be used for measuring amplifying items. Its electrical length is approximately 48 cm, largely independent of the attenuation setting. If a standard attenuator is provided in both the test branch and the reference branch it is possible to measure high positive or negative values of effective attenuation.

7.6.4.2 Measurement by Interchanging the Connections to the Coaxial Test Line and Coaxial Reference Line

Apart from the method described in section 7.6.4.1, a negative effective attenuation, i.e. gain, can be measured according to section 7.6.3 if, after adjustment of the Z-g Diagraph to 0^{o} and 0 dB and insertion of the 4-terminal network into the test branch, the connections to the coaxial test line and to the coaxial reference line are interchanged and the signal-generator voltage is so far reduced that the reading of the reference meter is again 100.

The measured quantity is then

$$\frac{2\underline{E}_2}{\underline{E}_o} = \frac{1}{r}\, e^{-j\varphi}$$

instead of

$$\frac{\underline{E}_o}{2\underline{E}_2} = r\, e^{j\varphi}$$

This method is described in more detail in section 7.11. Although this section deals with the measurement of negative impedance and admittance it also applies to the measurement of active 4-terminal networks.

7.6.5 Scattering Matrix

The scattering matrix is now frequently used above all in American literature for describing n-port networks (2n-terminal networks) such as directional couplers, filters, magic T's, etc.

The scattering matrix serves to calculate the waves reflected and transmitted by n-port networks as functions of the terminating loads and of the incident waves of the individual ports. A port corresponds to a reference plane for the measurement. One wave enters and one wave leaves every

port. The ratio of the two waves is determined by the connected 2-terminal networks.

In linear arrangements a linear relation exists between the incident waves

$$a_1 \ldots a_n$$

and the reflected waves

$$b_1 \ldots b_n;$$

for a 3-port, for example:

$$b_1 = S_{11}\, a_1 + S_{12}\, a_2 + S_{13}\, a_3$$
$$b_2 = S_{21}\, a_1 + S_{22}\, a_2 + S_{23}\, a_3$$
$$b_3 = S_{31}\, a_1 + S_{32}\, a_2 + S_{33}\, a_3$$

or as a matrix

$$\begin{pmatrix} b_1 \\ b_2 \\ b_3 \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \\ a_3 \end{pmatrix}$$

$$(b) = (S) \times (a)$$

It is found by comparison that S_{11}, S_{22}, S_{33} are complex reflection coefficients referred to the chosen reference planes, say the connection planes of a directional coupler, and that S_{12}, S_{21}, S_{13}, S_{31}, S_{23}, S_{32} are the complex effective transmission factors between the individual ports of the n-port if all other ports not involved in the measurement are terminated with zero reflection coefficient, i. e.

$$b_i / a_i = 0.$$

The scattering matrix is suitable to describe passive, reciprocal and non-reciprocal, as well as active elements (gyrators, amplifiers).

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The Z-g Diagraph is very useful for determining the elements of the scattering matrix since it indicates them directly on suitable charts.

7.7 Measuring the Phase Angle of Two Voltages of Identical Frequencies

When making investigations on directional antennas (straight groups, circular groups, etc.) and compensators, it is often necessary to determine the phase angle between two voltages of identical frequencies. After the amplitude and phase have been adjusted, apply one of the two voltages to be compared to (9) (Fig. 23), and the other to (11) (input impedance Z_o). Press the button (3) and, by turning the PHASE ADJ. knob (13), bring the pointer of the meter (4) to a maximum deflection. The result is then shown on the transfer constant chart (Fig. 30). In the case of an angle between 0 and 180°, the voltage applied to the coaxial test line is retarded by the measured angle in relation to the voltage present at the coaxial reference line. With angles between 180° and 360°, the conditions are reversed. The specified measurement accuracy holds under the assumption that the voltages applied deflect the spot galvanometer and the reference meter by at least 50%. If the voltages are too high, insert attenuator pads in both leads. The input 14 at the front panel remains open.

7.8 Using the Spot Galvanometer Section as a Linear Test Receiver

The input requirement of the coaxial test line is about 20 mV for full-scale deflection. The indication can be made either on a linear scale (reflection coefficient chart) or on a logarithmic scale (transfer constant chart), depending upon which of the two charts is used.

7.9 Measurements on Transistors

Similarly to the electron valve, a transistor can be treated as a 4-terminal network. For this reason it can be tested with the Z-g Diagraph like a 4-terminal network, i.e., the input and output impedances or admittances and the transmission characteristics can be measured as in any 4-terminal

network, thus permitting the determination of the 4-terminal network parameters in the high frequency range in question.

Due to the small size of the transistors, their connection to the Z-g Diagraph causes some difficulties, since the section of line between the coaxial test line and the transistor connection should have a characteristic impedance of Z_0, if possible, up to the pin. To this end, an adapter has been developed which meets these requirements and which, moreover, finds many other applications. This adapter serves for measuring the input impedances or admittances of transistors with three or more electrodes as set forth in sections 7. 2 and 7. 3 or their 4-terminal network transmission characteristics as outlined in section 7. 6. The often necessary impedance and admittance measurements, during which the output electrodes of the 4-terminal network are short-circuited or open for RF signals, can be made in a simple manner. Finally, this adapter also permits testing of diodes, chokes, resistors and other small circuit elements.

The Coaxial DC Feed Section with Capacitive DC Separation (BN 35616-2), which is supplied as an accessory unit to the Transistor Adapter (BN 35616) and is necessary for the measurement on transistors, can also be used without the adapter, if the test items must be fed with direct current. The electrical length of the Coaxial DC Feed Section is eliminated by a special compensating line.

7. 10 Measurement with Reduced Voltage

If too high an AC voltage is applied, say, for measuring the input impedance of a receiver, the measurement result will be incorrect due to overdriving. In the same manner, erroneous results may occur if the transistor is driven into the saturation region.

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To avoid this error, reduce the voltage applied to the unknown to one third. Proceed as follows: short the coaxial test line and the coaxial reference

line, reduce the generator voltage and insert a "normal" impedance-admittance chart (Fig. 24) into the chart holder. Switch to INDICATION SPREAD. This makes the galvanometer three times as sensitive as before. Adjust the generator voltage so that the crosslines of the light spot are on the outermost chart circle. Due to the higher galvanometer sensitivity, this is the case with one third of the generator voltage required for INDICATION NORMAL. The reference meter, therefore, gives one third of its full-scale deflection. Take this voltage as reference in the following measurements. To facilitate the adjustment and to increase the accuracy, adjust for an even value on the reference meter, using the REFERENCE VOLTAGE COR. knob.

7.11 Measurement of Negative Impedance and Admittance

Negative impedances occur in elements whose current-voltage characteristic is partly falling. Fig. 8 shows the characteristics of the two possible types of negative impedance, namely the electric arc and the element group, for example the tunnel diode.

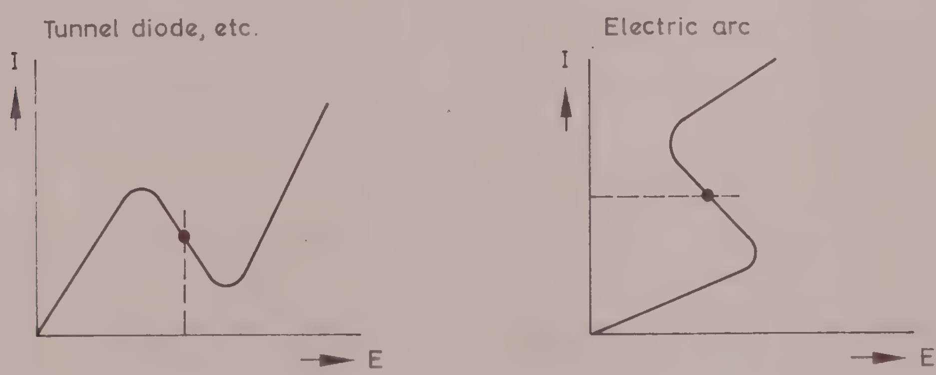

Fig. 8 Characteristics of the two possible types of negative impedance

Tunnel diodes have gained great importance at very high frequencies. A reliable and quick measuring method is therefore of great value. The measurement is best based on the directional-coupler principle since it is the only way to find, in addition to the magnitude of the impedance or

admittance, whether its real component is positive or negative. Since the Z-g Diagraph uses coaxial directional couplers it is suitable for measuring impedances and admittances having a negative real component. A directional coupler is the only means of determining whether the amplitude of the incident or the reflected wave is greater, whereas a slotted line always shows a standing wave irrespective of whether the real component of the terminating admittance is positive or negative. Thus it is impossible to determine whether the amplitude of the incident or reflected wave is greater, and consequently whether a positive or negative real component is concerned.

An impedance of the tunnel-diode type, presenting a falling voltage-current characteristic, requires a suitable parallel admittance for stable operation. This admittance is represented by attenuator pads in both the coaxial test line and the coaxial reference line. The Z-g Diagraph thus permits the direct measurement of such test items up to the reciprocal of its characteristic impedance (50 Ω, 60 Ω, 75 Ω). Higher negative admittances can be measured by connecting a suitable positive admittance in parallel to the test item and eliminating it from the measured result by calculation. The additional positive admittance must be so proportioned that together with that of the coaxial test line or the coaxial reference line it is equal to or greater than the negative admittance of the test item.

If an admittance with a negative real component is connected to the Z-g Diagraph in the normal way, the light spot goes beyond the outer circle of the chart. The measurement is nevertheless possible if the connections are changed, i. e. the test item is connected to the coaxial reference line and the coaxial test line is shorted. The reference meter gives a reading > 100 which is to be adjusted to 100 by reducing the signal-generator voltage. After the ordinary phase adjustment the negative impedance or admittance can be read on the chart. The impedance or admittance is referred to the negative impedance Z_o (50 Ω, 60 Ω or 75 Ω) or to the negative admittance Y_o.

The connection of a tunnel diode to the Z-g Diagraph via a DC feed section is shown in Fig. 9. The compensating line inserted between the coaxial test line and the short-circuit compensates for the electrical length of the DC feed section. If the test item is connected directly to the coaxial reference line without a DC feed section the short-circuit is also to be connected directly to the coaxial test line.

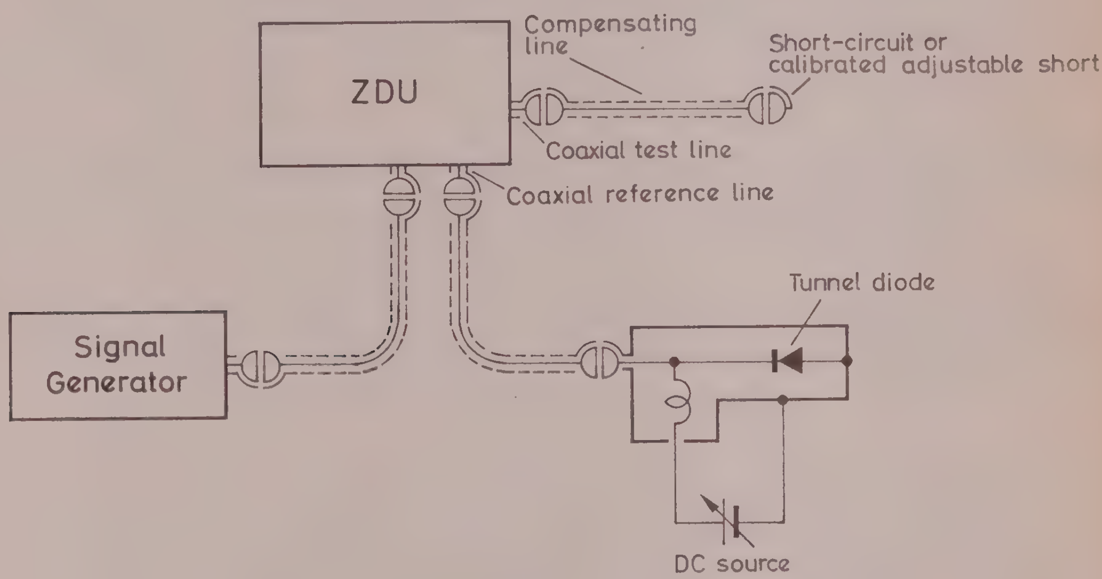

Fig. 9 Connection of a tunnel diode to the Z-g Diagraph via a DC feed section for impedance and admittance measurement

The described method for measuring impedances or admittances with negative real components is based on the following fact:

normally the Z-g Diagraph measures the complex reflection coefficient

$$r\,e^{j\varphi} = \frac{1 - \left(\frac{R}{Z_o} + j\frac{X}{Z_o}\right)}{1 + \left(\frac{R}{Z_o} + j\frac{X}{Z_o}\right)}$$

This expression is greater than unity if $\frac{R}{Z}$ is negative. A reflection coefficient > 1 cannot be measured with the Z-g Diagraph since the light spot goes

beyond the outmost circle of the chart. The reciprocal is therefore measured by interchanging the connections:

$$\frac{1}{r} e^{-j\varphi} = \frac{1 + \left(\frac{R}{Z_o} + j\frac{X}{Z_o}\right)}{1 - \left(\frac{R}{Z_o} + j\frac{X}{Z_o}\right)}$$

This value is less than unity for negative R values and can therefore be measured. The method is equivalent to the introduction of a negative reference impedance $-Z_o$.

The introduction of a negative reference impedance has the following effects in the representation of the result in impedance-admittance charts:

(a) The chart is oriented counterclockwise. This means that the curve representing the impedance of a line section as a function of frequency runs counterclockwise with increasing frequency.

(b) The imaginary component changes its polarity because of the negative reference impedance. A point on the outer circle of the chart lying in the region of positive imaginary components for a positive reference impedance (Fig. 10 a) appears in the region of negative imaginary components with a negative reference impedance (Fig. 10 b).

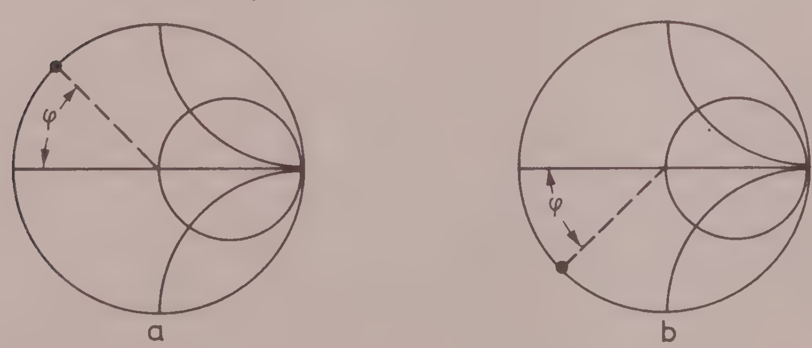

Fig. 10 Effect of the negative reference impedance on the imaginary component of an impedance or admittance

(c) As mentioned above, the negative reference impedance is obtained by interchanging the coaxial test line and the coaxial reference line. The chart remains in its normal position in the chart holder. If the reading obtained on the chart is, say,

$$\frac{R + jX}{(-Z)} = 0.3 + j0.7$$

the true impedance is

$$R + jX = 0.3Z - j0.7Z$$

where $Z > 0$.

(d) When the impedance curve of a tunnel diode is plotted as a function of the DC bias at a fixed frequency, some parts of the curve will lie in the positive and others in the negative impedance region. A typical curve is shown in Fig. 11.

The positive and negative real components can be shown immediately adjacent to each other if the chart is turned over on its axis while making the $\frac{1}{r}$ measurement with interchanged coaxials, so that the matte side comes against the plexiglass screen. The curves can then be traced with a grease pencil or something similar.

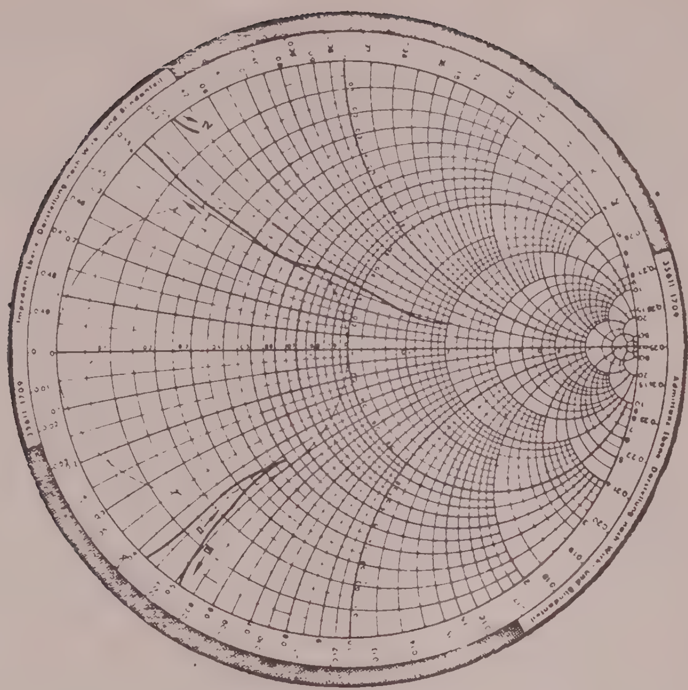

Fig. 11 Impedance curve of a tunnel diode as a function of DC bias. I and IV are portions with a positive real component (measured in the normal way), II and III are portions with a negative real component (measured with the coaxial test line and coaxial reference line interchanged).

7.12 Measurement with Higher or Variable Voltage Levels

The Z-g Diagraph requires a fixed voltage for indication. It is so proportioned that the reference meter or the mirror galvanometer gives full deflection for a reflection coefficient r = 1. This voltage corresponds to a level at the test item of about 20 mV at normal indication and about 7 mV at spread indication. Certain measurements, however, require a higher voltage at the test item, for example:

(a) Investigations on valves.

(b) Investigations on power transistors used for large-signal operation. The test voltage level must in this case correspond to the levels encountered in large-signal operation. The results obtained with small-signal values are not valid for large-signal operation.

(c) Measurements on items exposed to relatively high noise levels. If it is impossible to shield the test item the test voltage level must be so high that the noise level has no intolerable influence on the result. It is, of course, necessary that the test item withstands the test voltage level. An example is the measurement of input impedance or admittance of an antenna in a transmitter station where neighbouring transmitting antennas are operating.

Since it is impossible to increase the voltage level in the Z-g Diagraph because of the required fixed voltage, two external directional couplers must be connected each via a standard attenuator to the coaxial test line and the coaxial reference line, respectively. Suitable directional couplers can be supplied by R&S; please enquire in the case of need. Fig. 12 shows a test assembly for any kind of test item, Fig. 13 for impedance measurement on transistors and Fig. 14 for the measurement of 4-terminal parameters of transistors.

If the signal generator supplies sufficient power and if the directional couplers present a suitable coupling attenuation this test setup permits measurements up to very high power. For example, the impedance of an antenna under the effect of hoarfrost, ice, etc. can be measured in CW operation if suitable check points for the connection of the directional couplers are available on the transmitter.

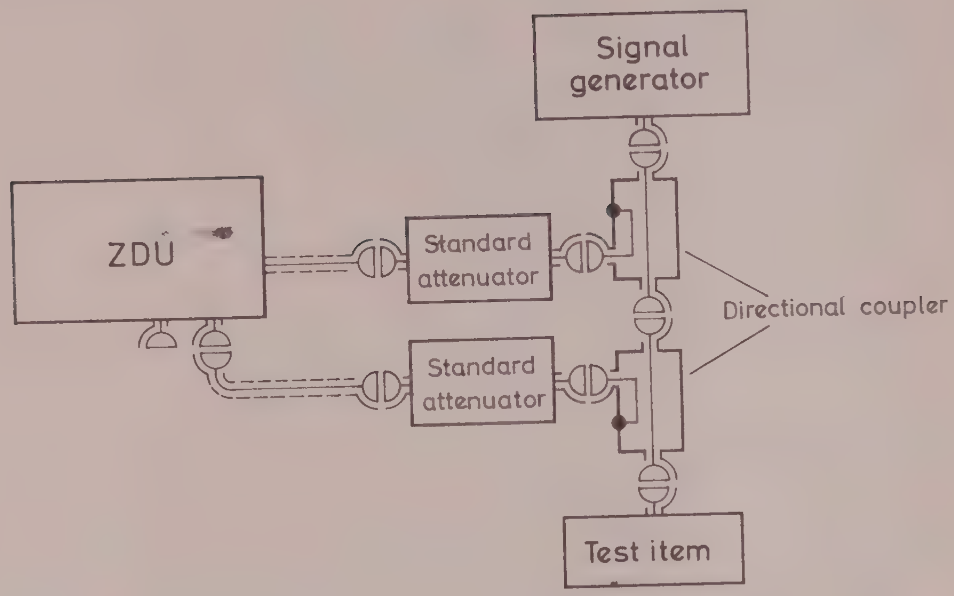

Fig. 12 Test setup for measurement with higher test voltage

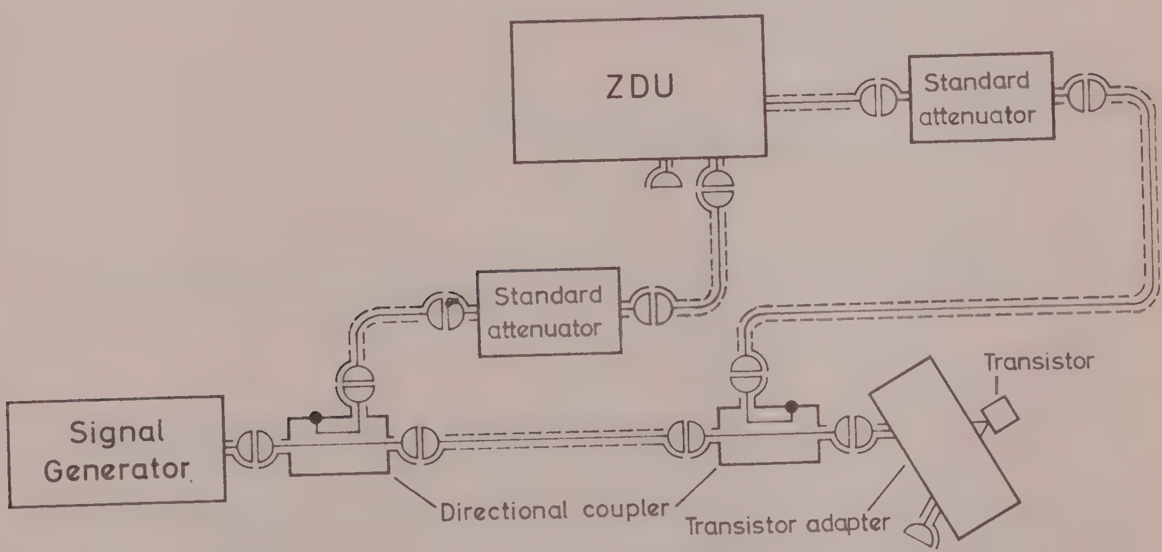

Fig. 13 Test setup for impedance measurement on transistors with higher test voltage

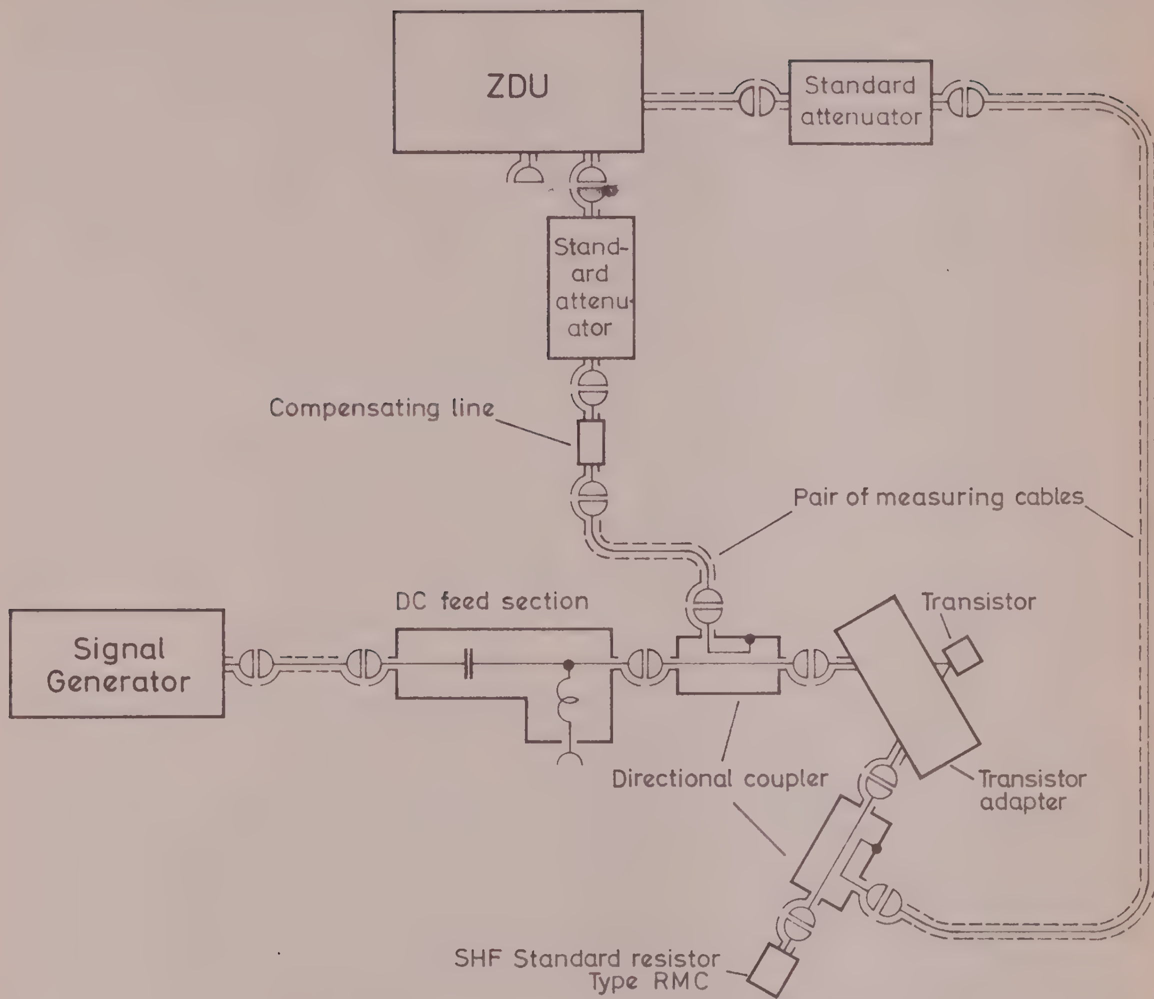

Fig. 14 Test setup for the measurement of transmission characteristics of transistors with higher test voltage

7.13 Measurement of Balanced Items

Since the coaxial test line of the Z-g Diagraph is unbalanced, measurements of balanced test items can be made only when a balun is connected between the test item and the set. For test items with the same characteristic impedance as the Z-g Diagraph in use (50 Ω, 60 Ω or 75 Ω), the Broadband Baluns Type BSU shown in Fig. 15 are very suitable. They are supplied in various models with different frequency ranges and with different

types of connection on the balanced side, as shown in the table in section 3.8.

Fig. 15 Broadband Baluns Type BSU

Balanced test objects frequently have high characteristic impedances (200 Ω, 240 Ω or 300 Ω) corresponding to those of commercial strip transmission lines. In order to enable such items to be measured with the Z-g Diagraph, a balanced Impedance Transformer Type BSI (Fig. 16) is connected between the set and the test item. This not only balances the coaxial test line but also transforms the characteristic impedance.

Fig. 16 Impedance Transformer Type BSI

Type BSI is available in nine models, differing in the characteristic impedance and frequency range. Six of them are listed in section 3. 7, and these are suitable for use with Z-g Diagraph Type ZDU. The characteristic impedance of the unbalanced side of Type BSI must always be the same as that of the Z-g Diagraph employed. For instance, a Type BSI BN 90634/240 or BN 90635/240 with 60 Ω on the unbalanced side and 240 Ω on the balanced side matches a Z-g Diagraph Type ZDU having Z = 60 Ω.

7. 14 Measurement of Material Characteristics

The measurement of the material characteristics ε_r, $\tan\delta_\varepsilon$, μ and $\tan\delta_\mu$ is indispensable for the use of permeable and dielectric materials in RF engineering. Since these material characteristics are closely related to the molecular structure their behaviour depending on frequency and temperature permits conclusions to be drawn on mechanical and chemical properties. On the other hand, they help to find new methods of surveying and controlling chemical processes. The material characteristics measurements thus gain growing importance.

The four material characteristics are determined from impedance measurements and the specimen dimensions. The Z-g Diagraph Type ZDU is suitable as an impedance meter especially for measurements on materials with heavy attenuation, but not on very low-loss materials (small $\tan\delta_\varepsilon$).

In addition to the Z-g Diagraph as impedance meter and a suitable signal generator, the material characteristics measurement requires a specimen container. Various models of specimen container are available. The description of the measurement and calculation of the material characteristics would go beyond the scope of this instruction book. The theory is treated in detail in the Kurzinformation 3-4/1962 and in the two papers by Dr. R. Eichacker:

(a) A Material-Characteristics Test Assembly for Determining the Electromagnetic Material Constants of Solid and Liquid Media

at Frequencies between 30 and 7000 Mc and Temperatures between -60 and +240°C (R&S-Mitteilungen No. 11/December 1958)

(b) Measurement of Material Characteristics Using Standing-Wave Detectors (R&S-Mitteilungen No. 15/April 1961)

Reprints of the two papers and No. 3-4/1962 of Kurzinformation can be obtained from R&S. It may also be interesting that ready-made programmes for IBM computers exist for the calculation of the material characteristics from the measured impedance values and the specimen dimensions.

7.15 Cable Measurement

7.15.1 Definition of the Quantities Characteristic Impedance, Attenuation, Propagation Velocity and Homogeneity

RF cables are designated by their characteristic impedance, attenuation and propagation velocity.

Also, to an increasing degree, the homogeneity plays a role as a measure of the constancy of these quantities and thus is a measure of the quality and usability of any given cable.

The homogeneity of a cable is determined by its structural and constructive make-up and is closely related to the wavelength at the operating frequency. Thus a coaxial cable with inner-conductor supports of Trolitul spaced periodically along its longitudinal axis is not homogeneous when the spacing is comparable with the operating wavelength; however, the line becomes quasi-homogeneous when the spacing is much smaller than the operating wavelength.

Almost all RF cables today are homogeneous with reference to their structure using materials such as Mipolan, Lupolen, polyethylene and Moltopren. The irregularities detectable on such cables are attributed to various

defects in manufacture, e. g., deviations in the outer diameter of the insulation, air bubbles and pockets, variations in winding pitch in the case of braided outer and stranded inner conductors of flexible cables. All of these defects are aggravated by continuous flexing movements. For this reason, appropriate acceptance tests must be made.

If the irregularities mentioned are periodic or statistically distributed along the cable, this causes variations in the three quantities characterizing the cable. Therefore, in addition to the general definition of the characteristic impedance,

$$Z \approx \sqrt{L' / C'} \qquad (1)$$

it was decided (par. 2. 8 of the IEC Recomm. 96-1, 1958) that an average characteristic impedance Z_m and an effective characteristic impedance $\underline{Z}_e$ should be differentiated. The average characteristic impedance Z_m is defined as the arithmetical mean of the characteristic impedance for successive sections of cable.

The effective characteristic impedance $\underline{Z}_e$ can be thought of as the input impedance of an infinitely long cable, this input impedance being caused by structural irregularities and measured at the operating frequency. For an infinitely long cable one could substitute a cable of such a length that its attenuation has a value of at least 20 dB.

This "effective characteristic impedance", i. e., the input impedance at any given test frequency, can under certain circumstances deviate substantially from the "average characteristic impedance", above all at frequencies whose wavelength along the cable is equal to twice the spacing of a periodic irregularity. Depending upon the regularity with which such an inhomogeneity is repeated, the peaks of the $\underline{Z}_o$ variations as a function of frequency have varying sharpness. Such peaks occurring in the frequency range of the intended energy transmission may render it impossible to use the cable.

In addition to determining the three basic constants Z_m, α and v, checks are now being made to determine the homogeneity using impedance measuring equipment or directional couplers. Since irregularities are especially noticeable in Z and α, it is sufficient to investigate only one of these two quantities. This is usually the characteristic impedance.

The attenuation of a cable is the logarithm of the ratio of the input power (P_1) to the output power (P_2) of a cable for a pure incident wave.

$$\alpha = \alpha l = \frac{1}{2} \lg \frac{P_1}{P_2} = \left(\frac{R'}{2Z} + \frac{G'Z}{2}\right) l \qquad (2)$$

where l is the physical length of the cable.

The cross-talk or coupling attenuation of a cable determines, referred to the primary power, the power induced by the cable being tested in another cable through direct or electromagnetic coupling.

The phase constant β, propagation velocity v and the electrical length l_e can all be determined from the relationship

$$v = \frac{1}{\sqrt{L'C'}} = \frac{\omega}{\beta} = c \frac{l}{l_e} = \frac{\lambda_k}{\lambda_o} \qquad (3)$$

7.15.2 Determining the Characteristic Impedance

(see Mil C 17 B, 4.6.16 and IEC Publ. 96-1, 2.8 and 2.9)

7.15.2.1 Mean Characteristic Impedance Z_m

The usual method for determining Z_m from the distributed capacitance per unit length c' (measured at the low frequencies f_n) and the phase velocity v (measured at the operating frequency f) is only then reliable when the medium between the inner and outer conductor is exactly known and when the dielectric constant between f_n and f is practically independent of the fre-

quency. If this is true, in the most favourable case only one measurement is sufficient at the operating frequency to determine the mean characteristic impedance Z_m (section 7.15.2.1.1).

The method using the Calibrated Adjustable Short according to section 7.15.2.1.2 is somewhat more time consuming than the above method, but has the advantage that Z_m can be determined directly at the operating frequency without any limiting assumptions (dielectric constant does not change between f_n and f as described in section 7.15.2.1.1). A further advantage can be seen in the simultaneous determination of the cable attenuation (section 7.15.3).

Moreover, Z_m can be determined from the mean value of a large number of effective impedance values Z_e measured at frequencies at close intervals throughout the band of interest as long as this band is wide enough to provide an impedance curve with a sufficient number of deviations from its mean value.

7.15.2.1.1 Determining Z_m from the Phase Velocity v and the Capacitance C

Insertion of equation (3) and (1) gives

$$Z_m = \frac{1}{vC'} = \frac{1}{vC_{total}} \qquad (4)$$

The capacitance C_{total} = C' 1 of the cable is measured at a low frequency using a bridge of high accuracy; the phase velocity v is measured at the desired test frequency according to section 7.15.4.

Insertion of the relationship (16) found in section 7.15.4 in equation (4) gives

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$$Z_m = \frac{1}{2\Delta f C_{total}} \qquad (5)$$

This equation shows that Δf is constant with a given C_{total} and Z_k. The lowest frequency for a $\lambda_k/4$ resonance is $f_{min} = \frac{\Delta f}{2}$.

Equation (5) may therefore be written as follows:

$$Z = \frac{1}{4\, f_{min} C_{total}} \qquad (6)$$

Cables to be measured should not be more than 30 to 50 λ_k in length.

This is the most accurate method of determining the average characteristic impedance Z_m.

In addition to an error of 0.1 to 0.2% in the C_{total}, an error for v which is identical with the error of a frequency measurement must be considered. Accuracies of several tenths of a per cent may be obtained when using such equipment as the Frequency Synthesizer Type XUA BN 444463 as a standard signal generator with high stability, or a frequency meter with an error less than 0.1%, e.g. Type WAL BN 4321/2.

In contrast to all other possible measuring techniques, the measuring accuracy is negligibly affected by irregularities. The reason for this is that periodic or statistically distributed irregularities in the cable cause variations in L' and C' which are opposite to one another. Thus the characteristic impedance is very highly affected while the phase velocity is practically the same. Even if an additional phase shift is produced by impedance transformation at the points where irregularities occur, this will be less than the impedance disturbance.

7.15.2.1.2 Cable Input Impedance when Terminated with an Adjustable Short

If, with a constant test frequency, the short-circuit piston of the adjustable short is moved through a half wavelength, the locus of all input impedances is obtained as a circle in a Smith chart. The centre point with its real component gives the mean characteristic impedance Z_m.

The most satisfactory length of cable is only a few metres for determining Z_m. The minimum attenuation of the cable should be approximately 1.5 dB. In no case should the entire attenuation of the cable be more than approximately 6 dB for impedance averaging by the node-shift method. In the case of cables which are too long, the effective characteristic impedance is measured instead of the average characteristic impedance.

7.15.2.2 Effective Characteristic Impedance $\underline{Z}_e$

Measurements of $\underline{Z}_e$ and Z_m are justified in all those cases in which a doubt exists as to the frequency independence of the dielectric constant of an insulating material, or if a dispersion of the cable impedance appears possible because of the cable construction. In particular, such measurements will be useful if the actual input impedance of a long, terminated cable is to be determined.

The average characteristic impedance is obtained in the same manner using one of the three methods (7.15.2.2.1 - 3) by taking the average of a large number of individual measurements obtained at frequencies lying close to one another.

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7.15.2.2.1 Short- and Open-Circuit Measurements

The input impedance $\underline{Z}_K$ of a short-circuited section of cable with a characteristic impedance Z is

$$\underline{Z}_K = Z \tanh \gamma l \tag{7}$$

For an open-circuited cable, the following equation is valid

$$\underline{Z}_L = Z \coth \gamma l \tag{8}$$

Taking into account that the characteristic impedance is always practically inhomogeneous, the effective characteristic impedance is obtained from the measured open and short-circuit impedances.

$$\underline{Z}_e = \sqrt{\underline{Z}_K \, \underline{Z}_L} \tag{9}$$

The lengths of cable used for the measurement should be $(2k - 1)\ \lambda_K/8$; ($k = 1, 2, 3, \ldots$), i.e., in the most favourable range for measuring the reactance (small influence due to errors in length).

7.15.2.2.2 Input Impedance of Very Long Cables

In the case of long cables with an attenuation over 20 dB, the short-circuit and open-circuit input impedances become practically the same so that it is only necessary to make one measurement with any type of termination. The effective characteristic impedance $\underline{Z}_e$ is then

$$\underline{Z}_e = \underline{Z}_K = \underline{Z}_L \tag{10}$$

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7.15.2.2.3 Cables of Medium Length, Match-terminated

In the case of cables of medium length, it is possible to get by with only one measurement of the input impedance if provision is made for the attenuation of the reflected wave by proper termination. The cumulative effects of periodic irregularities, which cause a deviation of $\underline{Z}_e$ from $\underline{Z}_m$, can only be sufficiently detected when the attenuation of the cable section is at least 20 dB.

7.15.2.3 The Influence of the Connector on the Z Measurement

In the four measurement possibilities described above, it was assumed that the connector used to terminate the cable has the same characteristic impedance as the cable under investigation. In practice, this is not always the case. The connector can - although it is itself homogeneous - have another absolute value of characteristic impedance. It can also be badly mounted and thus cause a series inductive or a parallel capacitive component between the cable and connector. If the connector is itself inhomogeneous (e.g., poorly compensated supports), and in addition is badly mounted, the evaluation of the above measurements can be substantially more difficult. If a result which is difficult to ascertain lies in the VHF-UHF range, it is best to lower the test frequency so far that the entire disturbance is much less than λ in order to obtain an average evaluation.

In the following paragraphs, typical examples are given for the determination of the effective characteristic impedance and the evaluation of the respective impedance charts.

7.15.2.3.1 Homogeneous Cable with a Reactive Discontinuity only at the Input, Discontinuity much less than λ

Z errors of the connector, defective mounting or equalization of the supports manifest themselves as concentrated series inductances or parallel capacitances under the assumption that the discontinuity is much smaller than the wavelength. Since the cable is assumed to be homogeneous, the mean characteristic impedance and the effective characteristic impedance are the same.

In the case of measurements according to 7.15.2.2.1 - 3, the input impedance of the cable in the Smith chart, as shown in Fig. 17a, is depicted as a point whose real component is the cable Z_o and whose reactive component is the inductive discontinuity of the connector. In case b (capacitive discontinuity caused by connector), the characteristic impedance Z_m is designated by the intersection with the real axis of a circle which passes through Z = 0 and the measured value b since this involves a shunt quantity.

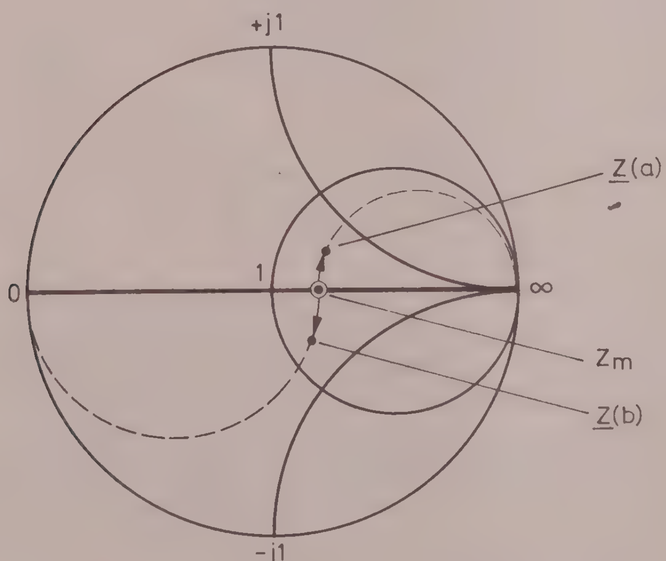


Fig. 17 Cable input impedance $\underline{Z}$ with discontinuity at one end
(a) Inductive discontinuity,
(b) Capacitive discontinuity

7.15.2.3.2 Homogeneous Cable with a Reactive Discontinuity at the Input and at the Output, Discontinuity much less than λ

In contrast to section 7.15.2.3.1, in this case both ends of the cable have discontinuities. A single measurement according to one of the methods 7.15.2.2.1 - 3 is not sufficient to evaluate the result. Measurements made at close frequency intervals (e.g. f_1 to f_6) result in a circle around Z (a) or Z (b) whose diameter depends upon the amount of reflection from the end of the cable. In the case of long-length cables, the reflected wave is attenuated so that the points Z (a) or Z (b) are again obtained. Evaluation of Z (a) and Z (b) is made according to section 7.15.2.3.1.

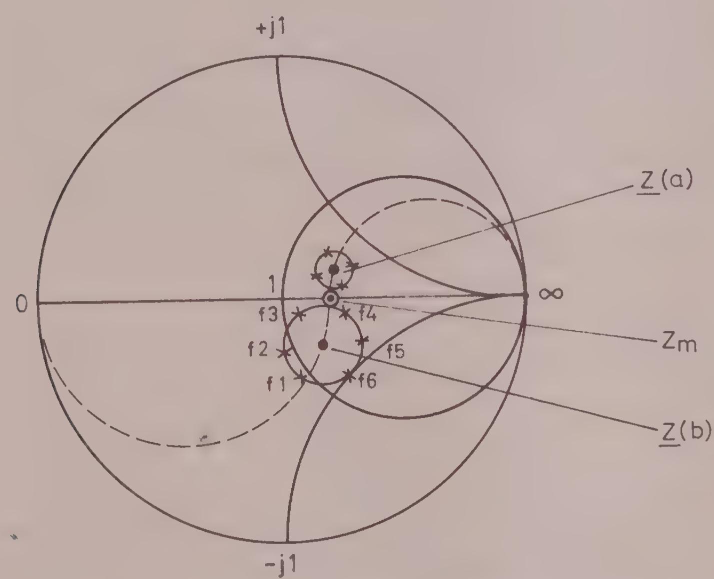


Fig. 18 Cable input impedance $\underline{Z}$ with discontinuities at both ends (frequency as parameter) for
(a) Inductive discontinuity at input,
(b) Capacitive discontinuity at input of cable with a characteristic impedance Z_m.
The reflection from the output discontinuity is in the case of (b) much greater than in the case of (a).

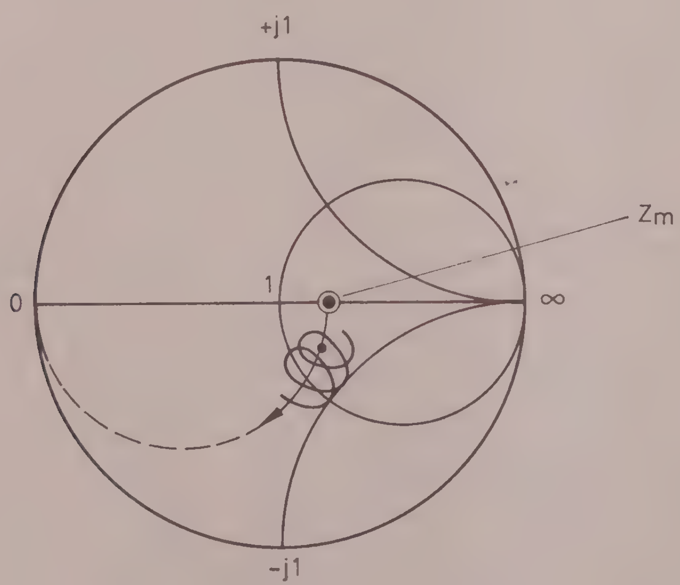
In order to obtain a circle, five or six points should be measured, the frequency interval being estimated very simply from the electrical length of

the cable and the operating wavelength. A circle may be obtained from a total frequency variation of

$$\frac{\Delta f}{f} \approx \frac{\lambda K}{2 l} \qquad (11)$$

This frequency interval is then divided into approximately five or six equal periods. In order to check the homogeneity of a cable, several circles should be obtained, all circles being the same in the case of a perfectly homogeneous cable.

If the total frequency interval is too large in comparison with the starting frequency, the circle will become a spiral (because of the change in reflection with frequency at the end of the cable), whose centre point wanders along the dashed semi-circle because of the frequency-dependent input reflection. Fig. 19 results from the assumption of two discontinuities, a capacitive one at the cable input and one of either kind at the cable end, which are equal in amplitude.



0357 Fig. 19 Cable input impedance with a capacitive discontinuity at the input and either kind of discontinuity at the output (frequency
69 as parameter), when Δf is not small compared with the test frequency.

In practice, the cables are always more or less inhomogeneous (see 7.15.2.3.5 and 7.15.2.3.6). It is therefore recommended that such spiral forms be avoided by sufficiently small frequency variations in order to avoid unnecessary complication of the evaluations.

7.15.2.3.3 Inhomogeneous Cable with a Reactive Discontinuity only at the Input, Discontinuity much less than λ

With reference to section 7.15.2.3.1, the impedance characteristic as shown in Fig. 20 is obtained in the case of inhomogeneous cables.

The input impedance curls in relatively small loops about a mean impedance value whose real component gives the mean absolute characteristic impedance. If this group of impedance loops is transposed through the distance of the discontinuity to the axis of reals, this transposed curve is identical with the effective characteristic impedance according to 7.15.2.2.

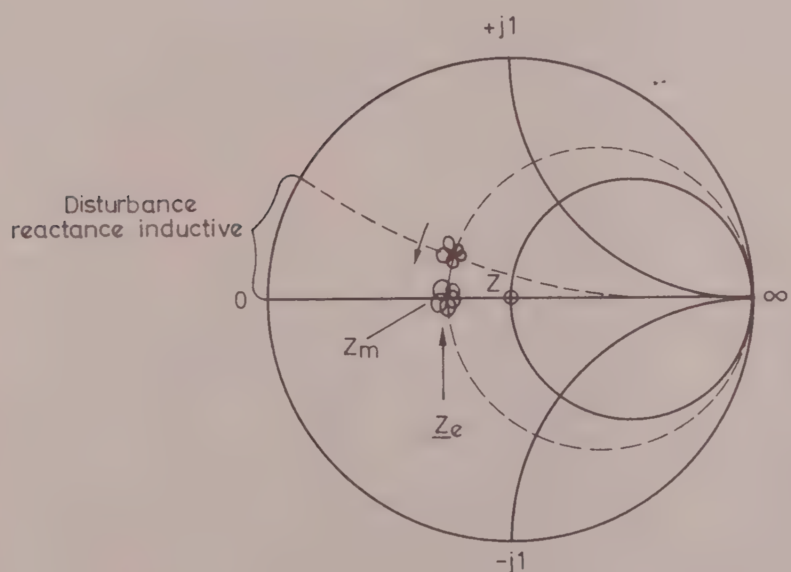


Fig. 20 Determining the effective characteristic impedance $\underline{Z}_e$ and the mean characteristic impedance Z_m from the input impedance of a long cable.

If the loop family lies in the capacitive section of the Smith chart, it is best to use an admittance chart, the resistive component then being the centre point of the admittance which equals the characteristic impedance $Y_O = \frac{1}{Z_O}$.

A cable with an input impedance corresponding to that shown in Fig. 23 can be designated as satisfactory to good depending upon the diameter of the loop family. The discontinuities of the characteristic impedance are mostly of statistical nature or residual reflections of the cable connector. The centre point of the loop family transposed to the horizontal axis is equal to the mean characteristic impedance Z_m to within a good approximation.

7.15.2.3.4 Inhomogeneous Cable with Periodic, Statistical and Input-connector Discontinuities in a Smith chart and in a Reflection-coefficient Chart. Analysis

The diagrams below are the two most commonly used representations of the cable impedance or reflection.

The more general display is naturally in the complex plane since, with the exception of the attenuation, all important cable characteristics are represented: the mean characteristic impedance, the effective characteristic impedance, and thus the homogeneity (see Fig. 21).

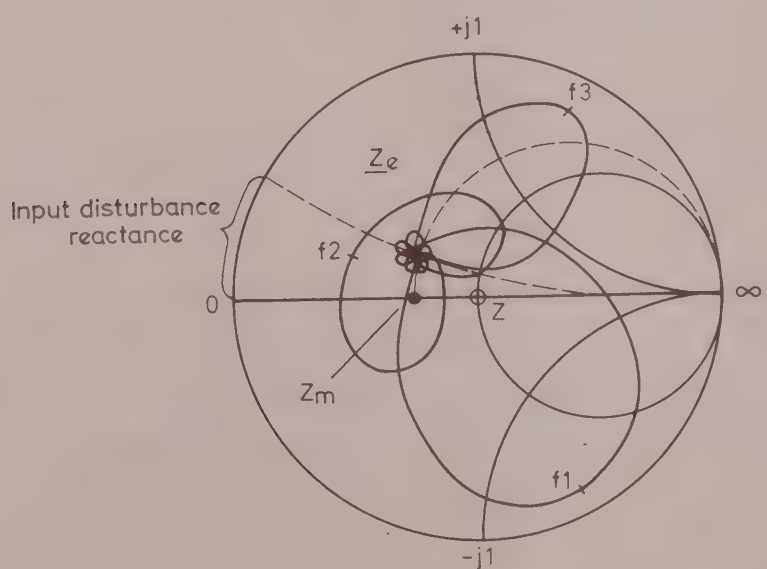


Fig. 21 The input impedance of an inhomogeneous cable with periodical, statistical and input-connector discontinuities

In addition to the loop family, whose details are no longer recognizable for long cables, large loops appear with the centre frequencies f_1, f_2 and f_3 which are caused by large periodic discontinuities in the cable. The reactive component of the centre impedance of the loop family can be attributed to a connector discontinuity at the cable input while the resistive component again gives the mean characteristic impedance. The effective characteristic impedance can be read in magnitude and phase for each frequency when the entire loop family with its centre impedance is transposed to the horizontal axis. This effective characteristic impedance is an excellent measure of the cable homogeneity.

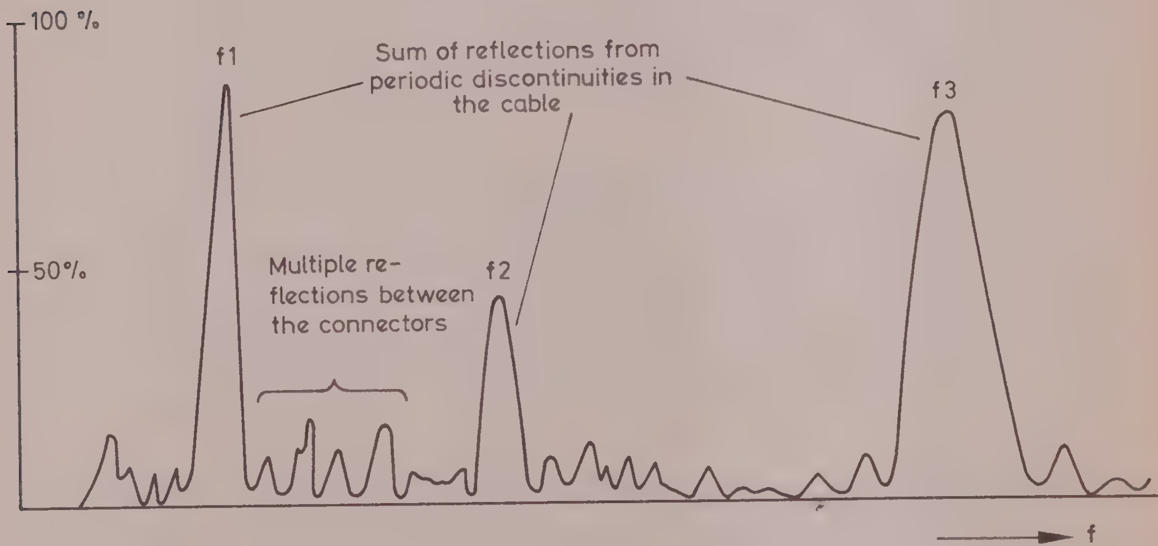


Fig. 22 Reflection coefficient of the non-transposed input impedance of the cable whose values are shown in complex representation in Fig. 21

For the same cable, Fig. 22 plotted against frequency gives a clearer picture, although only part of the information shown in Fig. 21 is obtainable, i.e., the reflection coefficient of the non-transposed input impedance. The mean characteristic impedance and the effective characteristic impedance are not shown.

The advantage of this representation lies in the easy interpretation of the loop family which now shows clear periodicity. In view of the small frequency intervals, the maxima are definitely to be traced back to the cable connector or the in-between multiple reflections. Maxima of the reflections are observed at the cable input when at least two reflections of the same type, i. e. equal-phase reflections are spaced from one another by $n\lambda_K/2$. A simple check is made by measuring the frequency difference Δf between two maxima, thus giving $n = \frac{f}{\Delta f}$ and thus the length of the cable when the cable wavelength $\lambda_K \frac{\lambda_o}{\sqrt{\varepsilon}}$ is known.

The sharp peak at f_1 can with great probability be traced back to a periodic discontinuity within the cable caused, for example, by periodic crimps in the outer conductor or in the outer diameter of the dielectric. The distance "a" between maxima may easily be calculated from the correlation to the corresponding cable length λ_K.

Although each of the crimps may only cause a disturbance of a few parts in 1000, substantial input reflections result from the summation of hundreds of individual irregularities in long lengths of cable. Periodical discontinuities of this type naturally manifest themselves at $a = \lambda_K$ and $a = 3/2\lambda_K$ as higher peaks and are thus easy to recognize.

The width of a peak or reflection maximum is a measure of the periodicity of the distance between the discontinuities. The more perfect the periodicity of "a", the narrower the reflection maximum; the greater the deviation Δa from a mean value "a", the flatter the reflection maximum. In general, the reflection maxima occurring at harmonics of f_1 become flatter since the deviation Δa becomes more significant.

Additional reflection maxima can arise from periodicities occurring in the manufacture or also from multiple reflections between individual discontinuities within the cable and connectors.

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The regularity of the high-frequency connector periodicity as seen in the graph permits the amount of statistical Z variations to be estimated as compared to the reflections caused by the connector. These statistical irregularities manifest themselves in the fine structure of the connector irregularities depending upon whether their amplitude changes are gradual or sudden.

Thus both methods of display, the complex and the amplitude method, are justified. In checking finished cables, the latter of the two displays is gaining increasing use, above all, in conjunction with a sweep frequency measurement in the operating frequency range using directional couplers which eliminate laborious transformation of measured values of the VSWR into reflection values as well as the time-consuming series of measurements by means of slotted lines.

However, for the determination of the mean and the effective characteristic impedance, the Non-slotted Line or semi-automatic impedance measuring sets (e.g. the Z-g Diagraphs Type ZDU and ZDD) will still be desirable.

7.15.3 Measuring the Attenuation

Cable attenuations can be measured with Type ZDU according to the procedure described in section 7.6.3. The cable specimens should be of such a length that their attenuation is between 5 dB and 20 dB. If the cable tested is too short and thus its attenuation too low, the inherent error of the Z-g Diagraph indicated in section 1.2 will be too large in comparison to the quantity to be measured. If, on the other hand, the tested cable is too long and thus its attenuation greater than 20 dB, a sufficiently accurate reading of the measured value cannot be obtained. With all measurements dependent on frequency, the zero adjustment must be made after each change of frequency.

The measurement of short lengths of cable is best made with standing-wave detectors, while for larger lengths the signal generator and measuring receiver is recommended.

7.15.4 Determining the Phase Velocity v and the Electrical Length le

The relationship between the two quantities is given by

$$\frac{v}{c} = \frac{\lambda_K}{\lambda_o} = \frac{1}{l_e} = \frac{1}{\sqrt{\varepsilon}} \qquad (12)$$

These quantities can be measured via the cable wavelength λ_K. To determine λ_K, the section of cable to be investigated, not too long in length, is operated with its output short-circuited or open-circuited. By choosing a suitable test frequency, an impedance minimum or maximum is adjusted. Depending upon the type of termination (short circuit or open circuit), multiples of $\lambda/4$ or $\lambda/2$ exist on the entire cable length.

The following example is given:
A short-circuit is at the cable output; an impedance maximum is adjusted.

The first resonance frequency used is f_1 and the associated wavelength along the cable is λ_{K1}. By raising the frequency, the next impedance maximum is adjusted, this being the frequency f_2 and the cable wavelength λ_{K2}.

The following is valid:

$$(2\,k - 1)\,\lambda_{K1}/4 = l = (2\,k - 1) + 2\ \ \lambda_{K2}/4 \qquad (13)$$

$$(k = 1,\ 2,\ 3,\ \ldots)$$

$$(2\,k - 1) = 2\,\frac{f_1}{f_2 - f_1} = 2\,\frac{f_1}{\Delta f} \qquad (14)$$

thus

$$\lambda_{K1} = 2\,l\,\frac{\Delta f}{f_1} \qquad (15)$$

and

$$v = c\,\frac{\lambda_{K1}}{\lambda_1} = f_1\,\lambda_{K1} = 2\,l\,\Delta f \qquad (16)$$

is a general expression for a cable of any length and any excitation $(2k - 1)\lambda/4$ or $k\lambda/2$.

Also, with $f_{res_{min}}$ being the resonant frequency of a cable section excited in $\lambda/4$,

$$v = 4 f_{res_{min}} l \qquad (17)$$

8. Periodical Checking of the Set

Should be carried out every 500 operating hours.

8.1 Checking the Anode and Filament Voltages (see circuit diagram)

(a) The anode-supply voltage across contact 9 of the multi-point connector C (Fig. 31) should be 220 V ±5% to chassis. Deviations from this value can be compensated for by resistor R172. For AC supply fluctuations of ±12% referred to rating, the anode-supply voltage fluctuation ΔE should be less than ±1 V. See also section 9.4.

(b) The filament voltage is preferably measured across contact 3 of the multi-point connector C (Fig. 31). It should be 6.5 V ±3% to chassis. Deviations can be compensated for by resistor R156. For AC supply fluctuations of ±12% referred to rating, the filament-voltage fluctuation ΔE should be less than +30 mV. If the specified values are not obtainable, refer to section 9.5.

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8.2 Relative Frequency Response of the Test Receiver versus Reference Receiver

Adjust amplitude and phase at any frequency whatsoever, according to section 6.4.2. Both the coaxial test line and the coaxial reference line remain shorted. Measure the voltage in each frequency range at several frequencies. Adjust the generator voltage each time so that the pointer of the reference meter points at the red mark (full deflection). The deviations of phase and amplitude, which are observed by means of the crosslines of the light spot, should not exceed 3° and 0.5 dB.

8.3 Checking the Quiescent DC Anode Current of Rö6

If valve Rö5 (Fig. 32) is removed from its socket, the pointer of the discriminator meter should exactly point to the centre of the red section. Correct for deviations using the variable resistor R37 (Fig. 31). If the adjustment range of R37 is not sufficient, replace valve Rö6 (Fig. 33).

8.4 Sensitivity of the Phase Indication with Respect to Frequency Adjustment within the Red Section RESONANCE

Tune the Z-g Diagraph to the generator frequency, change this frequency so that the pointer of the discriminator meter (4) (Fig. 23) deflects to the left end of the red mark. Adjust the phase with the coaxial test line and the coaxial reference line short-circuited. Adjust the generator frequency so that the pointer of the discriminator meter points to the right end of the red mark and repeat the phase adjustment. The difference in the phase angle $\Delta\varphi$ should be $\leqq 1^{\circ}$; if this is not the case, realign the IF circuits (section 10.3).

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8.5 Checking the Spread Chart Range

Insert the Smith chart (Fig. 24) as impedance chart into the chart holder. Short the coaxial test line and the coaxial reference line, adjust the generator for any desired frequency and tune the Z-g Diagraph to this frequency. Adjust the generator voltage so that the crosslines of the light spot lie on the outermost chart circle. The INDICATION switch (18) (Fig. 23) is at SPREAD. If you then switch to NORMAL, the crosslines should indicate 0.5 on the real axis of the chart. If this is not the case, readjust the sensitivity of the galvanometer for both ranges, starting with the SPREAD range. With the coaxial test line and the coaxial reference line shorted, feed in a signal of any convenient frequency and tune the Z-g Diagraph to this frequency. Adjust the voltage at the generator so that the reference meter points to 1/3 of full deflection (33.3 divisions). The crosslines of the light spot should then be on the outermost chart circle. If this is not the case, correct using the variable resistor R206 (Fig. 34). If you now switch to NORMAL, the crosslines should be at 0.5. If this value is not reached exactly, correct by means of resistor R204 (Fig. 34). Increase the voltage at the generator to give full scale deflection (100 scale divisions, red mark); the crosslines should again go to the outermost chart circle.

8.6 Checking the Zeroing of the Galvanometer

Valve Rö19 (Fig. 31) serves to compensate the initial-velocity current of the measuring diode Rö12 (Fig. 32) and to linearize its characteristic. The electrical zero is correct if, upon switching from NORMAL to SPREAD, the zero deflection of the light spot remains unchanged or shifts to the left by a maximum of 1 mm. This small shift is caused by noise. For this investigation, the signal generator should be cut off. If the shifting of the light spot upon switching is more than 1 mm, zero by using resistor R207

(Fig. 34). If no adjustment is possible with R207, it is a sign that the two valves Rö12 and Rö19 (EA 50) have aged at a different rate and must therefore be replaced (section 10. 1).

9. Trouble Shooting

Below are a few hintes to facilitate spotting any faults which may appear after a considerable period of operation. With their aid it should be possible to find and rectify the fault in the majority of cases.

9. 1 Pilot Lamp Does not Light

(a) Check AC supply voltage;

(b) Check fuse Si1 in power section (Fig. 31);

(c) Check pilot lamp Rl 3;

(d) Check power circuit in the set.

9. 2 No Light Spot

(a) Check that the set is in horizontal position;

(b) Check mechanical zero, HORIZONTAL, VERTICAL;

(c) Check projector lamp Rl 2 (Fig. 34);

(d) Check socket of projector lamp; after replacement obtain maximum brightness of light spot by turning and adjusting lamp vertically.

(e) Falvanometer defective (Fig. 33);

(f) Trouble in mirror case (Fig. 33).

9.3 No Pointer Deflection on Both Meters and on Galvanometer

(a) Check AC supply voltage;

(b) Check input voltage of signal generator (feeder);

(c) Check anode voltage across contact No. 9 of multi-point connector C (Fig. 31); rating: 220 V ±5% (see also section 8.1 a).

(d) Check filament voltage across contact No. 3 of multi-point connector C (Fig. 31); rating: 6.5 V ±3% (see also section 8.1 b).

9.4 Anode Supply Voltage Cannot be Adjusted to Rating, Stabilization Insufficient

Disconnect set from power supply. Check resistance to chassis at contact No. 9 of multi-point connector C (Figs. 31 and 33). Rating of resistance R = 10 kΩ. If R > 10 kΩ, check Rö21 to Rö25 in the power section and replace, if necessary. If R < 10 kΩ, check the capacitors in the anode leads.

9.5 Filament Voltage Cannot be Adjusted to Rated Value, Stabilization Insufficient

Check valves Rö17 and Rö18 in the power supply. Replace lamp Rl 1 if these valves are satisfactory. If necessary, also check the capacitors and resistors which are in circuit with Rö17 and Rö18.

9.6 No Light Spot Deflection and, at the Same Time, Phase Maximum not Obtainable

Check valves Rö8 (Fig. 33), Rö9 (Fig. 35), Rö10, Rö11, Rö13 and Rö14 in the test receiver (Fig. 32), and valves Rö15 and Rö16 in the phase amplifier, to find out whether the operating voltages of these valves are present. The fault can also lie with the mixer diode Gl 10. When replacing this crystal

diode refer to section 10. 2, when replacing a valve refer to section 10. 1. Be careful not to interchange the valves.

9. 7 No Light Spot Deflection, Phase Maximum Well Obtainable

(a) Check Rö12 (for replacing the valve see section 10. 1).

(b) Check galvanometer. Apply -10 V DC via 200 kΩ between chassis (+) and contact No. 6 of multi-point connector B (Fig. 32). This should give full deflection in the SPREAD range.

9. 8 No Deflection on Reference Meter, no Phase Maximum Obtainable

Check valves Rö1, Rö2, Rö3 and Rö4 in the reference receiver (Fig. 32), valve Rö7 (Fig. 33), and the valves Rö15 and Rö16 (Fig. 32) in the phase amplifier. Also check that the operating voltages of these valves are present. Mixer diode Gl 10 can also be faulty. When changing the crystal diode refer to section 10. 2, when replacing a valve refer to section 10. 1. Be careful not to interchange the valves.

9. 9 No Deflection on Reference Meter, Phase Maximum Obtainable

Check reference meter. Apply 30 V DC through 300 kΩ between chassis and contact No. 6 of multi-point connector A (Fig. 32). This voltage should produce about full deflection. The deflection also depends on the adjustment of resistors R188 (Fig. 36) and R189 (REFERENCE VOLTAGE COR. on the front panel).

9. 10 No Resonance Indication, Amplitude and Phase Indication Satisfactory

(a) If the pointer always stays at mid-position, there may be a breakdown of valve Rö5 (Fig. 32) or of its operating voltage.

(b) If the pointer is always at the left-hand stop, check valve Rö6 (Fig. 32) and replace if necessary. Also check push button (3) (Fig. 23) and incandescent lamp Rl 1 for troublefree operation. The anode fuse Si2 (Fig. 31) can also be defective.

(c) If the pointer is always at the right-hand stop, a short between the electrodes of valve Rö6 may be suspected. Check also the push-button switch (3) and incandescent lamp Rl 1 for accidental contact to chassis.

(d) If during tuning the pointer deflects only to the right or only to the left, the trouble is in the discriminator. Check crystal diodes Gl 1 and Gl 2, which are in the circuit of valve Rö6. For adjustment see instructions of section 10. 3. 2.

9. 11 Phase Meter Shows Only Very Flat or no Maximum, Amplitude and Resonance Indication Satisfactory

(a) The signal generator might be modulated or introduce considerable hum. If this is not the case,

(b) try to improve maximum with R47 (Fig. 31). Short coaxial test line and coaxial reference line, adjust for phase maximum as well as possible and make the maximum as sharp as possible by means of R47. Readjust the maximum several times. Turn the chart by 360° and readjust to maximum. If this maximum is not sharp, adjust for the same and optimum sharpness of the two maxima. Sharpness of the maximum and amplitude of the deflection depend upon one another.

9. 12 Phase Meter Shows Permanent Deflection

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(a) Check valves Rö15 and Rö16 and their operating voltages.

(b) Check crystal diode Gl 5, which lies in the anode circuit of valve Rö15.

(c) If necessary, readjust the circuits of the amplifiers. Section 10.4 contains instructions for this readjustment and for checking the sensitivity.

9.13 During Amplitude Adjustment According to Section 6.4.2.1 Reference Meter Cannot be Set to 100%

First to readjust R188 (Fig. 36) so that 100% full deflection can be obtained with the REFERENCE VOLTAGE COR. knob. At the same time the voltage of the signal generator must be adjusted so that the light spot stays in the largest circle of the diagram.

If this is not possible because the reference voltage is always less than 100%, the trouble is in the reference receiver. If, however, the reference voltage is always greater than 100%, the trouble is in the test receiver. In both cases, check respectively valves Rö1, Rö2, Rö3, Rö4 and Rö7, or Rö8, Rö10, Rö11, Rö13 and Rö14. If a replacement of valves becomes necessary, observe section 10.1.

9.14 In Spite of Amplitude and Phase Adjustment at a Medium Frequency (about 100 MHz), the Amplitude Error or Phase Error Exceeds the Specified Tolerances at Other Frequencies

Check the mixer diodes Gl 9 and Gl 10 (mixer head). Both diodes should have equal input impedances and their characteristics should be approximately identical. The check on the characteristics is not particularly critical and can be made by a point-by-point method using DC. In the non-conductive region a current of $< 20\ \mu A$ should flow with a voltage of 0.5 V; in the conductive region the current should be > 0.5 mA with ± 0.3 V. The forward current of the two diodes should be as equal as possible. The selection for equal input impedance is best made in the mixer head itself. One of the two diodes should be changed until a suitable pair has been found. Matched pairs of diodes may be ordered from ROHDE & SCHWARZ

by specifying the Serial Number (FNr.) of the set. However, a better frequency response will be obtained if the diodes are selected by inserting them in the mixer head as described above, since this will take care of any slight unabalnce of the mixer head due to aging.

9.15 Amplitude Difference between Short-circuit and Open-circuit Measurements Exceeds Tolerance

Check resistance of the matching elements. With the "input" open-circuited, $Z_o \pm 1\%$ should be measured at the connectors of the coaxial reference line and coaxial test line. If the resistance differs from the Z_o rating, replacement and elimination of the trouble can only be made at the factory. The amplitude difference can also be due to a fault in the coaxial directional coupler. In the case, too, the repair can only be carried out at the factory.

9.16 Light Spot Shows More than 1% Reflection with Exact Z_o Termination of the Coaxial Test Line, e.g., with Precision Termination Type RMC

(a) Check mechanical zero with respecto to VERTICAL and HORIZONTAL, with the signal generator disconnected from the input of the Type ZDU.

(b) Check terminating resistor used. Repeat measurement using another terminating resistor.

(c) Trouble in directional coupler. Replacement and readjustment only possible at our factory.

9.17 Phase Maximum Cannot be Adjusted to ZERO or 360° by Making Use of the PHASE COR. Knob

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(a) Check the contact being made by the two short-circuit terminations FZ 434 with reference line and test line.

(b) Check that mechanical drive for C24 (cord drive, Fig. 32) is in order.

(c) Check that the test and reference lines are screwed in as far as they will go.

(d) If necessary, readjust the reference and test receivers according to section 10.4.

9.18 Phase Maximum after Adjustment to 0^o Does not Agree with Phase Maximum after 360^o Rotation of Chart by Means of PHASE ADJ.

Zero frequency of discriminator is incorrect. Readjust discriminator and amplifier in accordance with section 10.3.

10. Maintenance and Replacement of Valves

The Z-g Diagraph Type ZDU does not require any routine servicing. Occasionally, it will be necessary to replace defective or extremely aged valves or crystal diodes. If the replacement of a valve or diode becomes necessary, please refer to section 10.1 or 10.2, respectively.

After a long time of operation, it may be possible that the brightness of the light spot of the galvanometer considerably decreases. This is due to dust covering the mirrors and the plexiglass screen. After removing the six screws, the plexiglass screen can be removed and easily be cleaned. To obtain access to the mirror case (Fig. 33), take the set out of its cabinet and remove the power supply. When taking off the lid, the mirrors and the window of the galvanometer can be cleaned from dust. It is, however, nec-
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865 as not to change the path of the rays. Use only a very soft and clean piece
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of leather for cleaning, since the surfaces of all mirrors contained in the mirror case are silver-plated and liable to be scratched.

10.1 Replacement of Valves

Rö1, Rö2, Rö3 and Rö4

Allow a warm-up period of one hour after insertion of the new valve; carefully adjust the IF circuits preceding and following the valve to obtain maximum amplitude. See also section 10.4.

Rö5

No adjustment necessary.

Rö6

After inserting the new valve, adjust the quiescent DC anode current in accordance with section 8.3.

Rö7, Rö8

No adjustment necessary.

Rö10, Rö11, Rö13 and Rö14

See Rö1, Rö2, Rö3, Rö4.

Rö15

Adjust C176, see section 10.4.3.

Rö16

Adjust C176 and C182, see section 10.4.3.

Rö21, Rö22, Rö23, Rö24 and Rö25

Adjust R172 (Fig. 31) so that the anode supply voltage E_a is 220 V. See also section 8.1 a.

Rö9

After inserting the valve (Fig. 35) allow the set to warm up. It is then advisable to make a few measurements in the frequency range 180 to 200 MHz, since with oscillator valves having UHF characteristics which depart considerably from average it is possible for dips or parasitic oscillations to occur.

Rö12

Open the cover on the underside of the lower IF amplifier and loosen the two cheese-head screws on the rear panel (Fig. 32). The socket of the valve Rö12 (EA 50) can then be drawn out downwards, so that after disconnecting the anode lead the valve can be replaced. Replace the socket with the new valve and the cover of the IF amplifier. The set can now be switched on. Allow a few minutes for warming up and adjust the electrical zero of the galvanometer using resistor R207 (Fig. 34) (see also section 8.6).

Rö17 and Rö18

After changing these valves, check the filament voltage according to section 8.1 b.

Rö19

After replacement, adjust the electrical zero of the galvanometer according to section 8.6.

10.2 Replacing the Diodes Gl 9 and Gl 10

These diodes are situated in the cans of the valves Rö7 and Rö8 (Fig. 33). Note: Diodes should be protected from shock and static charge. See also section 9.14.

10.3 Aligning the IF Circuits

The rated intermediate frequency of the Z-g Diagraph is the frequency for which the artificial line has a length of exactly π.

10.3.1 Finding the Rated IF

Allow a warm-up period of about one hour. Check the quiescent DC anode current according to section 8.3. Short both coaxial lines. Using a power signal generator of high frequency stability, apply a voltage to the input of the Z-g Diagraph, the frequency of which is equal to the intermediate frequency of the Type ZDU, which is between 10 and 11 MHz. Adjust the frequency of the signal generator so that the pointer of the discriminator is exactly at the centre mark. Do not press the button (3) (Fig. 23). The position of the FREQUENCY knob, i.e., the oscillator tuning, is of no importance. Adjust the amplitude of the signal generator so that the reference meter shows approximately full deflection. Insert a chart which shows a division in degrees on its outermost circle (e.g., Fig. 28, 29 or 30). Press the button (3). Once pushed in, it will remain depressed. Adjust for maximum deflection on meter (4) using the PHASE ADJ. knob and find the phase angle on the chart. Next, turn the chart by 360° using the PHASE ADJ. knob and again adjust for maximum. The same phase angle as before will then be obtained if the IF is correct and the discriminator is tuned to this frequency. A phase angle deviation of $\pm 0.5^{\circ}$ is permissible. If the deviation is greater, repeat the above measurement with another frequency. Use a higher frequency if for finding the second phase maximum the chart

must be rotated more than 360°. Use a lower frequency if the angle of rotation was smaller than 360°. For every degree $\Delta\varphi$, change the frequency by about 30 kHz.

10.3.2 Adjusting the Discriminator

If you have thus obtained the rated IF, i.e., the one for which the artificial line has a length of π, press the button (3) (Fig. 23) below the discriminator meter. This button is thus released and switches the meter (4) over for tuning indication. It can now be seen that, due to the previous frequency detuning, the pointer of the meter is no longer on the centre mark. Adjust the discriminator to the new IF. To do this, slightly turn the trimmer C46 (Fig. 32) by only a few degrees of angle, until the pointer of the discriminator meter (4) again points to the centre mark. Do not change the frequency at the signal generator between the adjustment for the rated IF as per section 10.3.1 and retuning of the discriminator. For this reason, it is also imperative that the signal generator has a high frequency stability. Use a tuning wand of insulating material for retuning the discriminator.

10.4 Adjusting the Individual Circuits

10.4.1 Reference Receiver

Apply a signal as set forth in section 10.3.1. Short the coaxial test line and the coaxial reference line each with a FZ 434. For the duration of the tuning procedure described in the following, the signal-generator frequency should be kept constant. It is, therefore, advisable to check this frequency several times with the aid of the discriminator meter. The pointer of this meter should always exactly point to the centre line over the red mark. After a warm-up period of at least one hour, adjust successively:

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(a) C3, C10 and C19 (Fig. 32) for maximum amplitude at the reference meter. Adjust very carefully and repeat the procedure several times.

(b) C26 (Fig. 32) for amplitude maximum. As tuning indicator connect a 50-μA moving-coil meter between test point 11 (Fig. 32) and chassis.

(c) C34 for amplitude maximum. As tuning indicator connect a 50-μA moving-coil meter between test point 13 (Fig. 32) and chassis.

C42 should be readjusted after a repair of the discriminator (amplitude maximum). As tuning indicator connect a 50-μA moving-coil meter between test point 15 (Fig. 33) and chassis.

10.4.2 Test Receiver

The conditions under which the adjustment must be made are the same as for the adjustment of the reference receiver (section 10.4.1). On the test receiver, adjust successively:

(a) C130, C137 and C146 (Fig. 32) for amplitude maximum at the light spot galvanometer. Adjust carefully and repeat the procedure several times.

(b) C156 for amplitude maximum. As tuning indicator connect a 50-μA moving-coil meter between test point 12 (Fig. 32) and chassis.

(c) C163 for amplitude maximum. As tuning indicator connect a 50-μA moving-coil meter between test point 14 and chassis (Fig. 32).

10.4.3 Phase Meter Amplifier

The conditions for adjustment are the same as set forth in sections 10.4.1 and 10.4.2. Adjust C176 and C182. Depress button (3) (Fig. 23). Using the PHASE COR. KNOB, bring the phase close to the maximum (indication on discriminator meter) and, using C176 and C182 alternately, adjust for minimum pointer deflection. Bring the phase still closer to maximum and repeat the adjustment. The position of C182 is shown in Fig. 32. C176

cannot be seen; it is situated in the shielding can behind valve Rö15, and can be reached from above. But in order to get at it, the power pack must first be removed. The latter is contained in a separate frame which is inserted from above and can be lifted out after removing the five countersunk screws seen in Fig. 31. The set can still be kept in operation by connecting the multi-point connector of the power pack to the multi-point connector of the set by means of a suitable cable.

After the phase meter amplifier is adjusted, check its sensitivity. For this purpose, disconnect cable K4 (Fig. 32) from the test receiver and connect this amplifier to a standard signal generator, e.g. the R&S Type SMAF BN 41409, via a cable, which has a capacitance of 91 pF just as K4, and via 5 pF. Tune the standard signal generator to the IF of the Type ZDU. For tuning indicator, use the discriminator meter; press button (3) below it and tune for minimum deflection. This tuning should be made with a signal-generator output voltage of 2 mV. Decrease the signal-generator voltage to 0 by disconnecting the patch cord and check that the pointer deflection of the discriminator meter increases by at least 10% in the direction marked by the arrow. If the sensitivity is not sufficient, check valves Rö15 and Rö16. The crystal diode Gl 5, too, may be cause of insufficient sensitivity. Check these circuit elements also if a minimum adjustment is impossible or if the sharpness of the minimum adjustment is insufficient.

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11. Table of Replaceable Parts

(ÄZ „t" Nr. 8856)

Ref. No.	Designation	Ratings	R&S Stock No.
C1	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C2	Capacitor, ceramic	47 pf 10 pf	CCH 31/47 CCH 31/10 parallel
C3	Trimmer, air	2.5 to 8.9 pf	CV 63206
C4	Capacitor, ceramic	150 pf	CCH 68/150
C5	Capacitor, synth. foil	10,000 pf/500 v	CKS 10 000/500
C6	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C7	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C8	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C9	Capacitor, ceramic	33 pf	CCH 31/33
		8 pf	CCG 68/8 parallel
C10	Trimmer, air	2.5 to 8.9 pf	CV 63206
C11	Capacitor, ceramic	150 pf	CCH 68/150
C12	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C13	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C14	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C15	Capacitor, ceramic	5 pf	CCG 68/5
C16	Capacitor, ceramic	5 pf	CCG 11/5
C17	Capacitor, ceramic	150 pf	CCH 68/150
C18	Capacitor, ceramic	39 pf 8 pf 8 pf	CCH 31/39 CCG 41/8 CCG 68/8 parallel
C19	Trimmer, air	2.5 to 8.9 pf	CV 63206
C20	Capacitor, ceramic	150 pf	CCH 68/150
C21	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C22	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C23	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250

Ref. No.	Designation	Ratings	R&S Stock No.
C24	Trimmer, air		
C25	Capacitor, ceramic	33 pf 8 pf	CCH 31/33 CCG 68/8 parallel
C26	Trimmer, air	2.5 to 8.9 pf	CV 63206
C27	Capacitor, ceramic	150 pf	CCH 68/150
C28	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C29	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C30	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C31	Trimmer, air	3 to 28 pf	CV 65225
C32	Trimmer, air	3 to 28 pf	CV 65225
C33	Capacitor, ceramic	18 pf 2 pf	CCH 31/18 CCG 41/2 parallel
C34	Trimmer, air	2.5 to 8.9 pf	CV 63206
C35	Capacitor, ceramic	100 pf	CCH 31/100
C36	Capacitor, ceramic	150 pf 15 pf 150 pf	CCH 31/150 CCH 55/15 CCH 68/150 parallel
C37	Capacitor, ceramic	4 pf	CCG 41/4
C38	Capacitor, synth. foil	250 pf	CKS 10 000/250
C39	Capacitor, synth. foil	250 pf	CKS 10 000/250
C40	Capacitor, ceramic	0.5 pf	CCG 11/0,5
C41	Capacitor, feed-through, ceramic	2000 pf	CFS 2000
C42	Trimmer, air	2.5 to 8.9 pf	CV 63206
C43	Capacitor, ceramic	47 pf 15 pf 10 pf	CCH 31/47 CCH 31/15 CCG 68/10 parallel
C44	Capacitor, ceramic	150 pf	CCH 68/150
C45	Capacitor, ceramic	22 pf 12 pf 3 pf	CCH 31/22 CCH 31/12 CCG 55/3 parallel
C46	Trimmer, air	2.5 to 8.9 pf	CV 63206

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Ref. No.	Designation	Ratings	R&S Stock No.
C47	Capacitor, ceramic	150 pf	CCH 68/150
C48	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C49	Capacitor, feed-through, ceramic	2000 pf	CFS 2000
C50	Capacitor, feed-through, ceramic	2000 pf	CFS 2000
C51	Capacitor, MP	2 µf/160 v	CMR 2/160/2
C52	Capacitor, ceramic	5 pf	CCG 68/5
C53	Capacitor, ceramic	5 pf	CCG 11/5
C54	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C55	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C56	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C57	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C58	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C59	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C60	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C61	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C62	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C63	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C64	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C65	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C66	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500

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Ref. No.	Designation	Ratings	R&S Stock No.
C67	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C68	Capacitor, feed-through, ceramic	2000 pf	CFS 2000
C69	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C70	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C71	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C72	Capacitor, synth. foil	10,000 pf/500 v	CKS 10 000/500
C73	Capacitor, synth. foil	2500 pf/500 v	CKS 2500/500
C75	Capacitor, bypass	35 pf ±1 %	
C76	Capacitor, bypass	115 to 120 pf	
C77	Capacitor, ceramic	15 pf 6 pf	CCH 31/15 CCG 55/6 parallel
C78	Capacitor, ceramic	1000 pf	CCG 94/1000
C79	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C81	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C82	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C83	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C84	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C85	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C86	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C87	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C88	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C89	Capacitor, bypass	35 pf ±1 %	
C90	Capacitor, bypass	115 to 120 pf	
C91	Capacitor, ceramic	15 pf 6 pf	CCH 31/15 CCG 55/6 parallel
C92	Capacitor, ceramic	1000 pf	CCG 94/1000

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Ref. No.	Designation	Ratings	R&S Stock No.
C93	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C95	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C96	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C97	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C98	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C99	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C100	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C101	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C102	Capacitor, feed through	2000 pf	CFS 2000/M 5
C103	Capacitor, bypass	approx. 55 pf	-
C104	Capacitor, ceramic	150 pf 39 pf	CCH 31/150 CCH 31/39 parallel
C105	Capacitor, bypass	450 to 520 pf	
C106	Capacitor, bypass	450 to 520 pf ±1 %	
C107	Capacitor, bypass	approx. 25 pf	
C108	Capacitor, bypass	approx. 25 pf ±1 %	
C109	Capacitor, ceramic	0.5 pf	CCG 11/0,5
C110	Capacitor, ceramic	0.5 pf	CCG 11/0,5
C111	Capacitor, variable	approx. 4 to 12 pf	
C112	Capacitor, bypass	approx. 7.5 pf	
C113	Capacitor, bypass	> 50 pf	
C115	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C116	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C117	Capacitor, feed through	2000 pf	CFS 2000/M 5
C118	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C119	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C120	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C121	Capacitor, feed-through	2000 pf	CFS 2000/M 5

Ref. No.	Designation	Ratings	R&S Stock No.
C122	Capacitor, feed-through	2000 pf	CFS 2000/M 5
C123	Capacitor, feed-through	2000 pf	CFS 2000
C124	Capacitor, feed-through	2000 pf	CFS 2000
C128	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C129	Capacitor, ceramic	47 pf 10 pf	CCH 31/47 CCH 31/10 parallel
C130	Trimmer, air	2.5 to 8.9 pf	CV 63206
C131	Capacitor, ceramic	150 pf	CCH 68/150
C132	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C133	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C134	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C135	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C136	Capacitor, ceramic	39 pf 4 pf 8 pf	CCH 31/39 CCG 41/4 CCG 68/8 parallel
C137	Trimmer, air	2.5 to 8.9 pf	CV 63206
C138	Capacitor, ceramic	150 pf	CCH 68/150
C139	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C140	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C141	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C142	Capacitor, feed through	5000 pf/500 v	CFR 1/5000/500
C143	Capacitor, by pass	1600 pf/350 v	CBR 1/600/350
C144	Capacitor, ceramic	150 pf	CCH 68/150
C145	Capacitor, ceramic	10 pf 3 pf 8 pf	CCH 31/10 CCG 41/3 CCG 68/8 parallel
C146	Trimmer, air	2.5 to 8.9 pf	CV 63206
C147	Capacitor, ceramic	150 pf	CCH 31/150
C148	Capacitor, ceramic	56 pf	CCH 31/56
C149	Capacitor, ceramic	150 pf	CCH 68/150

Ref. No.	Designation	Ratings	R&S Stock No.
C150	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C151	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C152	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C153	Capacitor, ceramic	10 pf 10 pf	CCG 41/10 CCG 68/10 parallel
C155	Capacitor, ceramic	39 pf 8 pf	CCH 31/39 CCG 68/8 parallel
C156	Trimmer, air	2,5 to 8.9 pf	CV 63206
C157	Capacitor, ceramic	150 pf	CCH 68/150
C158	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C159	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C160	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C161	Capacitor, ceramic	0.5 pf	CCG 11/0,5
C162	Capacitor, ceramic	22 pf	CCH 31/22
C163	Trimmer, air	2.5 to 8.9 pf	CV 63206
C164	Capacitor, ceramic	150 pf 15 pf 150 pf	CCH 31/150 CCG 55/15 CCH 68/150 parallel
C165	Capacitor, ceramic	100 pf	CCH 31/100
C166	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C169	Capacitor, ceramic	47 pf	CCH 68/47
C170	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C171	Capacitor, synth. foil	1000 pf/500 v	CKS 1000/500
C172	Capacitor, feed-through, ceramic	2000 pf	CFS 2000
C173	Capacitor, synth. foil	10,000 pf/125 v	CKS 10 000/125
C174	Capacitor, ceramic	150 pf	CCH 68/150
C175	Capacitor, ceramic	22 pf	CCH 31/22
C176	Trimmer, air	2.5 to 8.9 pf	CV 63206
C177	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C178	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C179	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500

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Ref. No.	Designation	Ratings	R&S Stock No.
C180	Capacitor, ceramic	150 pf	CCH 68/150
C181	Capacitor, ceramic	12 pf	CCH 31/12
C182	Trimmer, air	2.5 to 8.9 pf	CV 63206
C185	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C186	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C187	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C188	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C189	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C190	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C191	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C192	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C193	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C194	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C195	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C196	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C197	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C198	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C199	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C200	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500

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Ref. No.	Designation	Ratings	R&S Stock No.
C201	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C202	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C203	Capacitor, synth. foil	10,000 pf/500 v	CKS 10 000/500
C206	Capacitor, MP	1 µf/250 v	CMR 1/250
C207	Capacitor, MP	1 µf/250 v	CMR 1/250
C208	Capacitor, MP	1 µf/250 v	CMR 1/250
C209	Capacitor, MP	1 µf/250 v	CMR 1/250
C210	Capacitor, MP	1 µf/250 v	CMR 1/250
C211	Capacitor, MP	2 µf/160 v	CMR 2/160/2
C212	Capacitor, MP	0.5 µf/500 v 0,25 pf/500 v	CMR 0,5/500 CMR 0,25/500 parallel
C213	Capacitor, synth. foil	15,000 pf/500 v	CKS 15,000/500
C214	Capacitor, paper	100,000 pf/250 v	CPK 100 000/250
C215	Capacitor, MP	16 µf/350 v	CMR 16/350
C216	Capacitor, MP	16 µf/350 v	CMR 16/350
C217	Capacitor, synth. foil	5000 pf/500 v	CKS 5000/500
C220 : C325	Capacitor, tubular	4.3 pf ±1%	CT 4,3 ±1%
Gl1	Diode, crystal		GK/OA 95
Gl2	Diode, crystal		GK/OA 95
Gl3	Diode, crystal		GK 1111
Gl4	Diode, crystal		GK/OA 95
Gl5	Diode, crystal		GK/OA 95
Gl6	Diode, crystal		GK/OA 95
Gl7	Diode, crystal		GK/OA 95

Ref. No.	Designation	Ratings	R&S Stock No.
G18	Diode, crystal		GK/OA 95
G19	Diode, crystal		GK 1011 C
G110	Diode, crystal		GK 1011 C
G112	Diode, crystal		GK/BA 111
G113	Diode, crystal		GK/Z 10
J1	Ammeter, moving-coil		IBS 10101
J2	Ammeter, moving-coil, light-spot		IG 2
J3	Ammeter, moving-coil		IBS 20201
K1	Cable, RF		3561 - 40
K2	Cable, RF		3561 - 40
K3	Cable, RF		3561 - 41
K4	Cable, RF		3561 - 12
K5	Cable, RF		3561 - 41
K6	Cable, RF		3561 - 55
K7	Patch cord		LK 333
L1	Coil, filter		3561 - 6.15.3
L2	Coil, filter		3561 - 6.16.3
L3	Coil, filter		3561 - 6.16.3
L4	Coil, filter		3561 - 6.16.3
L5	Coil, filter		3561 - 6.18.1
L6	Coil, filter		3561 - 6.18.1
L7	Coil, filter		3561 - 6.19.5
L8	Choke, RF		DUF 311/20
L9	Choke, RF		DUF 311/20
L10	Choke, RF		DUF 311/20
L11	Coil, IF		3561 - 70.2.9

Ref. No.	Designation	Ratings	R&S Stock No.
L12	Coil, IF		3561 - 70.2.9
L13	Choke, RF		3561 - 7.4.8
L14	Choke, RF		3561 - 7.4.8
L15	Choke, RF		3561 - 7.4.8
L16	Choke, RF		3561 - 7.4.8
L17	Choke, RF		3561 - 7.4.8
L18	Choke, RF		3561 - 7.4.8
L19	Choke, RF		3561 - 7.4.8
L20	Choke, RF		3561 - 7.4.8
L21	Choke, RF		3561 - 7.4.8
L22	Choke, RF		3561 - 7.4.8
L23	Choke, RF		3561 - 7.4.8
L24	Choke, RF		3561 - 7.4.8
L27	Coil (trap)		3561 - 70.17
L28	Coil, oscillator		3561 - 7.56
L29	Coil, oscillator		3561 - 7.57
L30	Coil, oscillator		3561 - 7.58
L31	Coil, oscillator		3561 - 7.59
L32	Coil, oscillator		3561 - 7.60
L33	Coil, oscillator		3561 - 7.61
L35	Choke, RF		3561 - 7.4.8
L36	Choke, RF		3561 - 7.4.8
L37	Choke, RF		3561 - 7.4.8
L38	Choke, RF		3561 - 7.4.8
L39	Choke, RF		3561 - 7.4.8
L40	Choke, RF		3561 - 7.4.8
L43	Coil, filter		3561 - 6.15.3

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Ref. No.	Designation	Ratings	R&S Stock No.
L44	Coil, filter		3561 - 6.16.3
L45	Coil, filter		3561 - 6.16.3
L46	Coil, filter		3561 - 6.16.3
L47	Coil, filter		3561 - 6.18.1
L48	Coil, filter		3561 - 6.19.5
L49	Coil, filter		3561 - 8.12.5
L50	Choke, RF		DUF 311/20
L51	Choke, RF		DUF 311/20
L52	Choke, RF		DUF 311/20
L53	Choke, RF		DUF 311/80
L55	Coil, ring		
R1	Resistor, depos. carbon	300 Ω/0.25 w	WF 300/0,25
R2	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R3	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R4	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R5	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R6	Resistor, depos. carbon	300 Ω/0.25 w	WF 300/0,25
R7	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R8	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R9	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R10	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R11	Resistor, depos. carbon	12.5 kΩ/0.25 w	WF 12,5 k/0,25
R13	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R14	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R15	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R16	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R17	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R18	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R19	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R20	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R21	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R22	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R23	Resistor, depos. carbon	125 kΩ/0.25 w	WF 125 k/0,25
R24	Resistor, depos. carbon	585 Ω ±1%/0.25 w	WF 585/1/0,25
R25	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R26	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R27	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R28	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R29	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R30	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R31	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R32	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R33	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R34	Resistor, depos. carbon	100 Ω/0.25 w	WF 100/0,25
R35	Resistor, depos. carbon	1.25 kΩ/0.25 w	WF 1,25 k/0,25
R36	Resistor, depos. carbon	5 kΩ/0.5 w	WF 5 k/0,5
R37	Resistor, depos. carbon, variable	250 Ω lin.	WS 5122 F/250
R40	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R41	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R42	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R43	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R44	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R45	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R46	Resistor, depos. carbon	10 kΩ/0.5 w	WF 10 k/0,5

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Ref. No.	Designation	Ratings	R&S Stock No.
R47	Resistor, depos. carbon, variable	100 kΩ lin.	WS 5122 F/100 k
R48	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R49	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R52	Resistor, depos. carbon	160 Ω/0.5 w	WFO 160/0,5
R53	Resistor, depos. carbon	1 kΩ/0.5 w	WFO 1 k/0,5
R54	Resistor, depos. carbon	50 kΩ/0.5 w	WFO 50 k/0,5
R55	Resistor, depos. carbon	100 Ω ±1%/0.08 w	WFK 511/100/1/0,08
	only for BN 3561/50		
R57	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R58	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R59 R60	Resistor, divider	2 x 44.06 Ω ±0.5%	3561 - 7.5.4/50
R61	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R62	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R63	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R64	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R65 R66	Resistor, divider	2 x 44.06 Ω ±0.5%	3561 - 7.5.4/50
R67	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
R68	Resistor, divider	25.36 Ω ±1%	3561 - 7.5.8/50
	only for BN 3561/60		
R57	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
R58	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
R59 R60	Resistor, divider	2 x 52.87 Ω ±0.5%	3561 - 7.5.4/60
R61	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
R62	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
R63	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
R64	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60

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Ref. No.	Designation	Ratings	R&S Stock No.
for BN 3561/60:			
R65 R66	Resistor, divider	2 x 52.87 Ω ±0.5%	3561 - 7.5.4/60
R67	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
R68	Resistor, divider	30.43 Ω ±1%	3561 - 7.5.8/60
only for BN 3561/75:			
R57	Resistor, divider	38.05 Ω ±1%	3561 - 7.5.8/75
R58	Resistor, divider	38.05 Ω ±1%	3561 - 7.5.8/75
R59 R60	Resistor, divider	2 x 66.09 Ω ±0.5%	3561 - 7.5.4/75
R61	Resistor, divider	38.05 Ω ±1%	3561 - 7.5.8/75
R62	Resistor, divider	38.05 ±1%	3561 - 7.5.8/75
R63	Resistor, divider	38.05 Ω ±1%	3561 - 7.5.8/75
R64	Resistor, divider	38.05 ±1%	3561 - 7.5.8/75
R65 R66	Resistor, divider	2 x 66.09 Ω ±0.5%	3561 - 7.5.4/75
R67	Resistor, divider	38.05 Ω ±1%	3561 - 7.5.8/75
R68	Resistor, divider	38.05 Ω ±1%	3561 - 7.5.8/75
R89	Resistor, depos. carbon	160 Ω/0.5 w	WFO 160/0,5
R90	Resistor, depos. carbon	1 kΩ/0.5 w	WFO 1 k/0,5
R91	Resistor, depos. carbon	50 kΩ/0.5 w	WFO 50 k/0,5
R92	Resistor, depos. carbon	100 Ω ±1%/0.08 w	WFK 511/100/1/0,08
R94	Resistor, depos. carbon	600 Ω/0.5 w	WFO 600/0,5
R95	Resistor, depos. carbon	600 Ω/0.5 w	WFO 600/0,5
R96	Resistor, depos. carbon	20 kΩ/0.5 w	WFO 20 k/0,5
R97	Resistor, depos. carbon	20 kΩ/0.5 w	WFO 20 k/0,5
R98	Resistor, depos. carbon	1 kΩ/0.05 w 6 kΩ/0.5 w	WF 1 k/0,05 WFO 6 k/0,5 in series
R99	Resistor, depos. carbon	300 Ω/1 w	WFO 300/1

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Ref. No.	Designation	Ratings	R&S Stock No.
R102	Resistor, depos. carbon	300 Ω/0.25 w	WF 300/0,25
R103	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R104	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R105	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R106	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R107	Resistor, depos. carbon	300 Ω/0.25 w	WF 300/0,25
R108	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R109	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R110	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R111	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R112	Resistor, depos. carbon	12.5 kΩ/0.25 w	WF 12,5 k/0,25
R113	Resistor, depos. carbon	125 kΩ/0.25ww	WF 125 k/0,25
R114	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R115	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R117	Resistor, depos. carbon	20 kΩ/0.25 w	WF 20 k/0,25
R118	Resistor, depos. carbon	1.6 MΩ/0.5 w	WF 1,6 M/0,5
R119	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R120	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R121	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R122	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R123	Resistor, depos. carbon	800 kΩ/0.5 w	WF 800 k/0,5
R124	Resistor, depos. carbon	125 kΩ/0.25 w	WF 125 k/0,25
R125	Resistor, depos. carbon	585 Ω ±1%/0.25 w	WF 585/1/0,25
R126	Resistor, depos. carbon	1 kΩ/0.5 w	WF 1 k/0,5
R129	Resistor, depos. carbon	125 kΩ/0.5 w	WFO 125 k/0,5
R130	Resistor, depos. carbon	100 kΩ/0.5 w	WFO 100 k/0,5
R131	Resistor, depos. carbon	3 kΩ/1 w	WFO 3 k/1
R132	Resistor, depos. carbon	50 kΩ/1 w	WFO 50 k/1

Ref. No.	Designation	Ratings	R&S Stock No.
R133	Resistor, depos. carbon	1 kΩ/1 w	WFO 1 k/1
R134	Resistor, depos. carbon	160 Ω/0.25 w	WF 160/0,25
R135	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R136	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R137	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R138	Resistor, depos. carbon	20 kΩ/1 w	WF 20 k/1
R139	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R140	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R142	Resistor, depos. carbon	300 Ω/0.5 w	WF 300/0,5
R143	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R144	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R145	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R146	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R147	Resistor, depos. carbon	160 kΩ/0.25 w	WF 160 k/0,25
R148	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R149	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R150	Resistor, depos. carbon	500 Ω/0.5 w	WF 500/0,5
R151	Resistor, depos. carbon	4 MΩ/0.5 w	WF 4 M/0,5
R152	Resistor, depos. carbon	100 MΩ/0.25 w	WF 100 k/0,25
R154	Resistor, depos. carbon	10 kΩ ±1%/0.5 w	WF 10 k/1/0,5
R155	Resistor, depos. carbon	10 kΩ ±1%/0.5 w	WF 10 k/1/0,5
R156	Resistor, depos. carbon variable Resistor, depos. carbon	25 kΩ lin. 1 kΩ/0.5 w	WS 5122 F/25 k WF 1 k/0,5 in series
R157	Resistor, depos. carbon	1 kΩ/0.5 w 2 kΩ/0.5 w	WF 1 k/0,5 WF 2 k/0,5 parallel
R158	Resistor, depos. carbon	2 MΩ/0.25 w	WF 2 M/0,25
R159	Resistor, depos. carbon	400 kΩ/0.5 w	WF 400 k/0,5

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Ref. No.	Designation	Ratings	R&S Stock No.
R160	Resistor, depos. carbon	1.6 MΩ/0.5 w	WF 1,6 M/0,5
R161	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R162	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R163	Resistor, depos. carbon	800 kΩ/0.5 w	WF 800 k/0,5
R164	Resistor, depos. carbon	10 kΩ/0.25 w	WF 10 k/0,25
R165	Resistor, depos. carbon	2 kΩ/0.5 w	WF 2 k/0,5
R166	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R167	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R168	Resistor, depos. carbon, variable	10 kΩ lin.	WS 9122 F/10 k
R169	Resistor, depos. carbon	80 kΩ/0.5 w	WF 80 k/0,5
R170	Reisitor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0.25
R171	Resistor, depos. carbon	16 kΩ/2 w	WF 16 k/2
R172	Resistor, depos. carbon, variable	10 kΩ lin.	WS 5122 F/10 k
R173	Resistor, depos. carbon	5 kΩ/0.5 w	WF 5 k/0,5
R174	Resistor, depos. carbon	2 kΩ/0.5 w	WF 2 k/0,5
R175	Resistor, wire-wound	30 kΩ/6 w	WDG 30 k/6
R176	Resistor, depos. carbon	3 kΩ/0.5 w	WF 3 k/0,5
R177	Resistor, depos. carbon	30 kΩ/0.5 w	WF 30 k/0,5
R178	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R179	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R180	Resistor, depos. carbon	1 MΩ/0.5 w	WF 1 M/0,5
R181	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R182	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R183	Resistor, depos. carbon	10 kΩ/0.5 w	WF 10 k/0,5
R184	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R185	Resistor, wire-wound	2.5 kΩ/12 w	WD 2,5 k/12
R187	Resistor, wire-wound	4 kΩ/4 w	WD 4 k/4
R188	Resistor, depos. carbon, variable	10 kΩ lin.	WS 5122 F/10 k

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Ref. No.	Designation	Ratings	R&S Stock No.
R189	Resistor, depos. carbon, variable	10 kΩ lin.	WS 7126/10 k
R190	Resistor, depos. carbon	8 kΩ/0.5 w	WF 8 k/0,5
R191	Resistor, depos. carbon	2.5 kΩ/1 w	WFO 2,5 k/1
R192	Resistor, depos. carbon	2.5 kΩ/1 w	WFO 2,5 k/1
R193	Resistor, depos. carbon	1 kΩ/1 w	WFO 1 k/1
R194	Resistor, depos. carbon	1 kΩ/1 w	WFO 1 k/1
R195	Resistor, depos. carbon	2.5 kΩ/1 w	WFO 2,5 k/1
R196	Resistor, wire-wound	15 kΩ/4 w	WDG 15 k/4
R197	Resistor, depos. carbon	5 kΩ/2 w	WF 5 k/2
R198	Resistor, depos. carbon	5 kΩ/2 w	WF 5 k/2
R199	Resistor, wire-wound	50 Ω/4 w	WV 4/50
R200	Resistor, depos. carbon	5 kΩ/0.5 w	WF 5 k/0,5
R201	Resistor, wire-wound	100 Ω/4 w	WV 4/100
R202	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R203	Resistor, depos. carbon	1 kΩ/1 w	WF 1 k/1
R204	Resistor, depos. carbon, variable Resistor, depos. carbon	500 Ω lin. 1 kΩ/0.5 w	WS 5122 F/500 WF 1 k/0,5 in series
R205	Resistor, depos. carbon	1 kΩ/1 w	WF 1 k/1
R206	Resistor, depos. carbon variable	500 Ω lin.	WS 5122 F/500
R207	Resistor, depos. carbon, variable	500 kΩ lin. 10 kΩ/0.5 w	WS 5122 F/500 k WF 10 k/0,5 in series
R210	Resistor, depos. carbon	406.5 Ω ±1%/0.25 w	WF 406,5/1/0,25
R211	Resistor, depos. carbon	133.3 Ω ±1%/0.25 w	WF 133,3/1/0,25
R212	Resistor, depos. carbon	133.3 Ω ±1%/0.25 w	WF 133,3/1/0,25
R213	Resistor, depos. carbon	406.5 Ω ±1%/0.25 w	WF 406,5/1/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R11	Lamp, incandescent	150 v/15 w	RL 93015
R12	Lamp, projector	6 v/5 amps	RL 301
R13	Lamp, glow, miniature	220 v	RL 210
R14	Lamp, scale	6 v/0.5 amp	RL 165 S for I1
R15	Lamp, scale	6 v/0.5 amp	RL 165 S for I3
Rö1	Pentode		EF 80
Rö2	Pentode		EF 80
Rö3	Pentode		EF 80
Rö4	Pentode		EF 80
Rö5	Pentode		EF 80
Rö6	Pentode		EF 80
Rö7	Pentode		EF 800
Rö8	Pentode		EF 800
Rö9	Triode		EC 81
Rö10	Pentode		EF 80
Rö11	Pentode		EF 80
Rö12	Diode		E 91 AA
Rö13	Pentode		EF 80
Rö14	Pentode		EF 80
Rö15	Pentode		EF 80
Rö16	Pentode		EF 80
Rö17	Pentode		EF 80
Rö18	Pentode, output		EL 84
[illegible]	[illegible]		[illegible]
Rö20	Reference tube		85 A 2
Rö21	Pentode		EF 80

Ref. No.	Designation	Ratings	R&S Stock No.
Rö22	Pentode, output		PL 81
Rö23	Pentode, output		PL 81
Rö24	Rectifier		EZ 80
Rö25	Rectifier		EZ 80
S1	Switch, coil		
S2	Wafer		3561 - 7.46
S3	Push button		SR 62803
S4	Switch, wafer		SRN 324/2/32
S5	Fuse strip		FD 60517
S6	Connection link		
Si1	Fuse	1.6 amps	M 1,6 D DIN 41571 (for 220 & 235 v)
		2.5 amps	M 2,5 D DIN 41571 (for 115 & 125 v)
Si2	Fuse	250 ma	M 0,25 C DIN 41571
Tr1	Transformer, bridge		3561 - 3.16
Tr2	Transformer, output		3561 - 3.17
Tr3	Transformer, power		3561 - 3.15/2
Tr4	Transformer, power		3561 - 3.18/2

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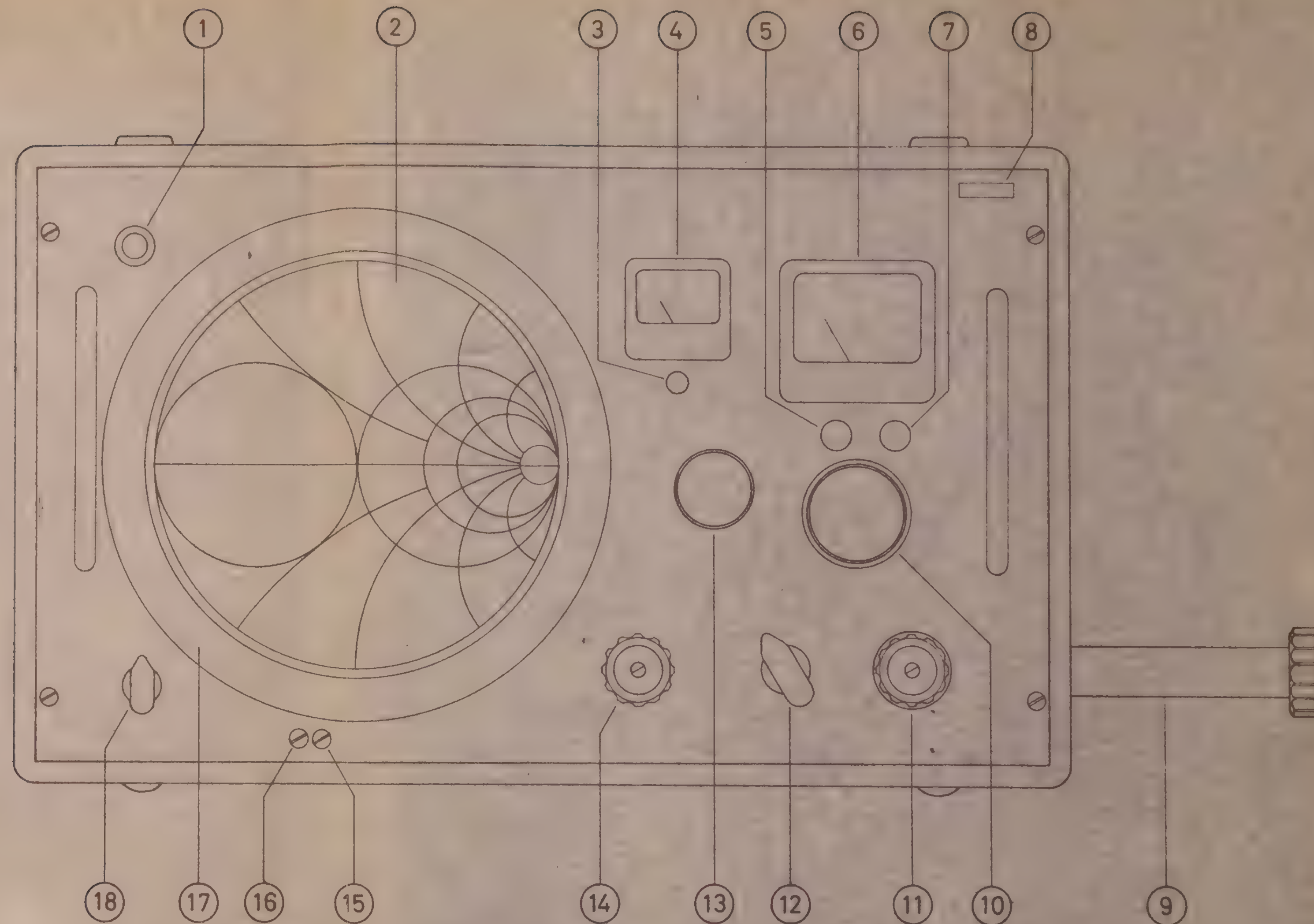


1) Pilot lamp

2 Chart

3) With button depressed discriminator meter (4) shows phase adjustment, with button not depressed, it shows oscillator tuning. Button remains down until it is released by being pressed anew.

4) Discriminator meter for oscillator tuning and phase adjustment, when button (3) is depressed.

5) REFERENCE VOLTAGE COR. knob

6) Reference meter

7) PHASE COR. knob

8) Identification of characteristic impedance

9) Coaxial test line

10 Coarse and fine adjustment for oscillator tuning

11) Coaxial reference line

12) FREQUENCY RANGE switch

13) PHASE ADJ. knob

14) Test voltage input

15) VERT. }
16) HORIZ. } Slotted screws for zeroing the galvanometer

17) Bezel

18) POWER and NORMAL-SPREAD switch

Fig. 23 Front view

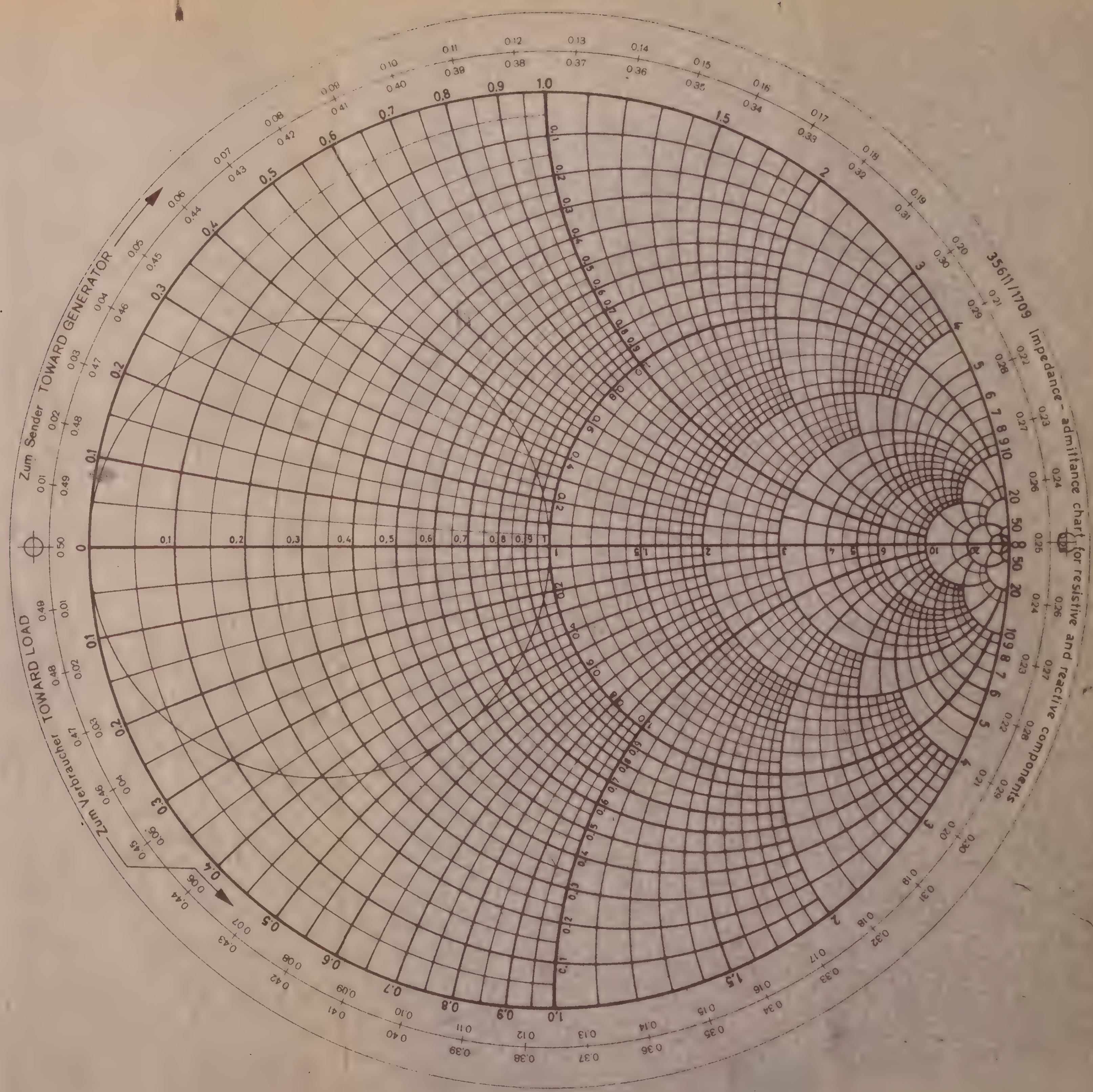


Fig. 24 Impedance-admittance chart
for resistive and reactive components

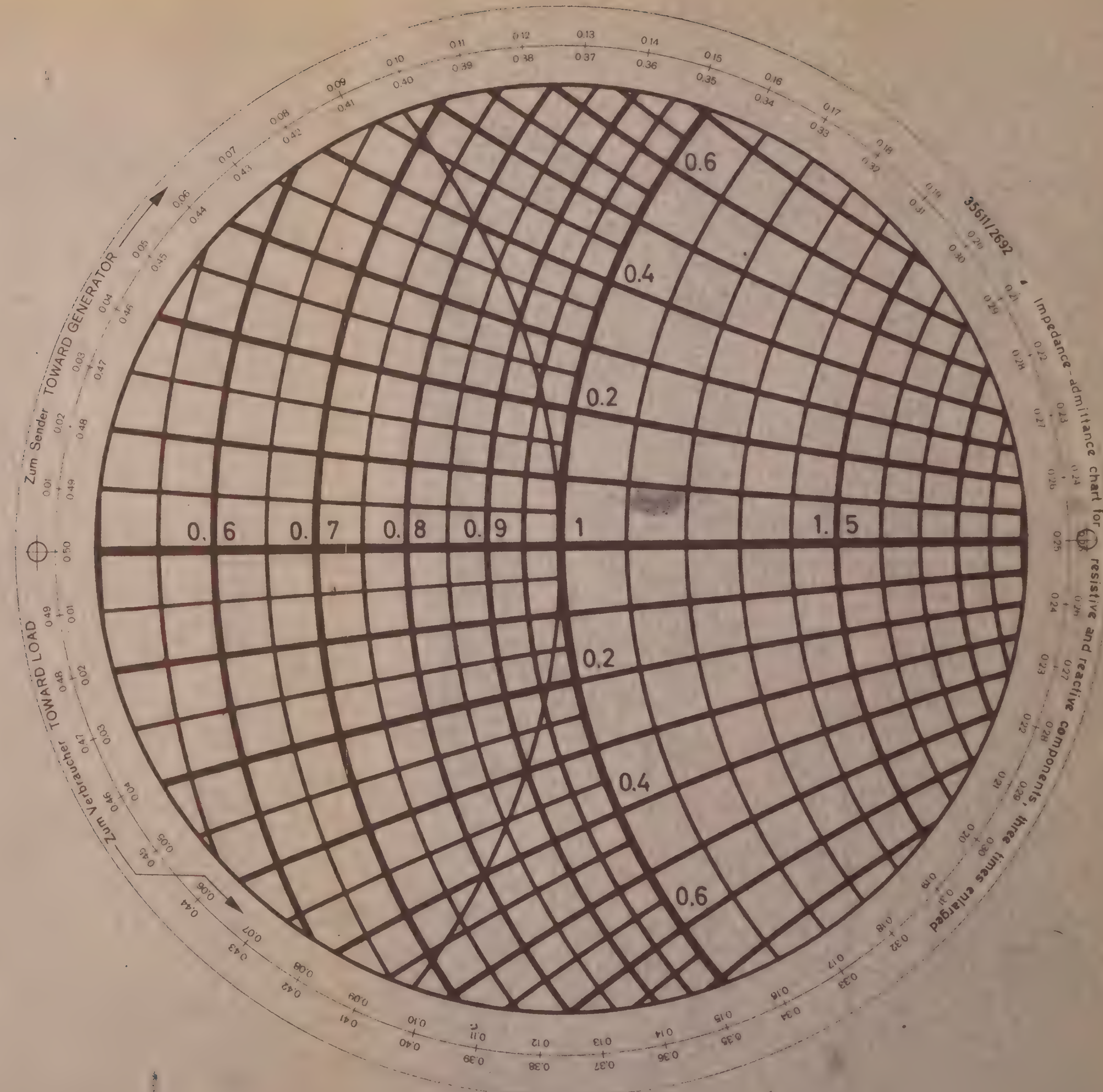


Fig. 25 Impedance-admittance chart for resistive and reactive components, three times enlarged

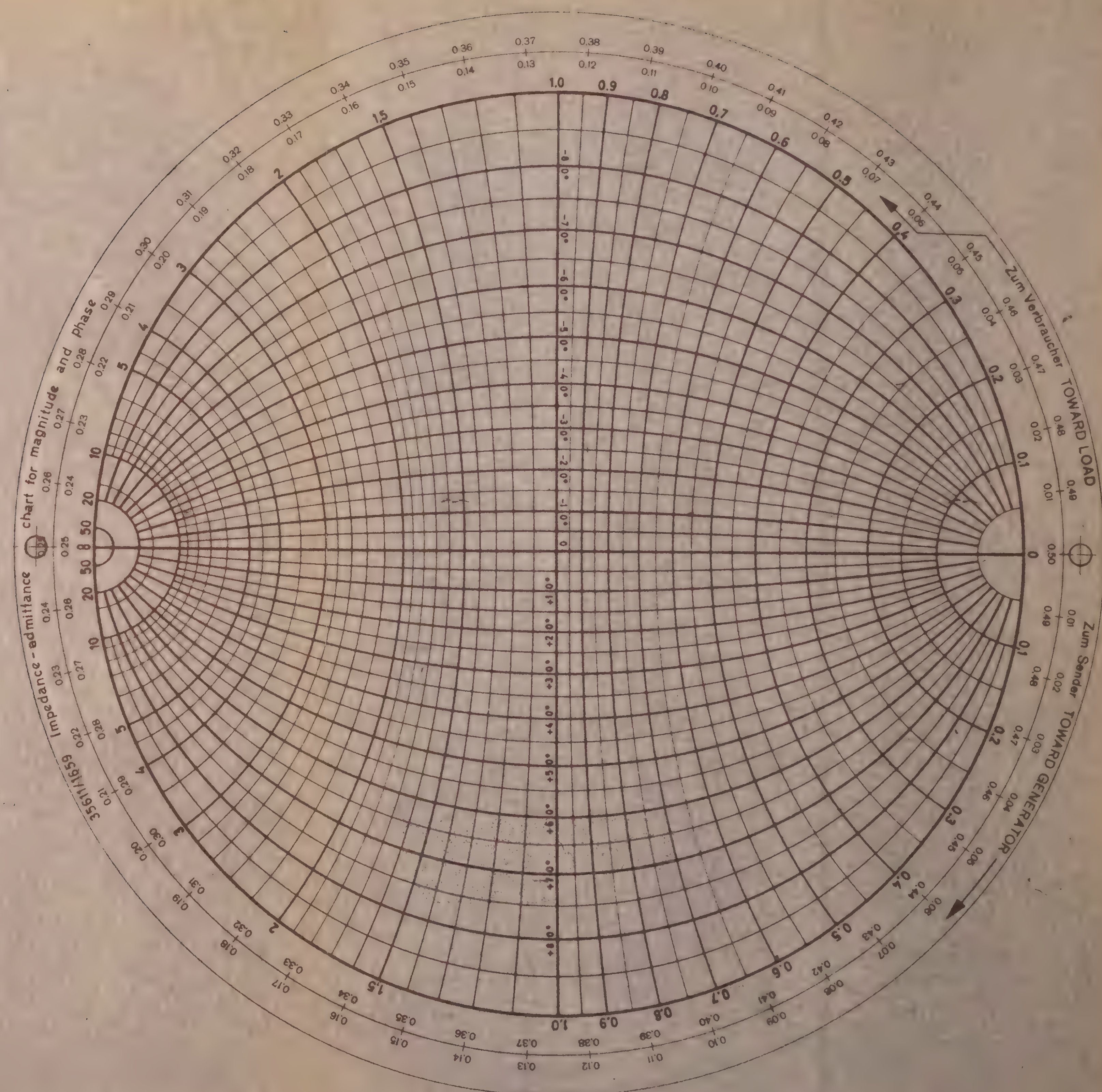


Fig. 26 Impedance - admittance chart
for magnitude and phase

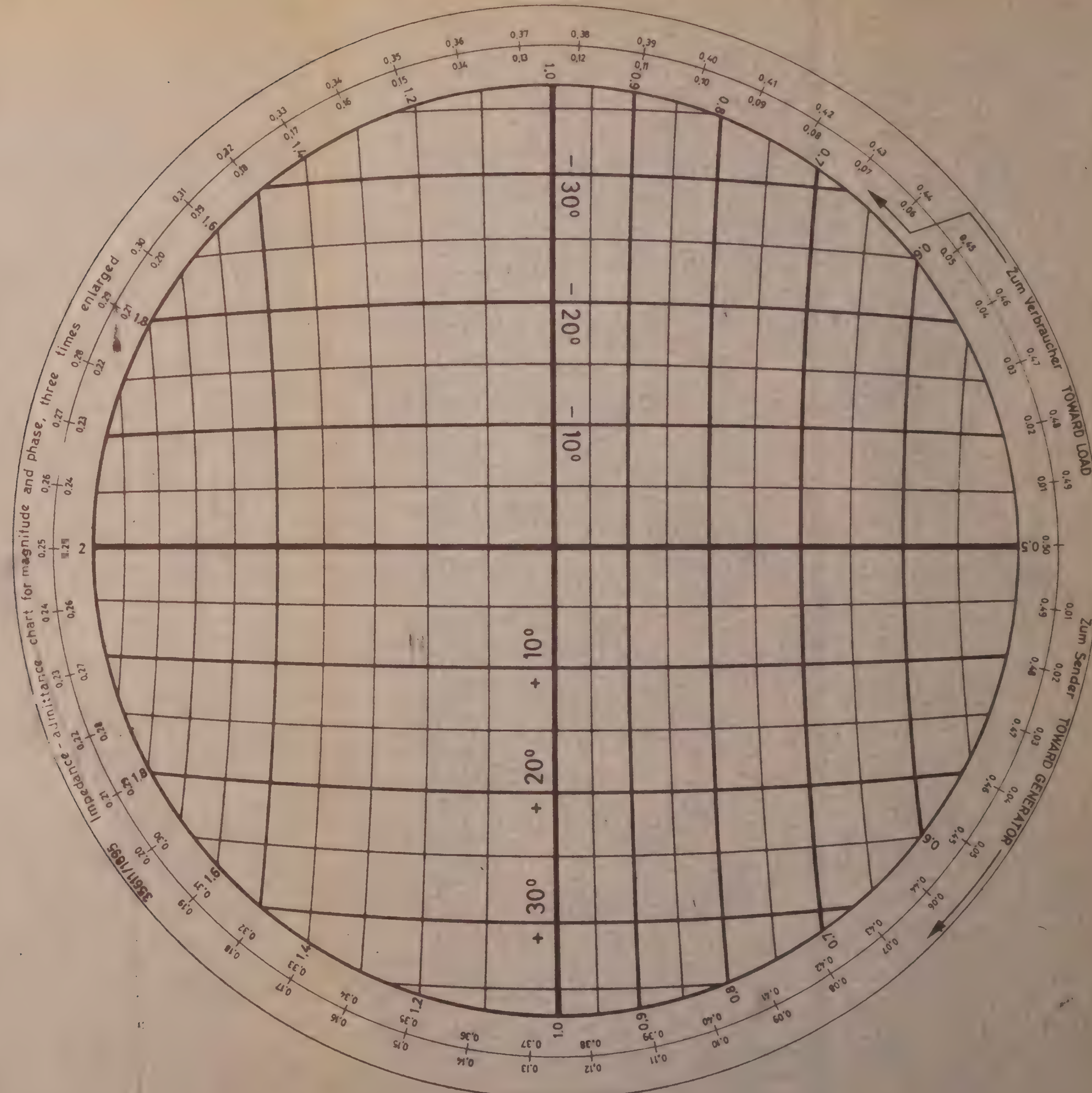


Fig. 27 Impedance - admittance chart for magnitude and phase, three times enlarged

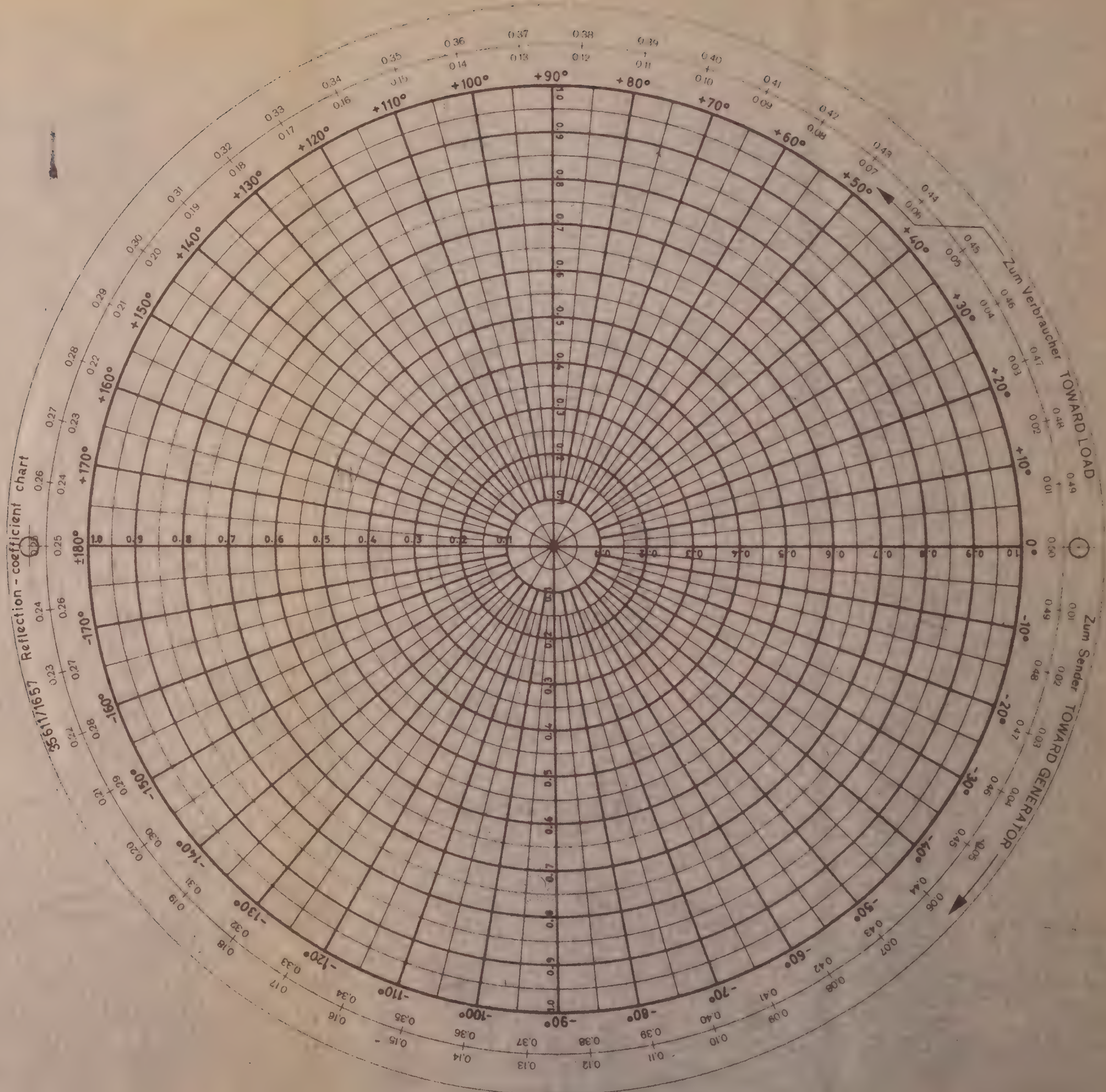


Fig. 28 Reflection-coefficient chart

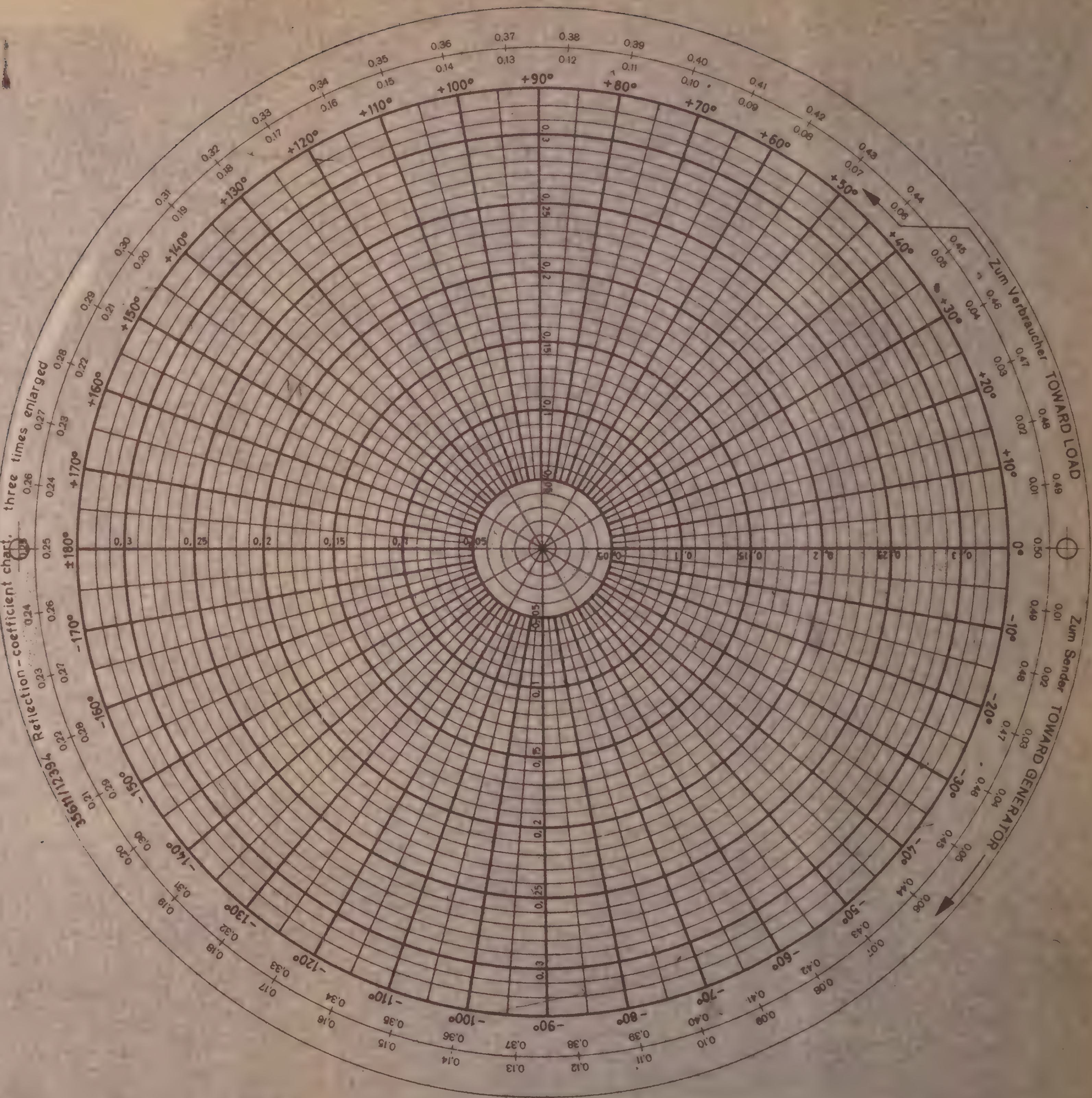


Fig. 29 Reflection-coefficient chart, three times enlarged

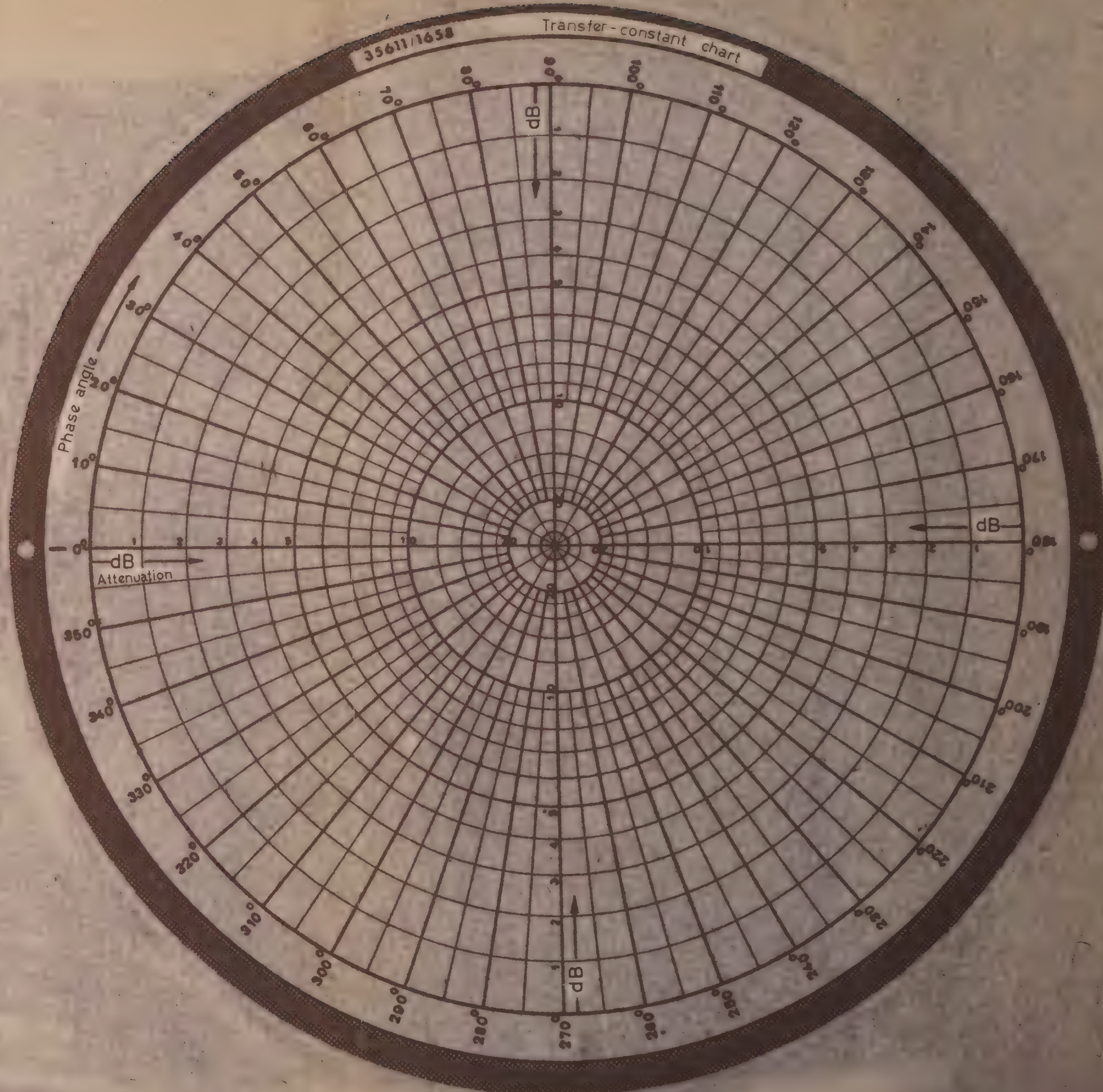


Fig. 30 Transfer-constant chart

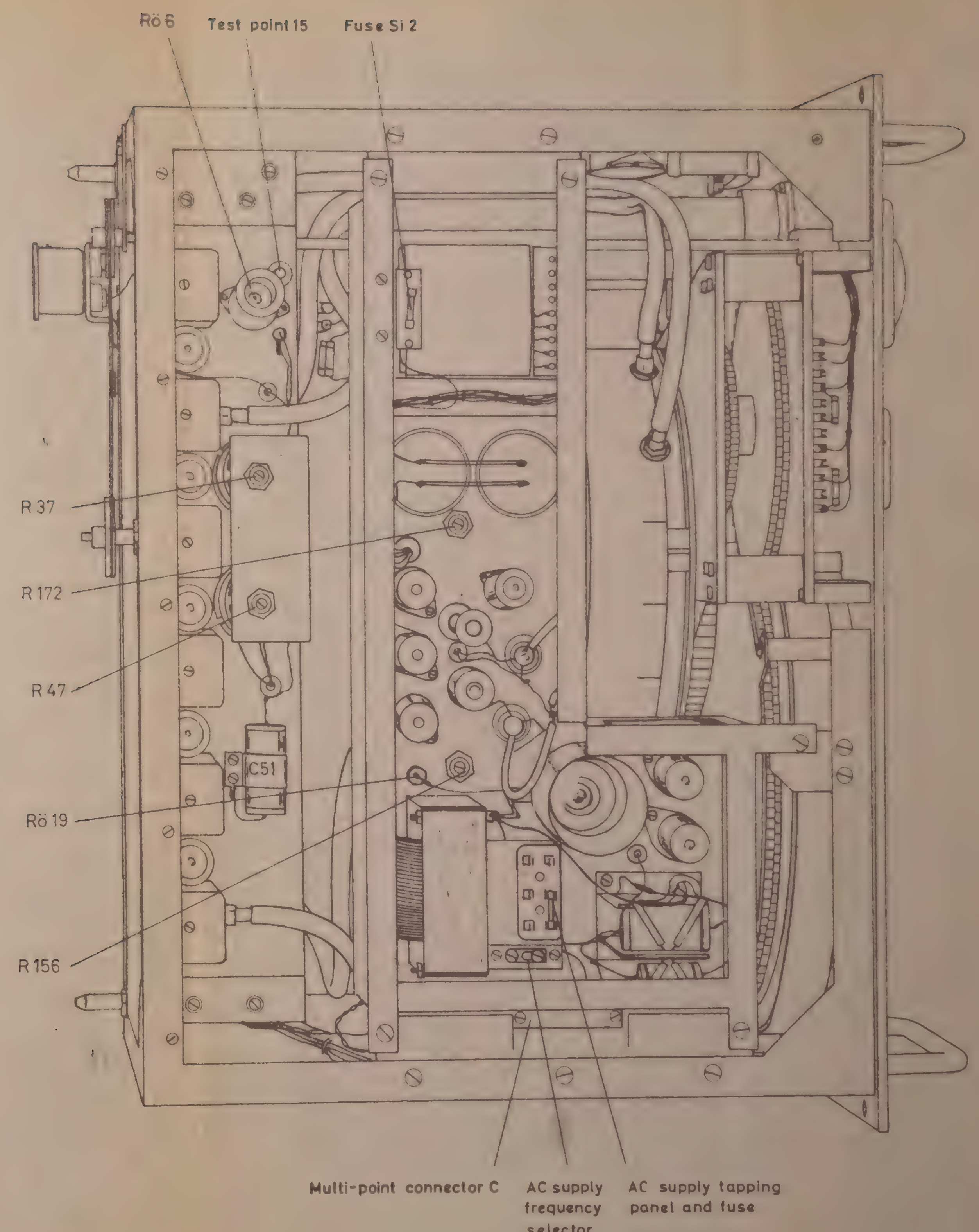


Fig. 31 Top view with power supply inserted

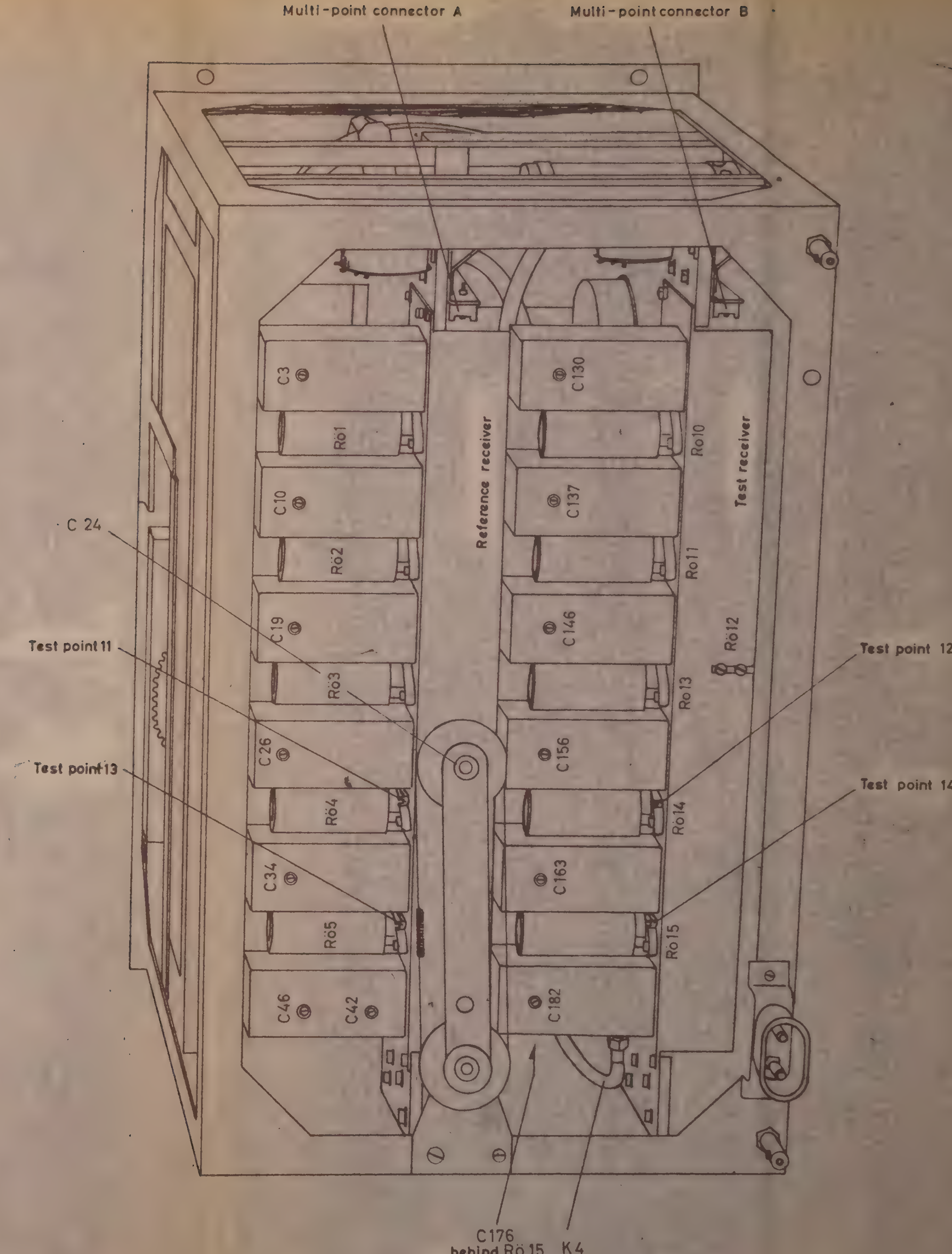


Fig. 32 Rear view

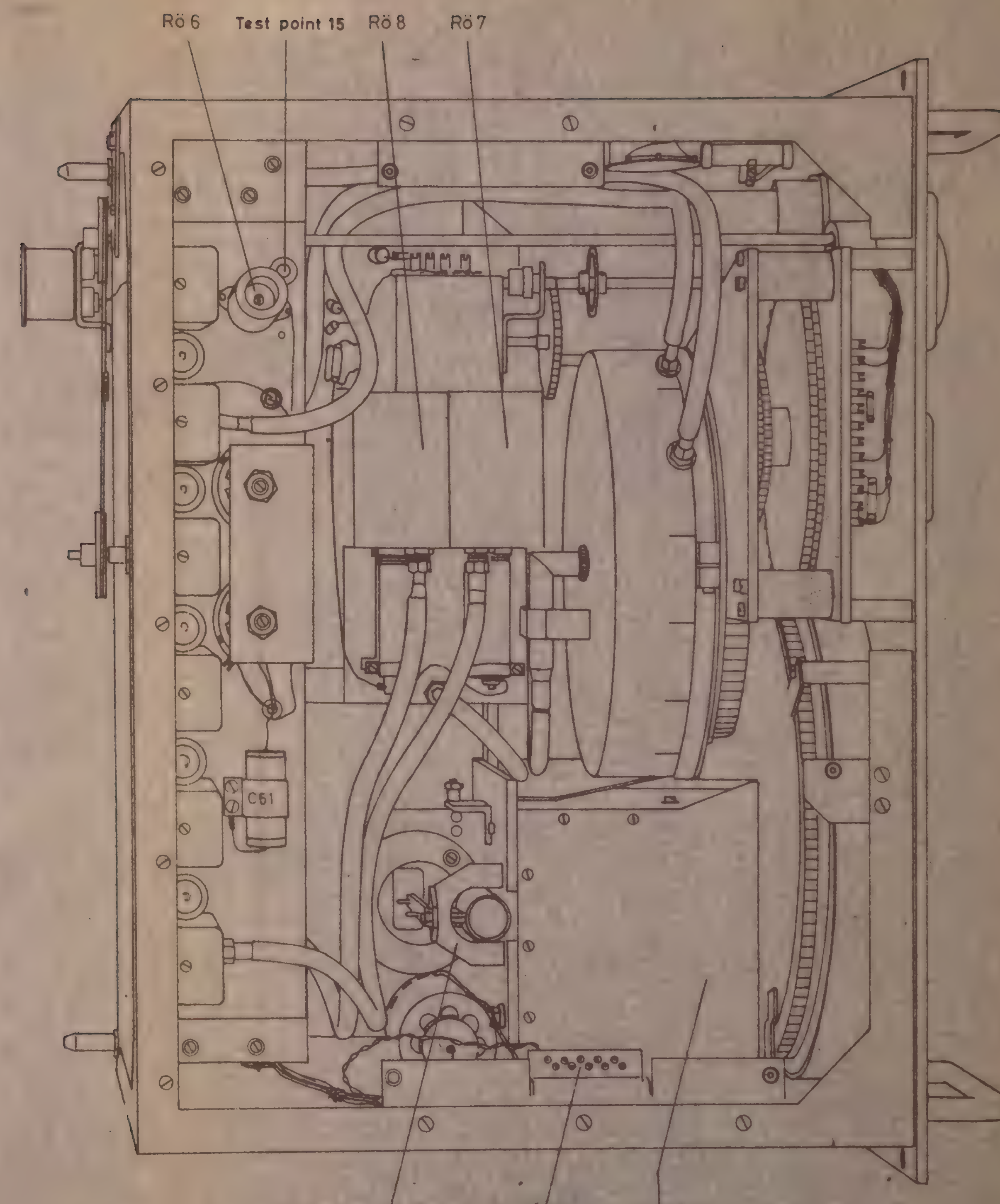


Fig. 33 Top view, power supply removed

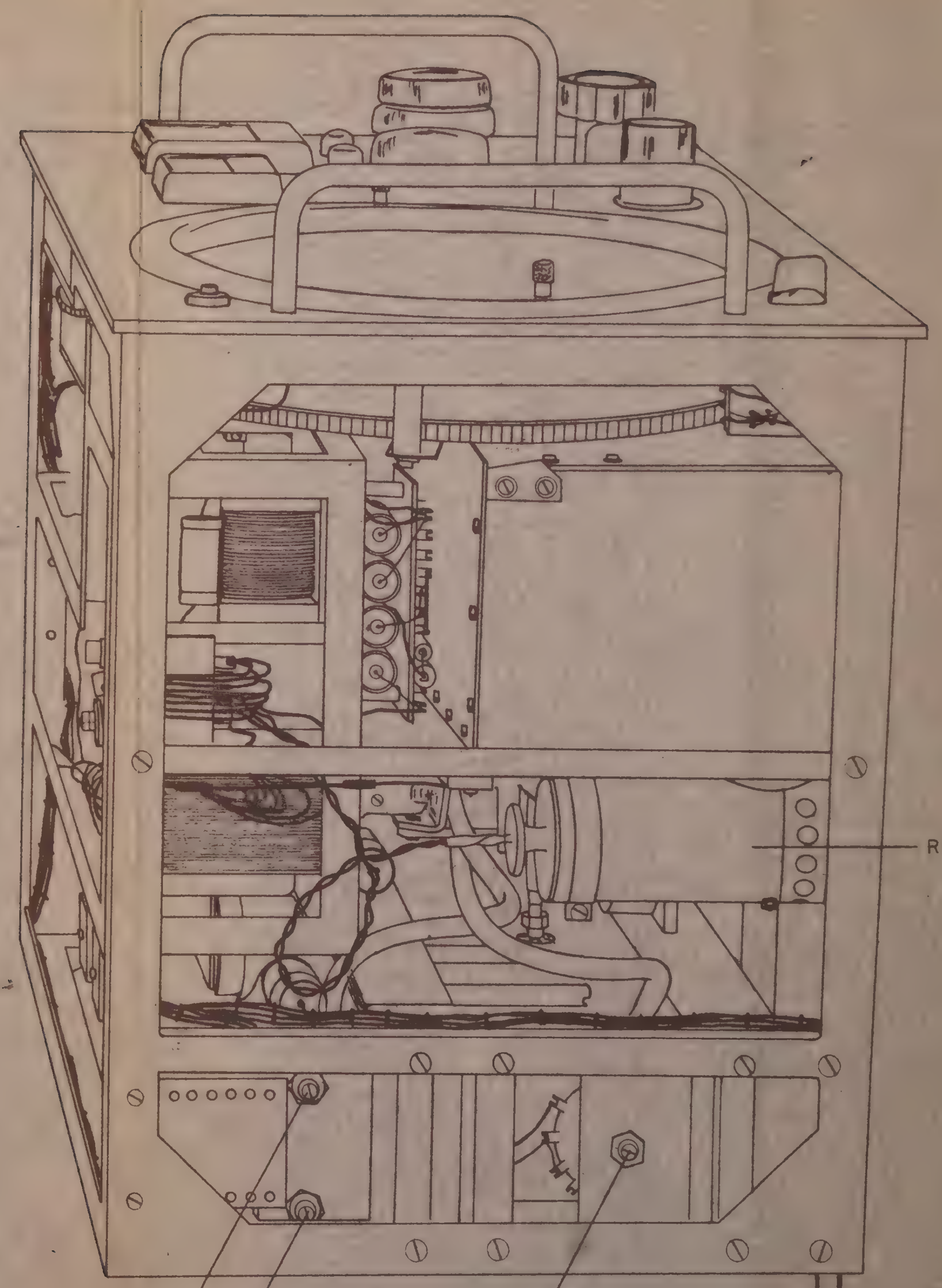


Fig. 34 Left–side view

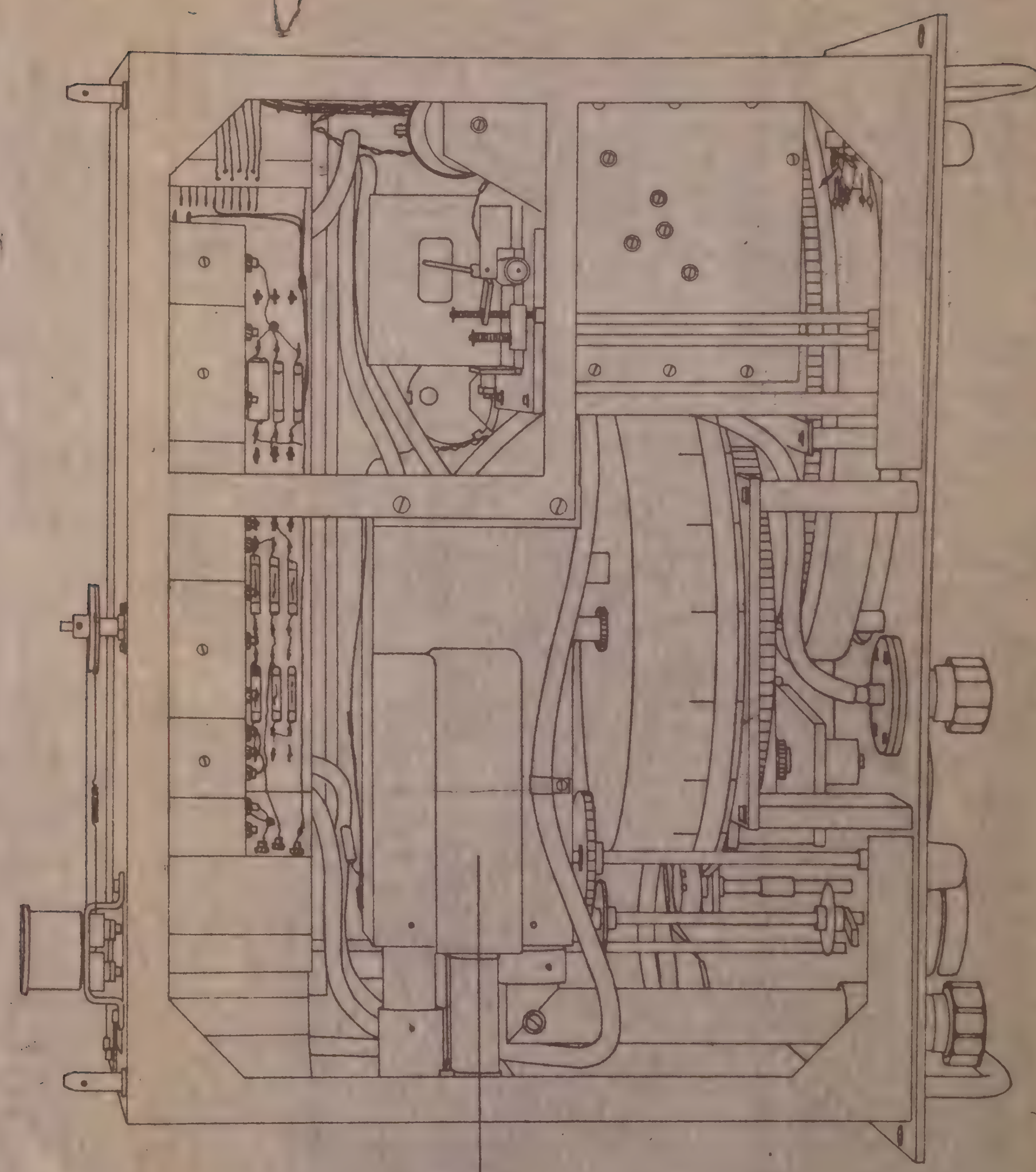


Fig. 35 Bottom view

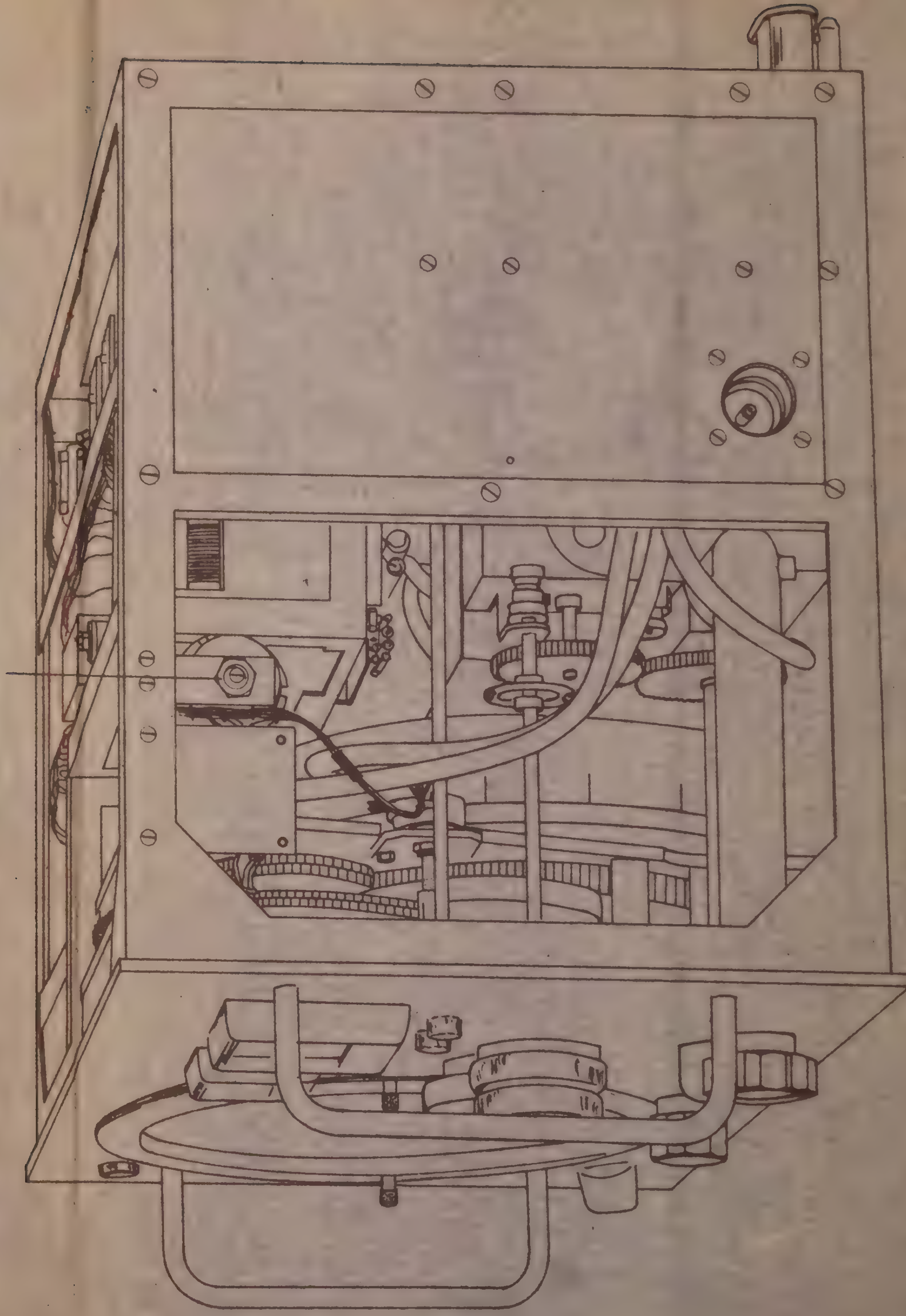
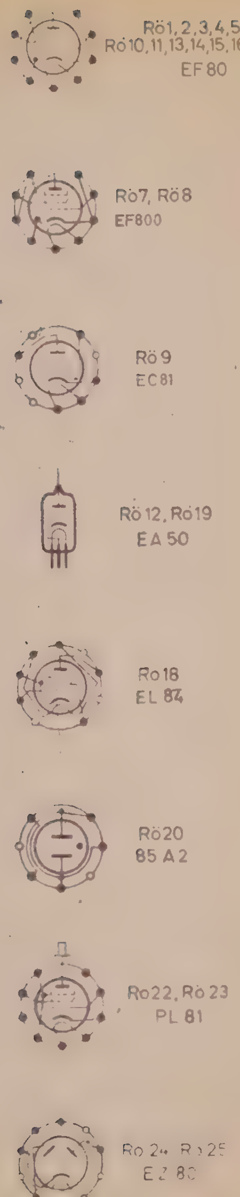
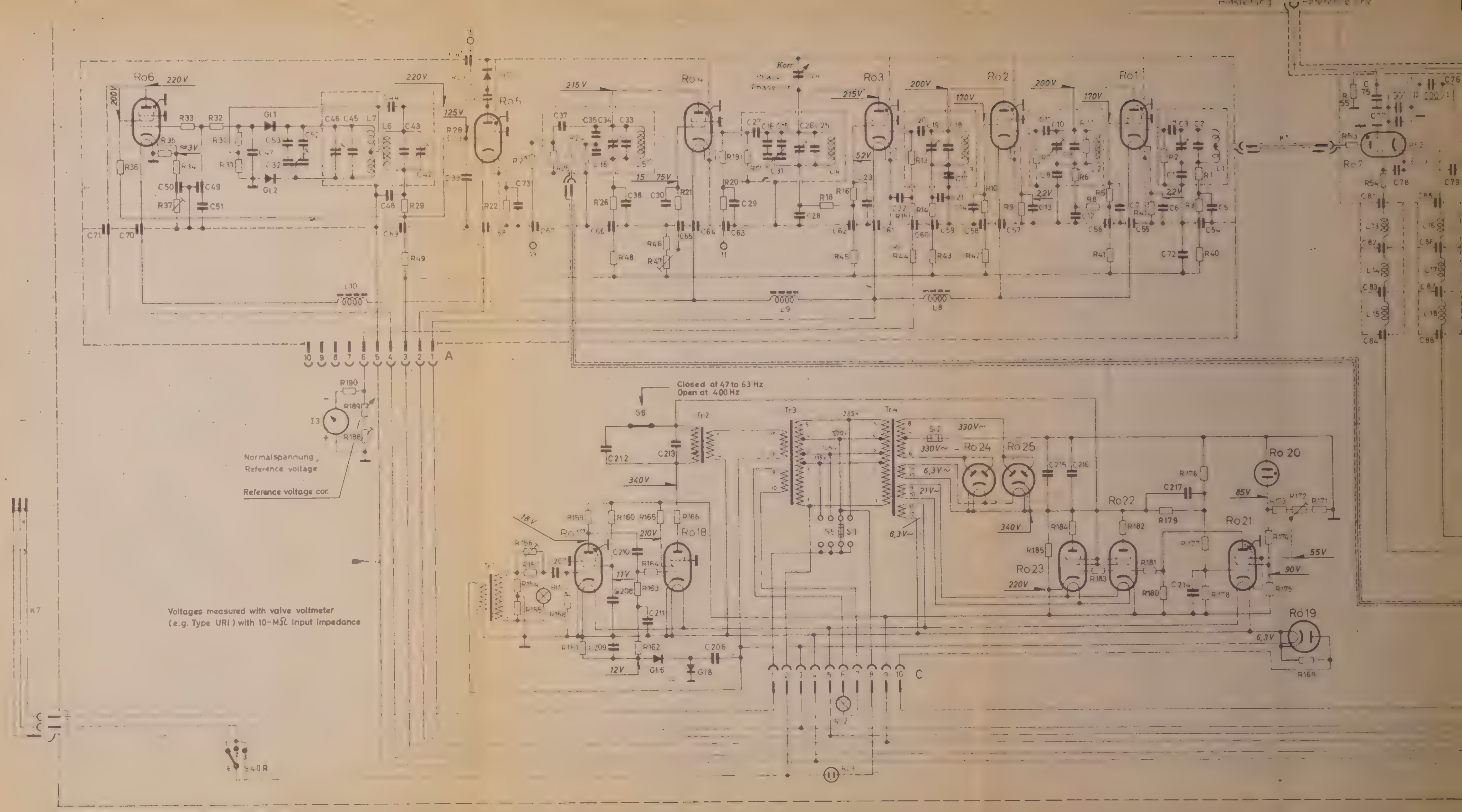
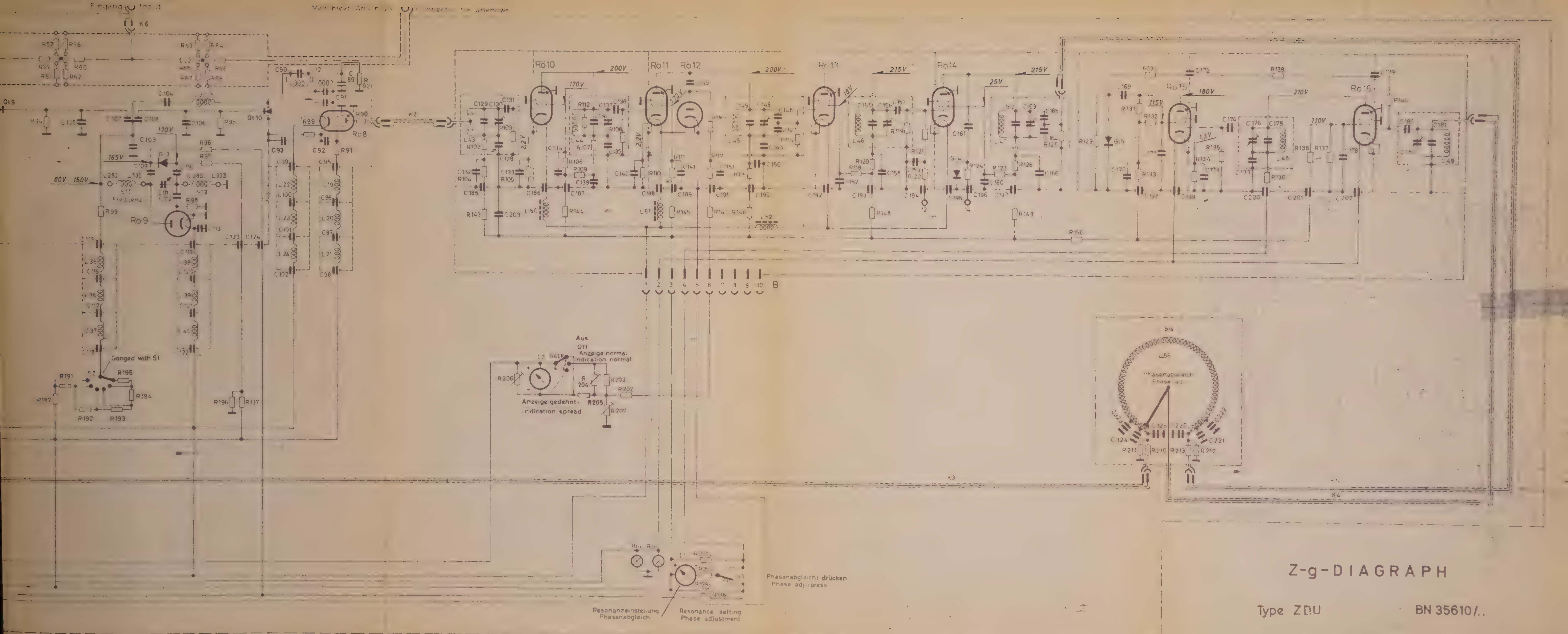


Fig. 36 Right-side view

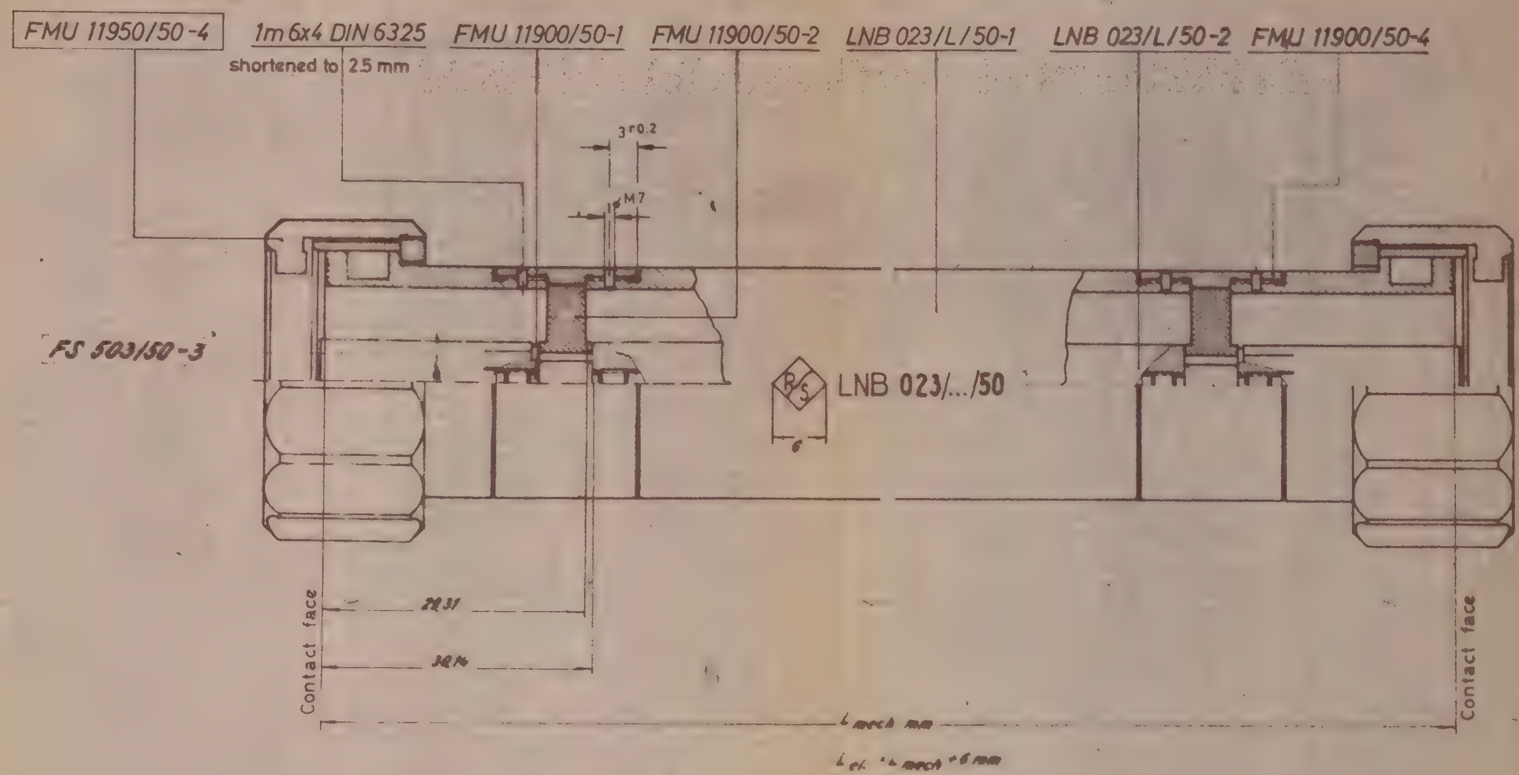

Rö1, 2, 3, 4, 5 u. 6
Rö10, 11, 13, 14, 15, 16, 17 u. 21
EF 80
Rö7, Rö8
EF800
Rö 9
EC 81
Rö 12, Rö 19
EA 50
Rö 18
EL 84
Rö 20
85 A 2
Rö 22, Rö 23
PL 81


Rö6
Rö5
Rö4
Rö3
Rö2
Rö1
Rö7
Rö17
Rö18
Rö22
Rö23
Rö21
Rö24
Rö25
Rö20
Rö19
Korr.
Normalspannung,
Reference voltage
Reference voltage cor.
Closed at 47 to 63 Hz
Open at 400 Hz
Voltages measured with valve voltmeter
(e.g. Type URI) with 10-MΩ input impedance
A
C
S40R



Z-g-DIAGRAPH

Type ZDU BN 35610/..



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ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff	Untolerierte Maße	Zeichn. Nr LNB 023/L/50
		Maßstab 2:1	Ersatz für Zeichnung
SEKB / Tag / Name	Änd.-zust / Änd.-Mittlg. Nr / Tag / Name	Line section with Precision Dezifix B on both sides	
gezeichnet 11.11.64			
bearbeitet			
geprüft			
normgepr.			

Lfd Nr Kenn-zeichen	Stück-zahl	Benennung	Sach-Nr		Bemerkungen
1	2	3	4	5	6
1	1	Outer conductor tube	LNB 023/L/50-1		
2	1	Inner conductor	LNB 023/L/50-2		
5	2	Inner conductor	FMU 11900/50-1		
6	2	Insulating disc	FMU 11900/50-2		
7	2	Case	FMU 11900/50-4		
9	2	Case	FMU 11950/50-4		
11	2	Inner-conductor end section, spring-loaded	FS 503/50-3		
14	4	Pin	1 m 6 x 4 DIN 6325		

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Vervielfält.-Pause Nr.
Arbeitspause Nr.

ROHDE & SCHWARZ MÜNCHEN			Änd.-zust.	Änd.-Mittlg Nr.	Datum	Name	Liste Nr. LNB 023/L/50 St	Liste besteht aus Blatt / Blatt Nr
	Datum	Name					Ersatz für Liste	
geschrieben							Stückliste / Schaltteilliste zu	
bearbeitet							Line section with Precision Dezifix B	
geprüft							on both sides	129
normgeprüft								

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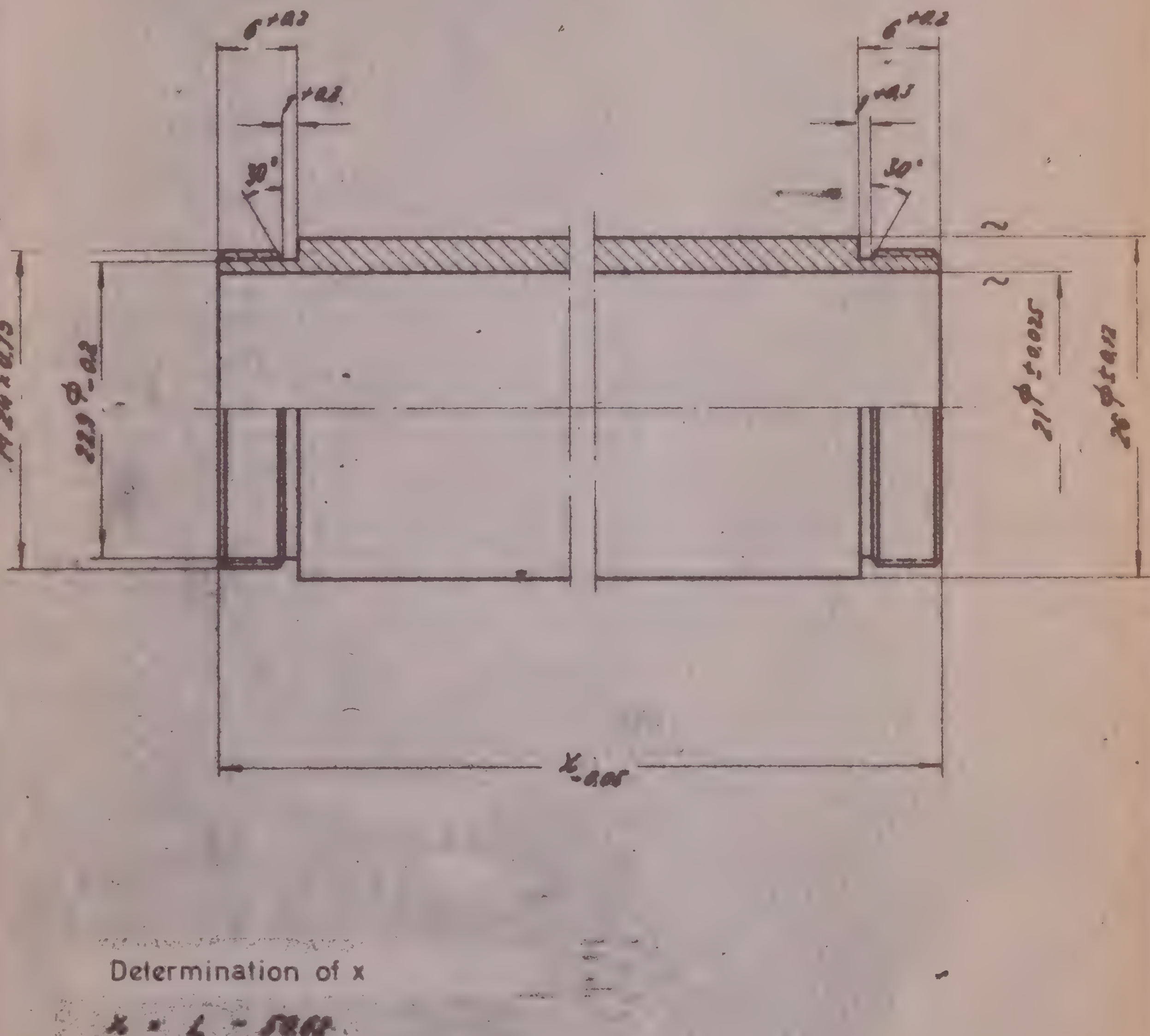


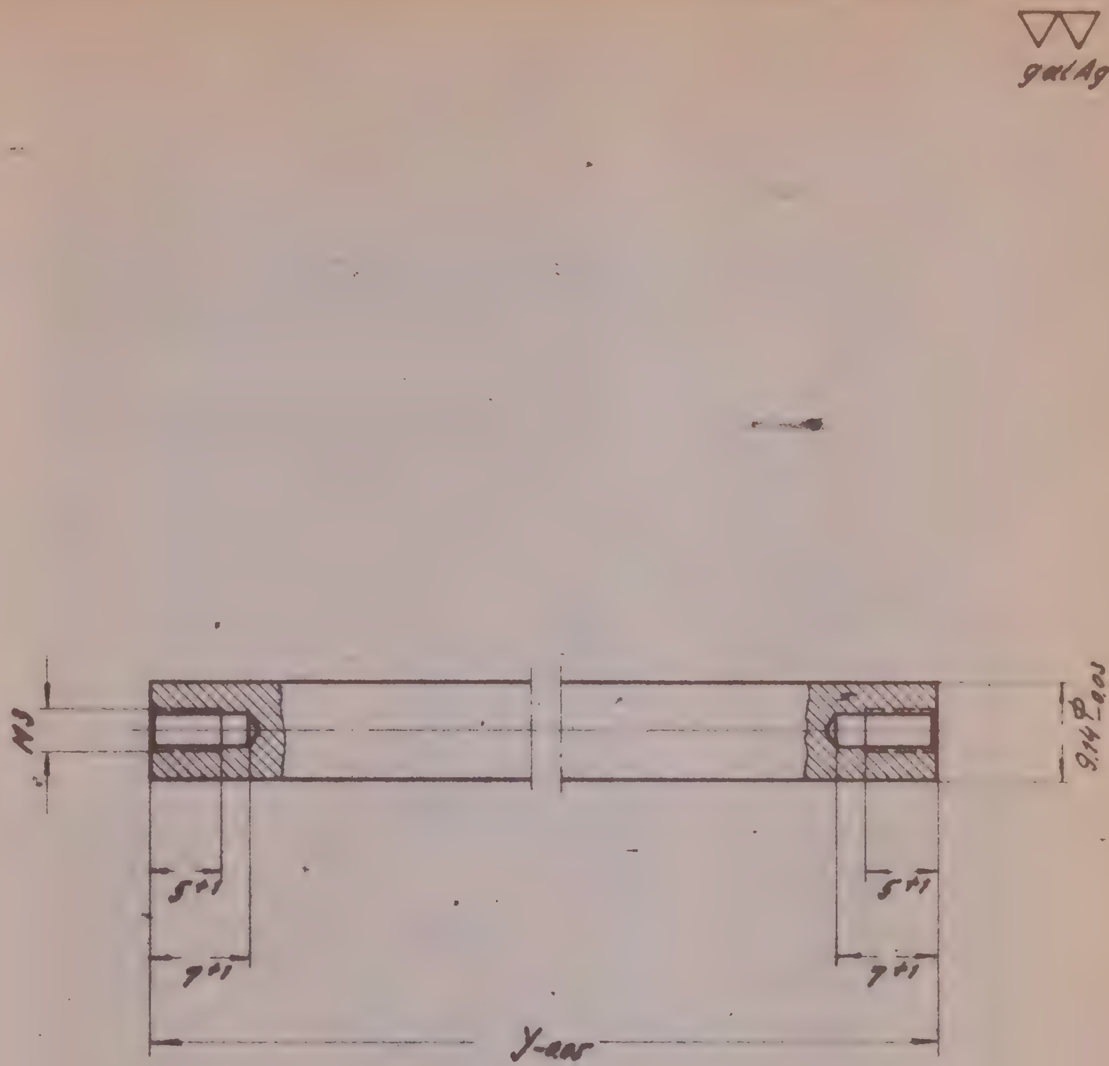
Determination of x

$x = L - 58{,}62$

ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff: Rohr 26 x 2,5 W 32 / Ms 63 hart / Präzisionsausführung A	Untolerierte Maße	Zeichn. Nr. LNB 023/L/50-1
		Maßstab 2:1	Ersatz f. Zeichn.

SEKB	Tag	Name	Änd. zust.	Änd.-Mitt.-Nr.	Tag	Name
gezeichnet	11.11.84					
bearbeitet						
geprüft						
normgepr.						

Outer conductor tube



Determination of y

$y = L - 60.20$

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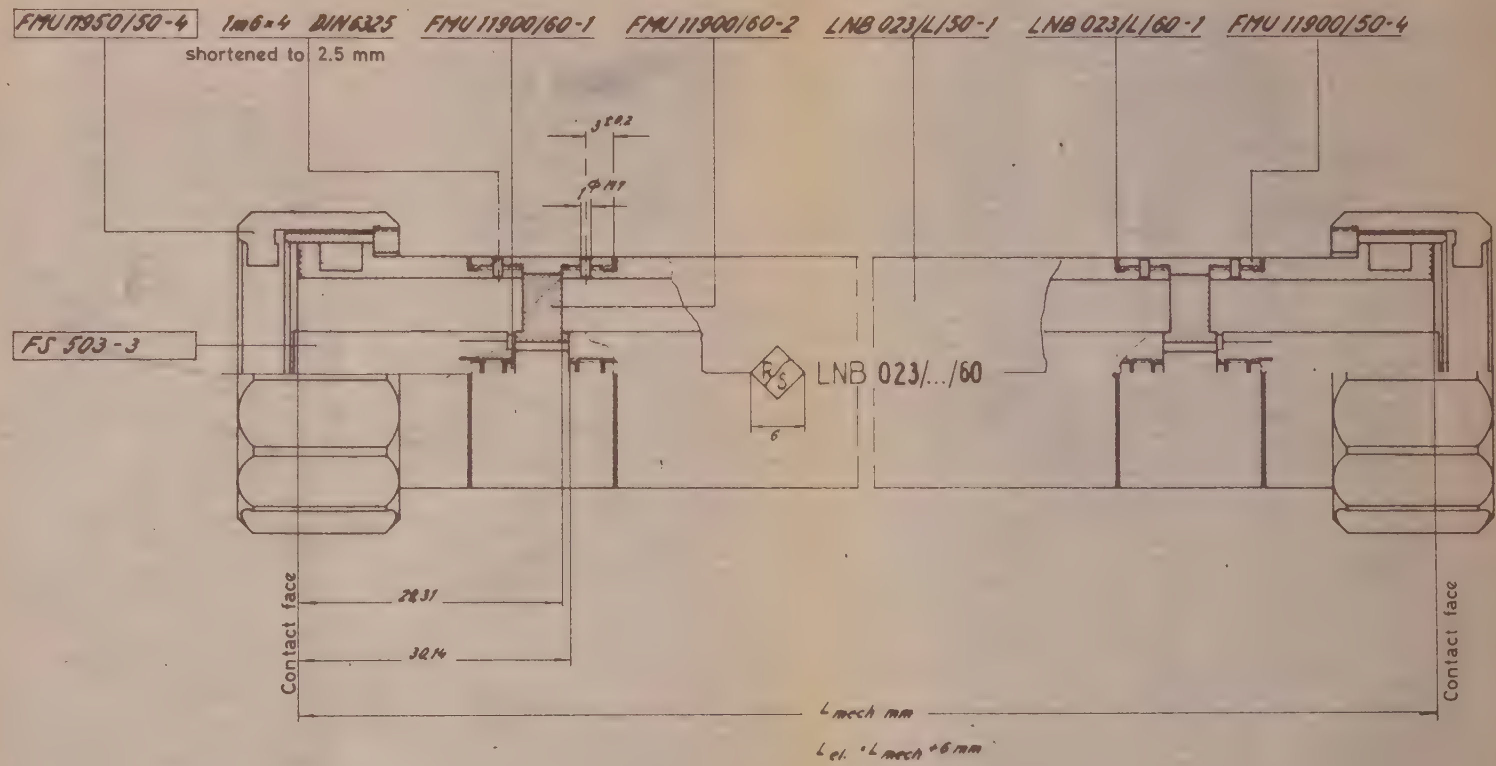
ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff: Ø 9,5 DIN 1756 Ms 58 zh	Untolerierte Maße	Zeichn. Nr. LNB 023/L/50-2
		Maßstab 2:1	Ersatz f. Zeichn.

SEKB	Tag	Name	Änd. zahl	Änd.-Mittlg. Nr.	Tag	Name
gezeichnet	11.11.64					
bearbeitet						
geprüft						
normgepr.						

Inner conductor

$_1\phi^{H7} = {}^{0}_{-0.003}$



Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

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ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff	Untolerierte Maße	Zeichn. Nr. LNB 023/L/60
		Maßstab 2:1	Ersatz für Zeichnung
SEKB Tag Name	Änd. zust. Änd. Mitteilg. Nr. Tag Name		
gezeichnet 11 11 64		Line section with Precision Dezifix B on both sides	
bearbeitet			
geprüft			
normgeprüft			132

Lfd. Nr. Kenn-zeichen 1	Stück-zahl 2	Benennung 3	Sach-Nr. 4	5	Bemerkungen 6
1	1	Inner conductor	LNB 023/L/60-1		
3	1	Outer conductor tube	LNB 023/L/50-1		
6	2	Inner conductor	FMU 11900/60-1		
7	2	Insulating disc	FMU 11900/60-2		
9	2	Case	FMU 11900/50-4		
12	2	Case	FMU 11950/50-4		
14	2	Inner-conductor end section, spring-loaded	FS 503-3		
17	4	Pin	1 m 6 x 4 DIN 6325		

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Vielfält.-Pause Nr.

Teilpause Nr.

ROHDE & SCHWARZ MÜNCHEN

	Datum	Name	Änd.-zust.	Änd.-Mittlg. Nr.	Datum	Name
geschrieben						
bearbeitet						
geprüft						
normgeprüft						

Liste Nr. LNB 023/L/60 St

Liste besteht aus Blatt

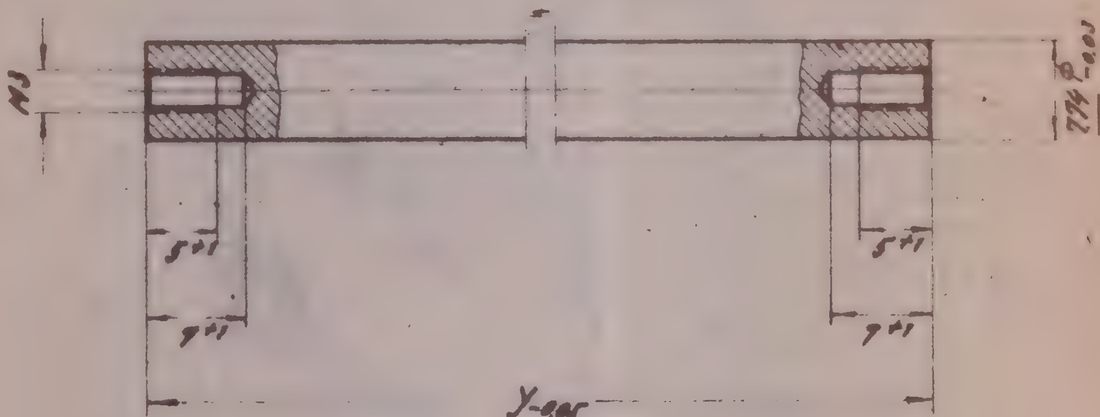
Blatt Nr.

Ersatz für Liste

Stückliste / Schaltteilliste zu
Line section with Precision Dezifix B on both sides

0864 100 5

galAg



Determination y

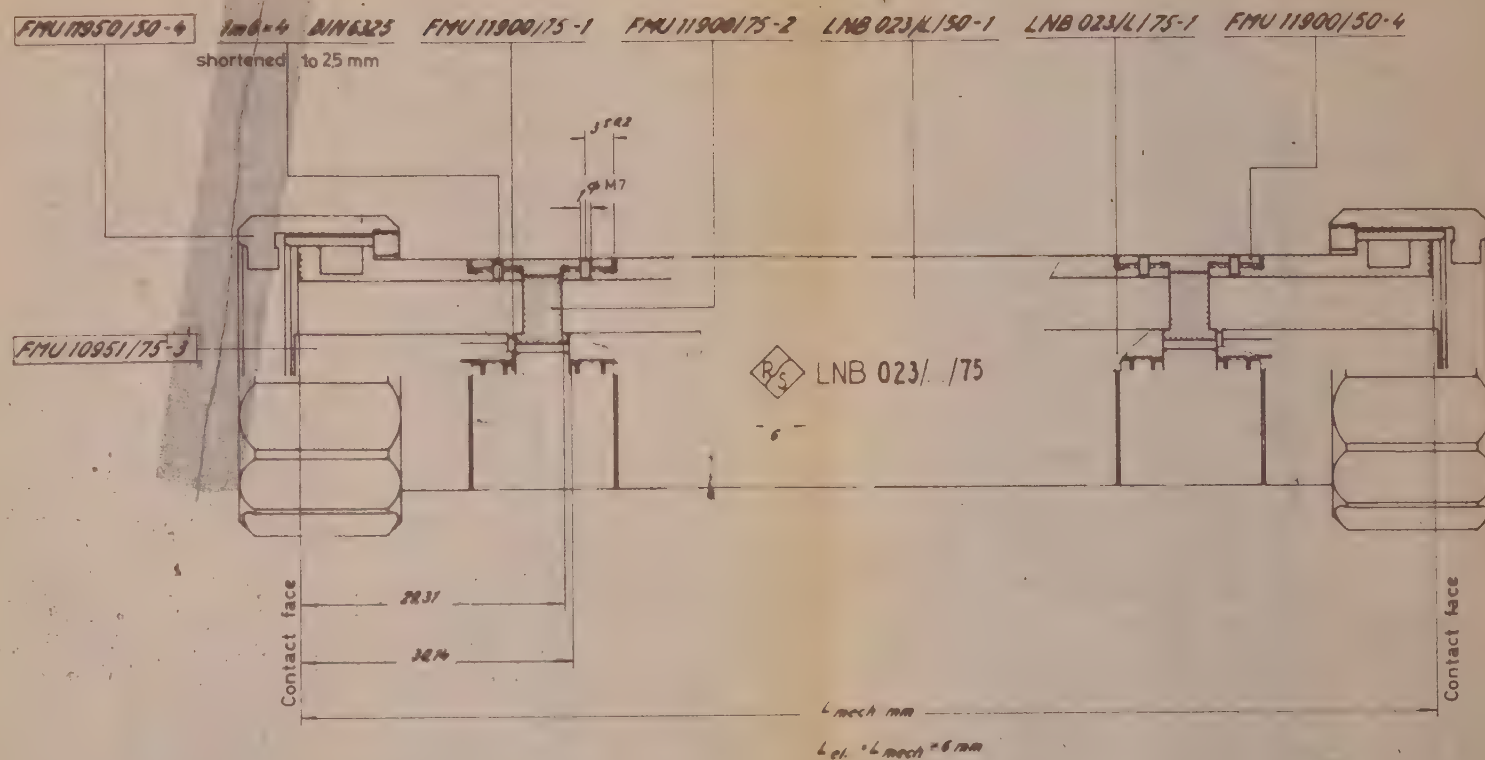
y = L - 60,30

R 10357
865
Bl. 134

ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff: ⌀ 8 DIN 1756 Ms 58 zh	Untolerierte Maße	Zeichn. Nr. LNB 023/L/60-1
		Maßstab 2:1	Ersatz f. Zeichn.

SEKB	Tag	Name	Änd. zust.	Änd.-Mitt. Nr.	Tag	Name
gezeichnet	11.11.64					
bearbeitet						
geprüft						
normgepr.						

Inner conductor



ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff	Untolerierte Maße	Zeichn Nr LNB 023/L/75
		Maßstab 2:1	Ersatz für Zeichnung
SEKB Tag Name	Änd. zust. Änd.-Mittlg Nr Tag Name		
gezeichnet 11 11 64		Line section with Precision Dezifix B on both sides	
bearbeitet			
geprüft			
normgepr.			

Lfd. Nr. Kennzeichen	Stückzahl	Benennung	Sach-Nr.		Bemerkungen
1	2	3	4	5	6
1	1	Inner conductor	LNB 023/L/75-1		
3	1	Outer conductor tube	LNB 023/L/50-1		
6	2	Inner conductor	FMU 11900/75-1		
7	2	Insulating disc	FMU 11900/75-2		
9	2	Case	FMU 11900/50-4		
12	2	Case	FMU 11950/50-4		
14	2	Inner-conductor end section, spring-loaded	FMU 10951/75-3		
17	4	Pin	1 m 6 x 4 DIN 6325		

R 10357
865
Bl. 136

Vervielfält.-Pause Nr.

Arbeitspause Nr.

ROHDE & SCHWARZ
MÜNCHEN

	Datum	Name
geschrieben		
bearbeitet		
geprüft		
normgeprüft		

Änd.-zust.	Änd.-Mittlg. Nr.	Datum	Name

Liste Nr.
LNB 023/L/75 St

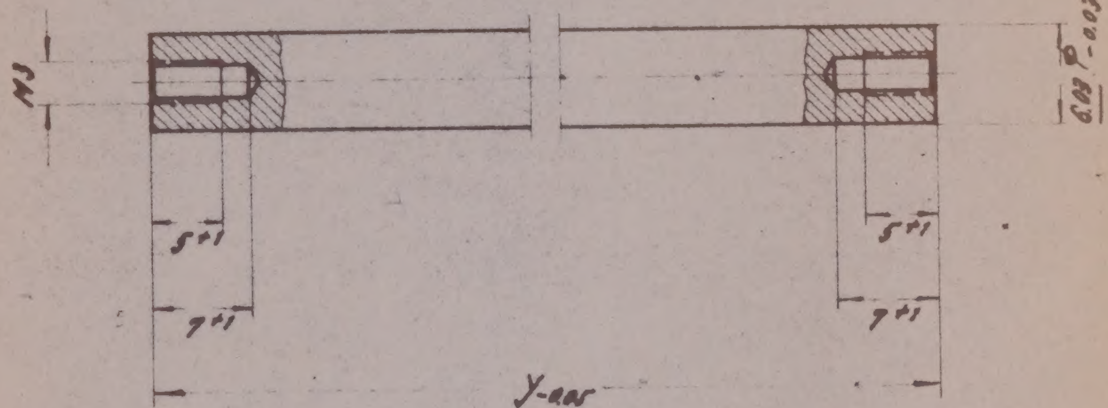
Liste besteht aus Blatt

Blatt Nr.

Ersatz für Liste

Stückliste / Schaltteilliste zu
Line section with Precision Dezifix B on both sides

428; 0864; 100 S



Determination y

y = L - 60.20

R 10357
865
Bl. 137

ROHDE & SCHWARZ MÜNCHEN	Halbzeug, Werkstoff: ∅6,5 DIN 1756 Ms 58 zh			Untolerierte Maße	Zeichn. Nr. LNB 023/L/75-L
SEKB / Tag / Name	Änd. zust.	Änd.-Mittlg. Nr.	Tag / Name	Maßstab 2:1	Ersatz f. Zeichn.
gezeichnet 11.11.64				Inner conductor	
bearbeitet					
geprüft					
normgepr.					