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Translation

HANDBOOK ON ELECTRONIC MEASURING INSTRUMENTS

By

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Moscow SPRAVOCHNIK PO IZMERITEL'NYM PRIBORAM (Handbook on Electronic Measuring Instruments) in Russian 1978 signed to press 19 Sep 78 pp 4-12, 197-237, 237-251, 252-289, 303-314, 317-328, 329-367

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CONTENTS

CHAPTER 1

BASIC REQUIREMENTS FOR THE PARAMETERS OF ELECTRONIC MEASURING INSTRUMENTS

1.1. Normative Documents (GOST) for Instrument Manufacturing

The Gosstandart (State Committee for Standards of the USSR Council of Ministers) of the USSR introduced (as of January 1, 1975) the following state standards for electronic measuring instruments:

GOST [All-Union State Standard] 9763-67* "Electronic Measuring Instruments. General Technical Requirements";

GOST 9771-61 "Heterodyne Frequency Meters. Technical Requirements";

GOST 9772-77 "Resonance Frequency Meters. Types. Technical Requirements";

GOST 9781-67 "Electronic Voltmeters. Technical Requirements";

GOST 9788-69 "Measuring Signal Generators. List of Parameters";

GOST 9810-69 "Cathode-Ray Oscillographs. General Specifications";

GOST 10086-68 "Meters of the Coefficient of Amplitude Modulation (modulometers). Types. Technical Requirements";

GOST 10501-74 "Low-Frequency Measuring Generators. Basic Parameters. Technical Requirements. Testing Methods";

GOST 10622-70 "High and Superhigh Frequency Signal Generators with a Frequency Range from 30 kHz to 300 MHz. Basic Parameters. Technical Requirements. Testing Methods";

GOST 11001-69 "Industrial Radio Interference. Radio Interference Meters. Technical Requirements";

*GOST 97-63 and GOST 1845-59 are replaced by GOST 22261-76 as of July 1, 1978.

GOST 11286-69 "Quality Factor Meters. Technical Requirements";

GOST 11294-74 "Measuring Lines. Technical Requirements. Testing Methods";

GOST 11113-74 "Measuring Pulse Generators. Types. Basic Parameters. Technical Requirements";

GOST 13100-67 "Measuring Receivers. Technical Requirements. Testing Methods";

GOST 13266-74 "Meters for the Impedance of Coaxial and Waveguide Channels and Admittance. Classification. Technical Requirements. Measuring Methods";

GOST 13317-73 "Microwave Band Electronic Measuring Instruments. Coupling Elements. Basic Dimensions";

GOST 13364-67 "Coaxial Loads. Types. Technical Requirements";

GOST 13605-75 "Microwave Wattmeters. Types. Technical Requirements. Testing Methods";

GOST 13606-68 "Receiving Converters (Heads) of Bolometer-Type and Thermistor Wattmeters. Types. Basic Parameters. Technical Requirements. Testing Methods";

GOST 13645-68 "Accurate Time and Frequency Signals Emitted by Shortwave and Long Wave Radio Stations of the State Time and Frequency Service of the USSR. Basic Characteristics";

GOST 13759-68 "Waveguide Loads. Types. Technical Requirements";

GOST 14126-69 "Measuring Signal Generators with a Coaxial Output. Technical Requirements";

GOST 15166-73 "Wobbling Frequency Generators of a Frequency Range from 1 MHz to 40 GHz. Type. Basic Parameters. Technical Requirements. Testing Methods";

GOST 17023-74 "Instruments for Studying Amplitude-Frequency Characteristics. Types and Basic Parameters. Technical Requirements. Testing Methods";

GOST 17193-71 "Measuring Signal Generators with a Waveguide Output. Technical Requirements".

1.2. Permissible Errors

The fundamental instrument error (including the systematic and random components) is taken to be the greatest difference between the indication of the

instrument and the actual value obtained as a result of measurement. When instruments are released by the manufacturer, the instrument error must not exceed 0.8 of the permissible value of the fundamental error.

The fundamental error of an instrument is expressed by one of the following methods:

in percent or in relative units of the instrument reading (for instruments with a reading device of any type) or of the nominal value (for measures with fixed values);

in percent of the finite value of the measurement range (for instruments with a one-way scale);

in percent of the sum of the finite values of the measurement range (for instruments with a center-zero scale);

in percent of the difference of the finite and the initial values of the measurement range (for instruments with a suppressed-zero scale);

in percent of the length of the measurement range [for instruments with a logarithmic, hyperbolic, or exponential (with an exponent higher than three) characteristic of the scale]. For instruments with logarithmic scales, expression of a relative error with respect to the reading is permitted;

in absolute values expressed in units of the value being measured (degrees, hertzs, watts, etc);

in decibels (or nepers) in relation to measured, compared, or regulated values (amplification, weakening, attenuation, intensity, etc);

in decibels (or nepers) in relation to a certain value taken as the initial or zero level (1 mW, 0.775 V per 600 Ohms, 1 V, etc);

in the form of a unit of two members one of which depends on the value being measured and the other does not depend on it. In this case, the error expressed in absolute values is written in the form of $\Delta = \pm (aA_x + \alpha)$ or $\Delta = \pm (aAx+bAk)$, where a is the error expressed in relative units of the instrument reading or normal value of the measure; b is the error expressed in relative units of the finite value of the established measuring limit; A_x is the reading of the instrument or the nominal value of the measure, A_k is the finite value of the established measuring limit; α is the error expressed in absolute values which does not depend on the value being measured. For the relative error $\delta = \pm (a = \alpha / A_x)$ or $\delta = \pm (a+bA_k/A_x)$.

It is permissible to record the instrument error with a discrete digital reading expressed in absolute values in the form of $\pm$ (a[%]reading A_x+mcounting units), where m is the discreteness error selected from the series: 0.5, 1, 2.

When permissible errors are indicated in percent, decibels, or in absolute values of the magnitudes being measured, the numerical values must be taken from the series $A_X \cdot 10^n$, where A_X is one of the numbers: 1, 1.5, 2, 3, 4, 5, 6, etc, and n is one of the numbers: 1, 0, -1, -2, -3, etc.

Additional errors under the effect of temperature and changes in the supply voltage of +10% of the nominal voltage must not exceed one-half of the fundamental error. Moreover, an additional error from temperature changes is to be shown for each 10°C of the temperature change. It is permissible to indicate the temperature error for one degree C of the temperature change.

Multirange or multiband instruments can have different errors for different subbands of scales and limits of measurements. Similarly, it is permissible to show for combined instruments different values of fundamental errors for different types of magnitudes being measured.

1.3. Scales, Reading Facilities, Impedances of Input and Output Circuits

Limbs and scales which are used to establish smoothly changing values must have a partial overlapping of neighboring subranges with graduation lines in the overlapping sections.

The edges of the band must have a margin not smaller than the double value of the fundamental error, and at the beginning and end of the subbands -- not less than the value of the fundamental error.

It is permissible not to have overlapping between neighboring subranges when the extreme positions of the limbs and scales correspond to the zero and maximum values, as well as there is a possibility of additional accurate regulation (tuning) of the instrument.

The limbs of reading devices must contrast with the background of the scale. Moreover, the scales must not create specks of light making the reading difficult.

The input and output impedances of instruments intended for work with a matched load are taken from the series: 0.1, 1, 5, 10, 50, 75, 100, 150, 200, 300, 500, 600, 1000 Ohms; 2, 5, 10, 20 kiloohms.

Nominal values of input and output impedance of instruments intended for work with a nonmatched load are indicated in individual standards and specifications in the form of effective resistance on one or several frequencies and, if necessary, in the form of shunting capacitance or impedance on one or several frequencies.

1.4. Electric Power Supply of Instruments

Instruments fed from a 50 Hz alternating current network must be designed for a voltage of 220 V $\pm$10%, a frequency of 50 Hz $\pm$1% with a harmonic content of up to 5%.

Instruments fed from a 400 Hz alternating current network must be designed for a voltage of 115 V ± 5% or 220 V ± 5% and a frequency of 400 Hz $^{+7\%}_{-3\%}$ with a harmonic content of up to 5%.

When fed from direct current chemical sources, instruments must be designed in accordance with the operating voltages and currents shown in the specifications for the use of chemical sources.

1.5. Stabilization Time and Length of Continuous Operation

The self-heating time after which instruments should operate normally following the moment they are turned on must be indicated in the specifications and is selected from the series 1, 5, 15, 30 minutes, 1 hour, 2 hours. For the instruments of the groups IV and V of Table 2, it is preferable to have a self-heating time of not more than 30 minutes. In special cases, it is permissible to establish the self-heating time at 4, 8, or 24 hours for instruments equipped with thermostatic devices.

Instruments must be designed for continuous work in the course of at least eight hours with consideration for the self-heating time if it does not exceed two hours.

1.6. Electric Strength and Resistance of Insulation

Electric circuits of instruments insulated from the casing which are under voltage during their operating must endure testing voltages shown in Table 1.1 in the absence of disruptive discharges.

Table 1.1

1) Рабочие напряжения, кВ	2) от 0,04	>0,1	>0,15	>0,25	>0,35	>0,5	>0,65
3) $U_{раб. макс}$, кВ, не более	0,1	0,15	0,25	0,35	0,5	0,65	0,8
4) Испытательное напряжение $U_{исп}$, кВ	0,25	0,5	0,25	1	1,5	2	2,5

1) Рабочие напряжения, кВ	>0,8	>1	>1,5	>2	>7	>30
3) $U_{раб. макс}$, кВ, не более	1	1,5	2	7	30	100
4) Испытательное напряжение $U_{исп}$, кВ	3	4	5	(5) $2U_{раб}+1$	(5) $1{,}3U_{раб}+6$	6) Устанавливаются ТУ

Key: 1. Operating voltages, kV
2. from 0.04
3. U operating, maximum, kV, not over
4. Testing voltage, $U_{testing}$, kV
5. Operating
6. Established by specifications

The values of voltages are rounded to integers of kilovolts in the upward direction.

1.7. Norms for Testing Conditions During Climatic and Mechanical Tests

Electronic measuring instruments are divided into five groups shown in Table 1.2 according to their operational conditions.

Table 1.2

Operational Conditions	Instrument Group
Instruments intended for operation in enclosed, dry, heated areas which do not experience shocks and bumps during their transfer from one work place to another.	I
Instruments intended for use in enclosed and heated areas which experience shocks and bumps during their transfer from one work place to another.	II
Instruments intended for work in enclosed unheated areas which experience frequent bumps and shocks when they are moved from one work place to another in the nonworking-state.	III
Instruments intended for work outdoors or under light shelters (if required due to a complex meteorological situation) which experience shocks and bumps in the nonoperating state during frequent transfers and transportation.	IV
Instruments intended for work outdoors under complex meteorological conditions without additional shelters which experience shocks and bumps in the nonoperating state during frequent transfers and transportation.	V

Depending on the group, instruments are subjected to various climatic tests according to the norms for testing conditions given in Table 1.3.

After the completion of the tests, instruments must retain the required characteristics within the limits of the norms shown in specifications and standards for individual types of instruments.

Instruments of groups IV and V also must not have any corrosion and damages to their surface after their presence in spray-bearing and dust-bearing media. Sprayproof and dustproof tests are done whenever mentioned in specifications. The norms for testing conditions during sprayproof tests are as follows: even spraying of the instruments from four sides one after

Table 1.3

(1) Условия испытаний	(2) Режимы климатических испытаний в зависимости от группы приборов				
	I	II	III	IV	V
Рабочие (3)					
(4) Температура, °С	+10÷+35	+10÷+35	−10÷+40	−30÷+50	−40÷+50
(5) Продолжительность, ч	4	4	4	4	4
(6) Относительная влажность, %	80	80	90	95	95
(4) Температура, °С	20	20	25	25	30
(5) Продолжительность, ч	48	48	48	48	48
Предельные (7)					
(4) Температура, °С	−40÷+50	−40÷+60	−40÷+50	−40÷+65	−50÷+65
(5) Продолжительность, ч	4	4	4	4	4
(8) Время выдержки в нормальных условиях, ч	4	4	4	4	4
(5) *Относительная влажность, %*	95±3	95±3	95±3	95±3	95±3
(4) Температура, °С	20	20	25	30	30
(5) Продолжительность, ч	48	48	48	96	96
(8) Время выдержки в нормальных условиях, ч	24	24	24	12	12

Key: 1. Testing Conditions
2. Conditions of climatic tests depending on the instrument group
3. Operating
4. Temperature, degrees C
5. Length, hours
6. Relative humidity, %
7. Maximum
8. Exposure time under normal conditions, hours

another at an angle of 45 degrees with an intensity of 5 + 2 mm/min in the course of four hours. Water temperature from +5 to +20 degrees C.

Instruments of Group IV are tested in a chamber in the form in which they are transported at short distances, or in storage boxes, if they are supplied, while instruments of Group V -- are tested in the form in which they are operated.

Dustproof tests are conducted in a special chamber under the following conditions:

length of dusting with dried dust mixture, hours (mixture composition: sand 70%, chalk 15%, kaolin 15%, respectively) 1

dusting speed, m/sec 10-15

Norms for Testing Conditions for Resistance to Vibration

Norms of testing conditions for resistance to vibration for Group I are not established.

Tests on One Frequency

Length of tests, minutes, for all groups..... 10

Vibration frequency, Hz, is established by specifications within the limits of..... 20-50

The shift or acceleration amplitude for the required frequency is established according to a special chart.

Tests Within a Frequency Range

Norms for the groups of instruments II and III are not established, and for groups IV and V they are summarized in Table 1.4.

Table 1.4

(1) Условия испытаний	(2) Режимы для групп приборов					
	IV			V		
(3) Частота вибрации, Гц	10—20	20—30	30—40	40—50	50—60	60—70
(4) Амплитуда смещения (половина полного размаха), мм	0,52	0,38	0,33	0,27	0,23	0,2
(5) Максимальное ускорение, м/с²	2—6	6—15	10—20	17—27	23—33	28—40
(6) Продолжительность, мин	60					

Note: The shift or acceleration amplitude is established for the required frequency according to a special chart.

Key: 1. Testing conditions
2. Conditions for instrument groups
3. Vibration frequency, Hz
4. Shift amplitude (half of total range), mm
5. Maximum acceleration, m/s^2
6. Length, min

Norms for Testing Conditions for Shock Resistance and Strength In Transportation (Table 1.5).

Table 1.5

	(1) Параметры и условия испытаний	(2) Нормы испытательных режимов в зависимости от группы приборов			
		I	II	III	IV
(3) Ударопрочность	Частота ударов, мин (4)	—	—	10—50	10—50
	Длительность ударного импульса, м/с (5)	—	—	10—12,5	10—12,5
	Максимальное ускорение, м/с² (6)	—	—	50	50
	Число ударов (7)	—	—	1000	2000
(8) Прочность при транспортировании	Число колебаний (9)	2—3	2—3	2—3	2—3
	Максимальное ускорение, м/с² (6)	30	30	30	30
	Продолжительность, ч (10)	1	1	2	2

Note: Norms for Group V are established in specifications.

Key: 1. Parameters and testing conditions
2. Norms of testing conditions depending on the instrument group
3. Shock resistance
4. Frequency of shocks, min
5. Length of the shock pulse, m/sec
6. Maximum acceleration, m/sec2
7. Number of shocks
8. Strength in transportation
9. Number of vibrations
10. Length, hours

1.8. Operational Safety

All measuring instruments are designed in such a way as to ensure the safety of the operating personnel. All external elements of instruments and electric power sources which are under a voltage exceeding 36 V in relation to the casing must be protected against accidental contacts during the operation of the instrument under normal conditions, and the external elements with voltages above 500 V must have warning signs.

In instruments which have a voltage of over 1000 V and the ground current may exceed 5 mA, removable and opening lids, casings and doors must be connected with an automatic blocking device which would turn off the voltage during the removal of casings, lids, sheaths, etc. Provisions must be ma

for the closure of high-voltage capacitors or connection of discharge resistors ensuring their discharge to a safe voltage in not more than 10 seconds.

Within instruments near assemblies where voltages above 500 V are present, there must be clearly visible inscriptions or signs warning about the danger. Instruments operated from the power network or connected to high-voltage networks (over 1000 V) must have a separate terminal for grounding the casing.

All instruments fed from the network must have a light indicator to show that the network voltage is turned on. If the general supply and high voltages are turned on separately, red light signals must correspond to the turning-on of high voltages.

1.9 Standards

Uniformity of measurements is achieved by exact reproduction and storage of the established units of physical values and transmission of their dimensions to the measuring devices used. Standards are the highest link in the transmission of the dimensions of units of measurements in the metrological chain.

The USSR Gosstandart approves the primary and special state standards. The primary standards serve for the reproduction of units with the today's highest accuracy. Special standards serve for the production of units under special conditions in which direct transmission of the dimensions of units from primary standards is technically unrealizable with the required degree of accuracy (high and superhigh frequencies, energy, pressure, temperature, special states of the substance, extreme sections of the range of measurements, etc). The state primary and special standards of the USSR are developed, reproduced, and preserved by metrological institutes.

Simultaneously with the approval of a primary or special standard, a state standard is approved which indicates the composition and the purpose of the approved state standard and establishes a checking scheme which determines the order of transmission of the dimensions of the units corresponding to the means of measurements.

Articles with descriptions of the most important characteristics of standards approved by the USSR Gosstandart are published regularly in the journal "Izmeritel'naya tekhnika" [Measuring Techniques], and since 1974 in the collection of information articles "Metrologiya i izmeritel'naya tekhnika" [Metrology and Measuring Techniques].

Since 1 January 1974, GOST 8.057-73 "Procedures for the Approval, Storage, and Use of Standards and Reference Measuring Devices" was put into effect; this GOST establishes a single procedure for the approval of standards and metrological certification of reference measuring devices, as well as of their storage and application.

Generalized information on the national primary and specialized standards of the USSR is published in the annual reference book "State Standards of the USSR".

Brief information on state standards serving for the reproduction of units of time and frequency, as well as of electrical and magnetic values approved by the USSR Gosstandart as of 1 January 1975 is given below (Table 1.6).

CHAPTER 7

FREQUENCY AND TIME MEASURING INSTRUMENTS

7.1. Frequency and Time Standards. Reference Generators

Field decade frequency standard Ch 1-28 is intended for the output of monochromatic oscillations, as well as for measuring the frequency of sinusoidal oscillations in a frequency range of 20 Hz - 600 MHz under climatic and mechanical conditions for Group IV of GOST 9763-67.

The decade frequency converter Ch 1-28 works on the principle of frequency synthesis of two parallel circuits. One of them is a 10 MHz reference frequency multiplier, and the second consists of five successively synchronized generators from whose output any arbitrarily selected frequency within a range of 60-70 MHz is delivered to the mixer. As a result of the mixing of two frequencies of the above-mentioned circuits, it is possible to obtain any frequency on three subranges (0-10 MHz, 10-20 MHz and 20-30 MHz) at the generator's output by using a 0-100 Hz interpolation frequency generator.

The decade frequency standard is designed in the form of individual units: a converter unit and a measuring unit.

The instrument set includes: 1) frequency converter unit: 2) measuring unit; 3) technical documentation (technical record, technical description and operation manual, checking instructions, album of simplified circuit diagrams); 4) a set of spare parts and accessories; 5) manufacturer's rating certificate.

Basic Specifications

The instrument puts out a sinusoidal-shape voltage in the frequency range, Hz	$100\text{-}30\cdot10^6$
Output voltage, V, in the 20 Hz - 10 kHz range at a load of 1 kiloohm and in the 10 kHz - 30 MHz range at a 75 Ohm load, not less than	0.5

Klirr factor, %, in a frequency range of 10 Hz - 8 MHz, not more than 15

When harmonics of the fundamental range are used and when the output voltage is not less than 100 microvolts at a load of 75 Ohms, the instrument puts out a frequency spectrum, MHz, in the range 30-600

Frequency error, Hz, does not exceed:
- when switching step-by-step ..... $1 \cdot 10^{-7} f_x$
- in stepless regulation ..... $\pm(1 \cdot 10^{-7} f_x + 0.5)$
- in a frequency range of 30 - 600 MHz ..... $\pm(1 \cdot 10^{-7} f_x + 0.5n)$

(f_x -- nominal frequency value: n -- number of the harmonic used)

Frequency range, MHz (harmonics of the fundamental range) ..... $20 \cdot 10^{-6}$-30; 30-600

Sensitivity, B, when measuring frequency in the ranges:
- 20 Hz - 30 MHz 0.1
- 30 - 600 MHz 0.2

Maximum input voltage, V 3

Frequency measurement error, Hz, does not exceed in the ranges:
- 20 Hz - 30 MHz ..... $\pm(1 \cdot 10^{-7} f_x + 0.5$ Hz)
- 30 - 600 MHz ..... $\pm(1 \cdot 10^{-7} f_x + 0.5$ n)

Frequency instability of the quartz generator of the instrument after a two-hour warm-up must not exceed:
- in 24 hours ..... $3 \cdot 10^{-8}$
- in 15 days ..... $1 \cdot 10^{-7}$
- in 6 months ..... $5 \cdot 10^{-7}$

Correction limit, frequency of quartz generator ..... $\pm 4 \cdot 10^{-7}$

Frequencies of sinusoidal voltages stabilized with quartz 10; 5; 1 MHz; 500; 100; 50; 10; 5; 1 kHz; 100 Hz (with a Klirr factor of not over 15% at all frequencies except 10 MHz)

Voltage of delivered frequencies, V, not less than:
- at frequencies of 10 and 5 MHz 0.5
- at other frequencies 1

The device can operate from an external source of fundamental frequency of 1 MHz:
- with a voltage, V 0.5-3

Length, hours:	
of self-heating of the instrument	2
of continuous operation	24
Consumed power, V·A, not over	500

The cesium frequency standard Ch1-Ch2 is intended for use as a reference in checking and graduation of frequency measures of high accuracy.

The instrument is a measure of frequency stabilized with respect to the frequency of the energy jump between the levels of the hyperfine structure of the normal state of the cesium-133 atom.

The instrument consists of a controlled quartz generator operating with a frequency of 5 MHz, a synthesizer converting the signal of the quartz generator to a signal close to the frequency 9 192 631 770 Hz of the energy jump in the atoms of cesium, and an atomic beam tube (ALT) performing the role of a discriminator, i.e., generating an error signal depending on the mismatching of the frequency of the synthesizer with the frequency of the energy jump in the atoms of cesium. The error signal is amplified and delivered to the frequency control device of the quartz generator.

The instrument contains also a frequency divider for obtaining signals with freqeuncies of 100 kHz and 1 MHz and power sources for various ALT devices.

An ALT (removable) is supplied with the frequency standard.

Basic Specifications

Nominal frequency values, MHz	$100 \cdot 10^{-3}$; 1; 5
Relative frequency error, not over	$\pm 2 \cdot 10^{-10}$
Relative root-mean-square error of the reproduction of the actual value of frequency from one "on" condition to another when the electronic part of the device works continuously does not exceed	$2 \cdot 10^{-11}$
Frequency instability during the measuring and reading time equal to 1 and 10 sec does not exceed	$2 \cdot 10^{-10}$

Frequency checking of the instrument is done with the aid of a reference measure of frequency of a higher accuracy, for example, a hydrogen generator.

The frequency of the instrument being checked is compared with the frequency of the reference measure with the aid of a frequency comparator and an electronic frequency meter.

The hydrogen frequency standard Ch1-46 is intended for use as a source of highly stable,highly accurate, spectrally pure sinusoidal signals in various measuring and special systems, including systems for the reproduction and storage of time and frequency units (Figure 7.1).

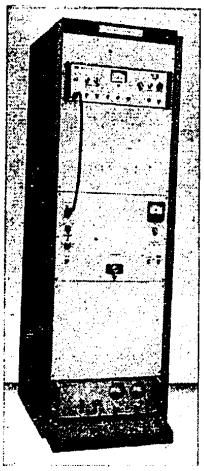

Figure 7.1

The instrument operates on the principle of phase synchronization of the signal of a quartz generator of 5 MHz by the signal of a quantum hydrogen generator. The instrument consists of two racks one of which contains an additional frequency meter Ch3-38. The instrument performs two kinds of operations: tuning and automatic phase adjustment of frequency (FAP). In the first kind of operation, the instrument tunes the hydrogen generator (VG) to the vertex of the spectral line. The signals of both VG of 1420, 405 MHz are delivered to the input of the synchronization unit through a coaxial switch whose control knob "Operation Type" is on the front panel of the instrument and through a coaxial tee (E6-11). For tuning, the frequency of one of the generators is shifted by the magnetic field by 1 Hz and the beat frequency signal of the VG of 7 Hz is delivered from the synchronization unit to the input of the frequency meter Ch3-38. In the FAP operation mode, the signal of the VG is sent to the input of its synchronization unit and, as a result of this, automatic phase adjustment of frequency of the quartz generator by the hydrogen generator is accomplished. The synchronization unit is a superheterodyne receiver with triple frequency conversion.

The instrument set includes: 1) hydrogen frequency standards (2 items); 2) electron-counting frequency meter Ch3-38; 3) preliminary selection unit Ya34-34; 4) power supply unit; 5) demagnetizing unit; 6) pump TsVN-1.5-3;

7) set of spare parts and accessories which includes: adapter, connecting cables (2 items), buses (5 items), bolts (3 items), washers (10 items), nuts (20 items), keys (2 items), sodium hydroxide 4Da (1 kg), special vacuum rubber tube (2 m), bifurcating device E6-11, protecting devices VP1-1-5A (5 items), 1-15 A(5), VP1-1-3A (5 items), VP1-1-1A(5), transistors 2T904A (10), pins (3 items); 8) technical description and operation manual; 9) reference generator YaZCh-35; 10) technical record.

Basic Specifications

Nominal values of output signals, MHz	5:1:0.1
Frequency production error from one instrument to another not more than	$\pm 5 \cdot 10^{-12}$
Systematic deviation from the nominal frequency value of output signals not more than	$4 \cdot 10^{-11}$
Root-mean-square error of the reproduction of the acrual value of frequency of the hydrogen generator from one tuning to another and from one "on" position to another not more than	$2 \cdot 10^{-13}$
RMS error of the reproduction of the actual value of the frequency of the output signal of 5 MHz from one tuning to another and from one "on" position to another not more than	$3 \cdot 10^{-13}$
Frequency instability of the output signal of 5 MHz (RMS value) with a band of the measuring device of 2 Hz not over:	
in 1 second	$1.5 \cdot 10^{12}$
in 10 seconds	$3 \cdot 10^{13}$
in 100 seconds	$4 \cdot 10^{14}$
in one hour	$5 \cdot 10^{14}$
(with temperature variation of the environment of not more than ± 1 degree C)	
Service life of the instrument, years, not less than	7
Operation life, hours, not less than	10,000

The instrument is checked in accordance with GOST 9763-67 and directions for checking shown in the section "Checking Instructions" of the technical description and instruction for operation.

The frequency standard Ch1-53 (reference quartz generator) is intended for producing frequency-stable sinusoidal shape, 0.1, 1, 5 MHz signals in the mode of long continuous operation. It is used as a source of reference frequency in various radio technical measurements.

The instrument operates on the principle of synchronous conversion of frequency of 5 MHz generated by the quartz generator into a signal with a frequency of 1 MHz and further with a frequency of 0.1 MHz. The instrument consists of a quartz generator, a quartz filter, a frequency divider, and a power unit.

The instrument is designed on a functional unit principle in the form of a portable table instrument without a case.

Basic Specifications

Output frequencies, MHz	0.1, 1, 5
RMS relative random variation of the frequency of the output signal after 24 hours of operation:	
in 1 second	$2 \cdot 10^{-11}$
in 10 seconds	$2 \cdot 10^{-11}$
Level of output signals 1 V for R_{warmed} = 50 Ohms. The weakening of the harmonic components of the output signals, dB, not less than	40
The power of the components of the signal spectrum of 5 MHz measured in a band of the analysis of 6 ± 2 Hz is, in dB, from the power and signal of the carrier for the frequencies removed from the carrier not more than:	
by 30 Hz	100
by 300 Hz	120
by 3000 Hz	135
Power supply from an alternating current network	
with a voltage of, V	$220 \pm 10\%$
with a frequency of, Hz	$50 \pm 1\%$
with voltages, V	$220 \pm 5\%$ $115 \pm 5\%$
with a frequency of, Hz	$400^{+7\%}_{-3\%}$
from a direct current network	
with a voltage of, V	27
Power consumption, V·A	25
Dimensions, mm	475X490X135
Weight, kg	20
Operating temperature range, degrees C	5-40

The Ch1-53 is checked in accordance with GOST 9763-67.

The reference generator Ch1-54 is intended for producing frequency-stable sinusoidal shape signals of 0.1, 1, 5, 10, 100 MHz in the mode of long continuous operation.

The instrument includes a quartz generator, a divider, a frequency multiplier, and a buffer amplifier. After sequential division of a 5 MHz signal, signals with frequencies of 1 and 0.1 MHz are removed from the divider. The multiplier converts the signal from the generator to signals with frequencies of 10 and 100 MHz.

This instrument is a bench model, has a functional-block arrangement system, and is based entirely on printed wiring.

The instrument set includes: 1) reference generator Ch1-54; 2) plate; 3) connecting cords (2 items); 4) connecting cables (3 items); 5) tubes SM-46 (2 items); 6) protective devices VP1-1-0.5 A (6 items); 7) technical description and operation manual; 8) technical records; 9) reference generator Ya34-36; 10) technical description and operation manual; 11) technical record.

Basic Specifications

Output frequencies, MHz	0.1; 1; 5; 10; 100
Relative changes of the mean value of the frequency of output signals in 24 hours	$\pm 5 \cdot 10^{-9}$
Temperature coefficient of frequency, degree C	$\pm 1 \cdot 10^{-9}$
Level of output signals, V	0.5
Level of noise components, dB	100
Power consumption, V·A	35

The instrument is checked in accordance with GOST 9763-67.

The selective amplifier of highly stable signals Ch5-22 is intended for improving spectrum of a signal with a frequency of 1 MHz transmitted through a cable at long distances and for eliminating interference of consumers.

The instrument consists of a quartz filter, four identical selective output amplifiers for a frequency of 1 MHz, and a power supply unit. The input signal is transmitted from the transmission line to the narrow-band quartz filter. The quartz filter is a temperature-controlled quartz resonator. The output signal from the quartz filter is delivered through the appropriate amplifier to the output connector. Four separate amplifiers at the

output of the instrument make it possible to eliminate interference of the consumers for all four output connectors.

This instrument set includes: 1) selective amplifier of highly stable signals Ch5-22; 2) box; 3) connecting cord; 4) protective devices VP1-1-1 A (3 items); 5) technical description and operation manual; 6) technical record.

Basic Specifications

Output frequency, MHz	1.0
Level of output signal, V	0.8
Level of internal noise components in the spectrum of the output signal, dB	90
Phase instability, microsecond	0.2
Passband at a level of 3 dB, Hz	250±50
Power consumption, V·A	20

The quartz generator Ch1-40 is intended for use as a synchronized source of the reference signal in various types of frequency-measuring units and systems. The instrument satisfies the requirements of GOST 9763-67.

This generator consists of the following main units: a quartz generator consisting of a driving stage, an amplifier of automatic amplification control, and a buffer amplifier situated in a single-stage thermostatic chamber; a thermostatic control unit; a quartz filter having an input and an output amplifiers; an automatic phase control unit (APF); a block of frequency dividers consisting of regenerative frequency dividers; and power supply unit.

The reference signal with a frequency of 5 MHz is generated by the quartz generator, is amplified and detected in the circuit of automatic level control, is amplified by the output amplifier, and is delivered from it to the output amplifying stage of the APF unit, as well as to the quartz filter from which signals of 5 MHz are delivered to the output connectors which are located on the back panel, as well as to the regenerative divider of 1 MHz. From this divider, the signal is delivered to the output connector and to the regenerative divider of 100 kHz from which the signal goes to the output connector.

The generator set includes: 1) case; 2) container; 3) box; 4) spare parts and accessories; 5) description, operation manual; 6) manufacturer's rating certificate.

Basic Specifications

Frequencies of output signals, MHz	5; 1; 0.1
Limits of the corrected frequency of the output signals with the resolving power of the corrector of $\pm 1 \cdot 10^{-9}$ must be not less than	± 1; $5 \cdot 10^{-7}$
The error in the establishment of the nominal frequency value after 8 hours of self-heating when the instrument is released by the manufacturer must be not more than	$\pm 3 \cdot 10^{-8}$
Frequency instability of the output signal of the instrument after 24 hours at an ambient temperature maintained to an accuracy of one degree C must be not over:	
after 24 hours of self-heating	$3 \cdot 10^{-9}$
after 30 days of continuous operation	$1 \cdot 10^{-9}$
Frequency instability of the output signal of the instrument after 24 hours of self-heating at an ambient temperature maintained to an accuracy of ± 1 degree C must be not over:	
in 10 minutes	$2 \cdot 10^{-10}$
in one hour	$5 \cdot 10^{-10}$
Maximum frequency drift in 30 days of continuous operation after one month of preliminary warmup and without turning the instrument off must not exceed	$5 \cdot 10^{-8}$
Frequency instability after 24 hours of self-heating must not be over:	
in 1 ms	$5 \cdot 10^{-9}$
in 10 ms	$1 \cdot 10^{-9}$
in 0.1 s	$3 \cdot 10^{-10}$
in 1 s	$1 \cdot 10^{-10}$
in 10 s	$1 \cdot 10^{-10}$
Temperature coefficient of the frequency of the instrument, degree C, in the temperature interval from 5 to 40 degrees C must be not over	$5 \cdot 10^{-10}$
Output signal level, V, for frequencies:	
1 MHz and 100 kHz at a load resistance of 50 ohms, not less than	1
5 MHz at a load resistance of 200 ohms	0.8

Power supply from an alternating current network	
with a voltage, V	220±10
with a frequency, Hz, of	50
at a harmonic level, %, not over	5
from a direct current network	
with voltage, V	27±3
with a pulsation level, mV, of not over	10

The switching of the power supply from an alternating current network to a direct current network must be done automatically.

Dimensions, mm	120X480X475
Weight, kg	20

7.2. Resonance Frequency Meters

Medium-Accuracy Resonance Frequency Meters Ch2-36 A, Ch2-37 A. Medium-accuracy resonance frequency meters Ch2-36 A and Ch2-37 A are intended for measuring frequencies of continuous and pulse-modulated microwave oscillations under field and laboratory conditions. These instruments operate at ambient temperatures from -30 to 50 degrees C and a relative air humidity of up to 95% at 30 degrees C.

These resonance frequency meters are portable instruments. They consist of an absorbing attenuator, a coaxial resonator with coupling elements and a retuning mechanism, a converter, an amplifier, and a needle indicator. The signal being measured is delivered through the communication cable to the instrument's input and then through the attenuator which makes it possible to measure the power level of the signal goes to the coaxial resonator connected with the attenuator by a coupling loop. The resonator is retuned by moving the plunger with the aid of a mechanism with reference scales. The reading is taken from two scales -- rough and accurate, after which the table attached to the instrument is used for determining the measured frequency.

The set of each instrument includes: 1) tables; 2) spare parts; 3) technical description and operation manual.

Basic Specifications

Frequency ranges, MHz	
for Ch2-36 A	5500-7700
for Ch2-37 A	7700-10,700
Frequency measurement error, %, not over	0.05

Sensitivity, mV·A, in measuring frequencies of:	
continuous oscillations, not lower than	0.5
pulse-modulated oscillations, not less than ...	0.2
Dimensions, mm	335X286X162
Weight, kg	9

Automatic Panoramic Resonance Frequency Meter Ch2-55 is intended for automatic and simultaneous observation and measurement of all frequencies of continuous as well as of pulse-modulated signals arriving at the input of the instrument within a range of 5.64-8.24 GHz. This instrument is intended for work under the conditions of laboratories, plants, and inspection and repair shops. The panoramic frequency meter utilizes the phenomenon of ferromagnetic resonance. For this reason, a ferrite band filter on two crossing waveguides is used.

A special ferrite sphere is installed strictly along the center of the coupling hole in the common wide wall of these waveguides. When microwave oscillations are delivered to the ferrite sphere, the microwave energy is reradiated from one waveguide to another on a frequency determined by the external magnetic field created by the electromagnet.

The operation of the entire instrument is synchronized by the pulse generator with a frequency of about 200 Hz. The formed and amplified sawtooth voltage of this frequency is delivered to the horizontal plates of the electron-ray tube (ELT). The formed and amplified voltage of the staircase-sawtooth form divided by six is delivered to the vertical plates of the ELT. The amplified sawtooth voltage of this frequency is sent to the electromagnet for creating a variable magnetic field.

The microwave signals arriving at the input of the instrument are passed by the ferrite waveguide system selectively and synchronously, are detected, amplified, and delivered to the vertical plates of the ELT.

Thus, there forms a line-frame scanning which creates on the screen of the ELT five horizontal action lines (the sixth one is beyond the screen) graduated directly in gigahertz and marks of the signals being studied whose frequency can be read directly on the scale of the ELT. For calibrating the frequency of the scale, a special calibrator is used which puts out signals of two fixed microwave signals whose frequencies are separated by approximately 2 GHz.

The instrument is designed in the form of individual units housed in one casing.

The frequency meter set includes: 1) storage box; 2) horn antenna; 3) draw tube; 4) power supply cord; 5) technical description and operation manual; 6) manufacturer's rating certificate.

Basic Specifications

Frequency range, GHz	5.64-8.24
Relative error of frequency measurements (%), not over	0.5
Instrument sensitivity, mV, when receiving microwave signals:	
continuous, not lower than	$5 \cdot 10^{-3}$
pulse-modulated signals with a length not less than one microsecond and a repetition frequency of not less than 1 kHz not below	$2 \cdot 10^{-1}$
Instrument's resolution, MHz, during reception of continuous signals when the difference of their levels is not more than 3 dB must be not less than.	8
Power supply from an alternating current network:	
with a voltage, V, of	$220 \pm 10\%$
with a frequency, Hz, of	$50 \pm 1\%$
Power consumption, V·A, not over	150
Dimensions, mm	490X255X480
Weight, kg	28

7.3. Electronic Counting Frequency Meters

F206-Type Digital Frequency Meter is intended for measuring frequencies from 0.01 to 100 kHz under the following operating conditions: ambient air temperature from +5 to +50 degrees C at a relative humidity from 30 to 80% within the entire range of operating temperatures (Group III GOST 12997-67); voltage of the alternating current network 220 V with permissible voltage variations from +10 to -15%; voltage frequency of the power network 50 ± 1 Hz.

This device can be used in informational measuring systems, in production, and in laboratory work.

The output code is used for registering the results of measurements on digital printers and punched cards; for duplicating the results of measurements with the aid of digital indicators; for code comparators; for feeding into a computer with the aid of special matching devices.

The F206 device consists of two units: converter P206 and frequency meter F206-4.

The converter includes the following main assemblies: input device; voltage-to-frequency converter (PNCh); linearization device; power supply unit.

The frequency meter consists of three units (A, B, C) and a power supply unit. The instrument operates on the principle of conversion of the value being measured to the frequency and its further measurement by a specialized digital frequency meter.

In order to reduce the error of the measurement results from the nonlinear output characteristic of the sensor, the instrument linearizes this characteristic with the aid of a special device. The instrument is based on integrated microcircuits with the use of discrete semiconductor elements and gas-discharge tubes with digital indication.

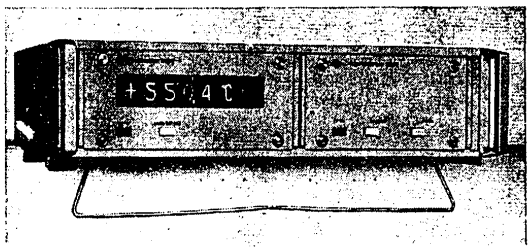

Figure 7.2

The instrument is designed in the form of two inserted units installed in a common frame (OST [All-Union Standard] 25.51-71). Moreover, the frequency meter F206-4 (Figure 7.2) is produced as a laboratory variant.

All instruments are divided into functional assemblies which are arranged on individual plates with printed wiring. The assembly wiring in each unit and the wiring of the instruments in the common frame are done with the use of bunched conductors. Sensors are connected to the instrument with the aid of a four-wire line the resistance of whose eash leg must not exceed 100 ohms.

The instrument has two operation modes: internal automatic triggering and external triggering.

The instrument automatically indicates the temperature sign.

The set of the instrument includes: 1) F206 device; 2) spare parts and accessories according to the list; 3) technical description and operation manual; 4) technical record.

Basic Specifications

Measurement limits:	
frequency, kHz	0.01-100
temperature, degree C	-200÷650
Basic measurement errors, %;	
frequency	±0.01
temperature	±0.2 (X_k-X_p)
operation speed, measurements/second, not less than	1
Time of preliminary warming-up before operation, minutes, must not be more than	30
Time of continuous work of the instrument without calibration and zero adjustment, hours, not less than	50
Dimensions of the instrument must not exceed, mm, for:	
F206	237X101X275
F206-1	490X110X450
Instrument weight, kg, must not exceed for:	
F206	4
F206-1	13

Instruments of the F206-type are checked by the method described in the technical specifications TU 25-04-2450-74 and in the operation manual.

The Electronic Counting Frequency Meter Ch3-36 is intended for measuring the frequency and period of sinusoidal and pulsed signals, pulse duration, and frequency ratios of electrical oscillations.

During the measurement of frequency, the instrument counts the number of pulses formed from the signal being studied during a reference time interval created by the signals of the internal quartz generator. During the measurements of the period or the pulse length, the instrument counts the number of pulses formed on the basis of the frequence of the internal quartz generator during the time interval determined by the period of the signal or the length of the pulse being studied.

The frequency meter set includes: 1) box with spare parts; 2) technical description and operation manual; 3) technical record.

Basic Specifications

Frequency range of sinusoidal and pulsed signals of negative polarity at the A input, Hz	10-50-10^6

Sensitivity, V, at the A output not less than:	
in a range of 10 Hz - 30 MHz	0.1
for sinusoidal signals	0.2
for pulsed signals in a range of 30-50 MHz	0.5
Error of the frequency of 5 MHz of the inner generator not over:	
in the course of one month	$\pm 1.5 \cdot 10^{-7}$
in the course of 6 months	$\pm 2.5 \cdot 10^{-7}$
Average relative frequency variation of the inner quartz generator in 24 hours must be not more than.	$\pm 3 \cdot 10^{-8}$
The unit and averaged coefficient of averaging is equal to	10, 10^2, 10^3, 10^4
Period of electrical signals, microseconds	$10\text{-}10^4$
Length of measured pulses, microseconds	$1\text{-}10^4$
Input voltage, V	0.5-50
Repetition rate of pulses being measured, kHz	100
Maximum frequencies of the frequencies of signals being compared, kHz:	
highest	$50 \cdot 10^3$
lowest	100

The instruments are checked in accordance with GOST 113305-67 and GOST 13628-68.

Electronic Counting Frequency Meter Ch3-37 is intended for automatic measurements of frequency, the period and the ratio of frequency of electrical oscillations; automatic measurements of time intervals and pulse length; counting the number of electrical oscillations; division of the frequency of electrical oscillations; output of voltages of quartz-crystal frequencies; and for work with plug-in units.

This instrument operates on the principle of counting the number of pulses during a definite time interval. The instrument includes blocks of amplifiers and shapers, a selector, a counting unit, an automation unit, a frequency divider, a generator or time marks, a quartz generator, and a power supply unit. This instrument is a desk model using printed wiring.

The instrument set includes: 1) electronic oounting frequency meter Ch3-37; 2) connecting cables (7 items); 3) connecting cords (2 items); 4) plate; 5) connecting cable; 6) laboratory clamp; 7) tubes INS-1 (2 items) and IP-12A; 8) protective devices VP1-1-1A (5 items) and RP1-1-2A (5 items); 9) jack plugs RPM 7-50 Sh-PBA (3 items); 10) box; 11) technical description

and operation manual; 12) technical records; quartz generator NChZ-35; technical description and operation manual; 13) technical records.

Basic Specifications

Frequency range, MHz	0-10
Input signal voltage being measured, V	0.1 - 100
Measured period in the frequence range, MHz	0-1.0
Input signal voltage, V	0.1-100
Pulse duration, microsecond, not less than	0.1
Frequency ratio measurement range, MHz	0-10
Power consumption, V·A	70

The instrument is checked in accordance with GOST 9763-67.

Analog Frequency Meter Ch4-29 is intended for measuring frequencies of sinusoidal signals and the repetition frequency of pulse sequences, as well as for use as a frequency discriminator.

The instrument is based on the pulse-counting discriminator. The functional part of the analog frequency meter Ch4-29 includes a video amplifier, a shaper, a converter, an interpolator, a calibrator, low-frequency filters, and a power supply unit. This instrument is designed as a table model and has a builtin power source. The main units have printed wiring with releasable connections.

The instrument set includes: 1) analog frequency meter Ch4-29; 2) combination set; 3) box; 4) repair plate; 5) circuit plate; 6) connecting cables (8 items); 7) network connecting cord; 8) connecting block; 9) safety devices VP1-10, 25A (5 items); 10) tube IPS-1; 11) laboratory clamps (2 items); 12) technical description and operation manual; 13) technical record.

Basic Specifications

Measured frequency range, Hz	$10 \div 10 \cdot 10^6$
Measurement error, %	1
Sensitivity, V	0.1
Power consumption, V·A	15

The instrument is checked in accordance with GOST 9763-67.

The Electronic Counting Frequency Meter Ch3-38 is intended for measuring the frequency, period, and frequency ratio of electrical oscillations; measuring time intervals and pulse duration; counting the number of electrical oscillations and delivering voltages of stabilized frequencies. The instrument operates at temperatures from -10 to 50 degrees C.

The instrument operates on the principle of counting the number of pulses during a definite time interval. During frequency measurements, the number of pulses formed from the measured input signal during the duration of the strobe pulse is counted. When the period is measured, the number of reference-frequency pulses is counted during the duration of the strobe pulse which in this case is equal to the period being measured.

The instrument is designed as a portable table model and it can be built into a standard rack.

The frequency meter set includes: 1) box; 2) connecting cables (10 items); 3) connecting cords (2 items); 4) plates (2 items); 5) matching transformer; 6) coaxial adapter; 7) laboratory clamps (2 items); 8) indicating lamps (3 items); 9) safety devices (10 items); 10) plugs (3 items); 11) technical description and operation manual; 12) technical record.

Basic Specifications

Frequency measurement range, Hz	From 0 to $5 \cdot 10^7$
Permissible relative error	$\pm(\delta_0 + 1$ of count)
Relative error of the frequency of the quartz generator after two hours of self-heating in the course of six months, not more than	$\pm 2.5 \cdot 10^{-7}$
Frequency range for the measurement of the period, Hz from	0 to $1 \cdot 10^6$
Permissible relative error ($\delta_0 \pm 3 \cdot 10^{-3}/n \pm 1$), (n is the averaging coefficient of the period being measured)	
Weight, kg	17

The instrument is checked according to GOST 9763-67 and checking instructions given in the technical description included in the set.

The Electronic Counting Frequency Meter Ch3-39 is intended for measuring the frequency, period and frequency ratio of electrical oscillations; for measuring time intervals and pulse duration; for counting the number of electrical oscillations; and for delivering voltages of stable frequencies.

The instrument operates at temperatures from 5 to 40 degrees C.

This instrument operates on the principle of counting the number of pulses for a definite time interval. During frequency measurements, the number of pulses formed from the measured input signal during the duration of the strobe pulse is counted. When the period is measured, the number of reference-frequency pulses during the duration of the strobe pulse, which in this case is equal to the measured period, is counted. It has a single-line eight-digit display with the "Pamyat'" [Memory] system.

The instrument is designed as a portable desk model and can be built into a standard rack.

The frequency meter set includes: 1) box; 2) connecting cables (10 items); 3) connecting cords (2 items); 4) plates (2 items); 5) matching transformer; 6) coaxial adapter; 7) laboratory clamps (2 items); 8) indicating lamps (3 items); 9) protective devices (10 items); 10) plugs (3 items); 11) technical description and operation manual; 12) technical record.

Basic Specifications

Frequency measurement range, Hz	From 10 to $2 \cdot 10^8$
Permissible relative error, $\pm(\delta_o \pm 1$ unit of count), δ_o -- frequency error of the instrument's quartz generator.	
Relative frequency error of the quartz generator after 2 hours of self-heating in the course of six months, not over	$\pm 2.5 \cdot 10^{-7}$
Frequency range during measurement of the period, Hz	From 0 to $1 \cdot 10^6$
Permissible relative error $\pm(\delta_o \pm 3 \cdot 10^{-3}/n \pm 1)$, (n -- averaging coefficient of the measured period).	
Weight, kg	18

The instrument is checked according to GOST 9763-67 and checking directions given in the technical description included in the set.

Electronic Counting Frequency Meter F5035 is intended for measuring the frequency and period of the electrical oscillations; for counting electrical signals; and for measuring the percentage deviation of the actual value of the measured frequency from its nominal value established on the frequency meter.

The instrument is intended for operation in enclosed heated areas at an ambient air temperature from 10 to 35 degrees C and a relative humidity of up to 80%.

The electronic counting frequency meter is based on elements of unified standard designs. Its functional units are based on integrated microcircuits with the use of printed wiring.

The frequency meter consists of a quartz generator unit (KG), a display unit, an input device, a frequency divider, a high-frequency meter, a control unit, a switching unit, a shaping unit, and a power supply unit.

The frequency meter has three control modes: manual, automatic, and remote-control.

Manual control is accomplished with the "Reset", "Start", and "Stop" buttons. In the automatic mode, the display time of the results of measurements is regulated smoothly within the range of 0.5-5 seconds. Remote control of the "Reset", "Start", and "Stop" inputs is accomplished by positive pulses with a duration of not less than one microsecond, a length of the leading edge of not more than 0.1 microsecond, and an amplitude of 3-30 V.

The instrument set includes: 1) frequency meter F5035; 2) set of connecting cables; 3) spare lamps of the types KM 24-35, IP-12B; 4) technical description and operation manual.

Basic Specifications

Frequency of measured electrical oscillations in the frequency range, Hz	$0.1\text{-}50\cdot10^6$
Period of measured electrical oscillations in the frequency range, MHz	0.1-1
Relative frequency error of the inner quartz generator in the course of 10 days after tuning	$\pm5\cdot10^{-8}$
Relative value of the average 24-hour systematic frequency change not over	$1\cdot10^{-8}$
Relative value of the average 24-hour frequency instability not over	$\pm3\cdot10^{-8}$
Maximum sensitivity, mV	100
Power consumption, V·A	80
Weight, kg	13
Dimensions, mm	490X130X380

F5035 instruments are checked in the following order:

1. Checking of the relative error and frequency instability of the inner quartz generator. Checking is done in accordance with the requirements of GOST 13628-68 "Highly Stable Generators. Methods and Means of Checking the Frequency of Electrical Oscillations".

2. Checking the range of measured frequencies. The checking is done by delivering a signal to the input of the frequency meter from the frequency synthesizer Ch6-31.

3. Checking the range of the measured period. The checking of frequency periods is done at the lowest values of the voltages of signals delivered to the instrument's input from the generators G3-49A and F590 synchronized by a frequency of 1 MHz from the frequency standard Ch1-50. Amplitude control is accomplished by the volt meter VK7-9 and oscillograph S1-17.

4. Determination of errors in the count of electrical signals. The checking is done by delivering signals to the input of the frequency meter from the generator F590 or G3-40 synchronized by the frequency of the frequency standard Ch1-50.

5. Determination of the fundamental error in measuring the value of the percentage deviation.

The signal of the generator G3-49A synchronized by the frequency standard Ch1-50 is delivered to the input of the frequency meter through the UPT [direct-current amplifier], and, when operating at ultrahigh frequency, signals are delivered from the frequency synthesizer Ch6-31. The output signals of the synthesizer Ch6-31 are amplified to 1 V with the aid of the broad-band amplifier U3-29.

6. Checking the resolving power of counting.

The checking is done in the pulse counting mode with the aid of the generator G5-30 syncrhonized by the generator G5-15.

7.4. Frequency Synchronizers

Frequency Synchronizers Ch5-17 are intended for stabilizing the frequency of the generator with electronic tuning by the frequency of the reference signal (Figure 7.3).

The instrument is based on the principle of converting the frequency of the synchronized signal to an intermediate frequency of 20 MHz which is then compared with respect to the phase with the signal of the reference frequency of 20 MHz. The error signal of the signals compared with respect to the phase acts upon the frequency of the synchronized generator and tunes it to the frequency of the reference generator. The synchronizer is designed

in the form of a portable bench-type instrument. Its assemblies are connected to each other by means of coaxial high-frequency cables and low-frequency plug-type connectors.

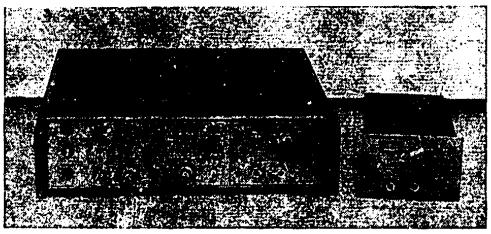

Figure 7.3

The instrument set includes: 1) frequency synchronizer Ch5-17; 2) box; 3) connecting cord; 4) high-frequency connecting cables (2 items);5) connecting cable; 6) coaxial adapters E2-115/3 (2 items); 7) waveguide-to-coaxial adapters E2-109 (2 items); 8) waveguide adapters (2 items); 9) safety devices VP1-2A (5 items); 10) technical description and operation manual; 11) technical records; 12) technical description and operation manual for quartz generator YaZCh-36; 13) technical record for quartz generator YaZCh-36.

Basic Specifications

Input frequency range, GHz	1-15.6
Maximum level of the output signal, mW	5
Controlling voltage, V	10
Power consumption, V·A	50

The Frequency Synchronizer Ch5-20 is intended for stabilizing frequencies of the generators using electronic frequency retuning. It makes it possible to evaluate the phase and frequency fluctuations of generators being synchronized and observe visually the envelope of the amplitude-modulated signal.

The instrument operates at ambient air temperatures from 5 to 40 degrees C and a relative humidity of 50-95% at a temperature of 30 degrees C.

The signal being synchronized goes to the mixer. The frequency of the signal is converted to intermediate frequency equal to 10 MHz. Harmonics from the frequency of the external reference signal of 100-500 MHz serve as the heterodyne signal. The intermediate frequency signal of 10 MHz is delivered to the control unit, where it is intensified and compared with respect to the phase with the reference frequency signal of 10 MHz. The error signal acts upon the frequency of the external reference signal through a low-frequency filter.

The frequency of the synchronized generator is determined by the formula $F_c = NF_{ref} \pm 10$, where F_{ref} is the frequency of the reference signal, MHz; N is the number of the operating frequency harmonic of the reference signal of 100-500 MHz.

In the generator synchronization mode, it is possible to evaluate phase fluctuations of the signal. Fluctuations are registered by the display device. At this time, the intermediate frequency signal is delivered to the frequency detector. Its output voltage is fed to the plug "To Display".

The instrument can be used for observing the envelope of the AM [amplitude-modulated] signal. For this, the entry of the frequency of the converted signal to the passband of the intermediate frequency amplifier (UPCh) is achieved by adjusting the frequency of the reference signal. The signal goes from the UPCh to the amplitude detector. The shape of the amplitude modulation envelope is observed on the screen of the oscillograph connected to the output of the detector.

The instrument has no casing.

The instrument set includes: 1) connecting cord; 2) connecting cables (5 items); 3) safety devices (5 items); 4) coaxial adapter; 5) coaxial attenuator; 6) description, operation manual; 7) manufacturer's rating certificate.

Basic Specifications

Frequency range of input sinusoidal signals, GHz ..	0.1-10
Instrument's sensitivity, microwatts	50
Input reference frequency range, MHz	100-500
Instrument's sensitivity of the UPCh channel, microvolts	100
Controlling voltage, V, not less than	10
Output signal amplitude, V, with a frequency of 1-25 kHz on a load of 200 ohms, not less than	0.1

Power consumed by the instrument from the network, V·A, at a nominal voltage	80
Dimensions, mm	480X120X475
Weight, kg	30

The Frequency Converter Ch5-13 is intended for converting the frequency range of sinusoidal electrical signals of 10-70 GHz to a range of 3.3-5 GHz. The instruments operate at an ambient air temperature from -10 to 50 degrees C.

The instrument operates on the principle of comparing the frequency being measured with the frequency of the instrument's heterodyne or with the frequency of the harmonics of the signal of the heterodyne and further measurement of the frequency of the heterodyne with an electronic counting frequency meter with a frequency converter.

In the continuous mode, frequencies are compared by means of a system of automatic phase adjustment of the frequency of the heterodyne with the frequency being measured.

The instrument set includes: 1) mixers (5 items); 2) waveguide adapter; 3) connecting cables (4 items); 4) connecting cord; 5) klystron; 6) electron tube; 7) semiconductor instruments (9 items); 8) safety devices (5 items); 9) signaling lamps (3 items); 10) plugs (2 items); 11) technical description and operation manual; 12) technical record.

Basic Specifications

Frequency range of the input sinusoidal electrical signals, GHz	10-70
Instrument sensitivity in the mode of measuring frequencies of sinusoidal signals, microwatt, not less, in the ranges:	
from 10 to 37.5 GHz	100
from 37.5 to 70 GHz	500
Carrier frequency range of pulse-modulated signals, GHz, at a pulse length of not less than 1 microsec and a repetition rate of from 100 Hz to 10 kHz	10-70
Heterodyne frequency range, GHz	3.3-5
Level of heterodyne output signals, mW, not less, at the connectors:	
"to converter"	0.5
"to mixer"	5
Weight, kg	18

The instrument is checked according to GOST 9763-67 and instructions for checking given in the technical description which is included in the set.

Frequency Converter Ch9-2 is intended for forming a reference signal of 30 MHz with various types of modulation.

The instrument is based on the principle of converting frequencies of reference signals. The phase of the output signal is changed by switching high-frequency signals with electronic switches.

The instrument includes: frequency synthesizer; controlled frequency converter and phase shifter; sensor of direct-current signals (DPTP); output frequency converter. All units with the exception of the sensor of direct current signals are fully transistorized and use semiconductor diodes and printed wiring.

The sensor of direct-current signals uses, chiefly, microcircuits and a small number of transistors.

The instrument set includes: 1) frequency converter Ch9-2; 2) box; 3) connecting cord; 4) bunched connecting conductors; 5) high-frequency connecting cables (8 items); 6) plates; 7) safety devices (10 items); 8) signaling lamp; 9) plugs (2 items); 10) connecting box; 11) technical description and operation manual; 12) technical record.

Basic Specifications

Output signal frequency, MHz	30
Output signal voltage at a load of 50 Ohms, mV	100±1.5 dB
Weakening of spectral components with frequencies which are not multiples of the output frequency, dB	50
Power consumption, V·A	30

Modulation modes: frequency telegraphy (ChT); two-channel frequency telegraphy (DChT); amplitude telegraphy (AT); relative phase telegraphy (OFT); double relative phase telegraphy (DOFT).

Manipulation speed, bauds, 2, 4, 5, 8, 10, 20, 40, 50, 80, 100, 200, 400, 500, 800, 1000, 2000, 4000, 5000, 8000, 10,000.

7.5. Signal Frequency Converters

The Frequency Converter Ch9-3 is intended for obtaining program signals ensuring frequency sweeping or discrete changes in other parameters of output signals of remotely controlled frequency synthesizers (Figure 7.4).

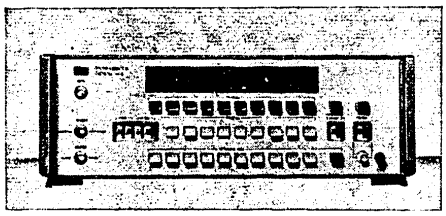

Figure 7.4

The instrument is based on the principle of counting the number of pulses with decimal ring counters when a pulse on one of the counter's outputs corresponds to each pulse arriving at its input. As a result of this, the aggregate of the output signals of the counters is an aggregate of the input pulses in the unitary-decimal code which can be used as a program signal for instruments remotely controlled in this code.

The ring counters in the frequency converter Ch9-3 are triggered by an external reference signal with a frequency in the range of 100 kHz - 1 MHz. The output oscillations are converted with the aid of a forming device into a pulse signal which passes through the divider with a variable scaling factor and is delivered to the network of the ring counters connected in series. Depending on the established scaling factor which changes in steps which are multiples of the power of the number 10, the input of the lowest-order counter receives from 1 to 10^5 pulses per second. Potential outputs of the ring counters are used for remote control of other instruments. In this case, the switching program is determined both by the number of pulses, and by their repetition period.

The frequency converter must have a single and a periodic modes of triggering the counting and triggering and stopping the work of the instrument must be performed from the front panel and remotely by voltage difference from 0 to 19 V$\pm$10%.

The instrument set includes: 1) frequency converter Ch9-3; 2) box; 3) connecting cord; 4) high-frequency connecting cables (3 items); 5) plugs RPM 7-50 Sh-KPA (3 items), RPM 7-12-KPA; 6) plates (2 items); 7) tube IN-12A; 8) plate; 9) tube SM-37; 10) safety devices VP1-1A (3 items); 11) technical description and operation manual; 12) technical record.

The instrument is checked in accordance with GOST 9763-67.

Basic Specifications

Frequency converter must deliver potential program signals with maximum:	
switching voltage in relation to the casing,V..	12.6±10%
current, mA	20
Switching rate of program signals (switching)	from 1 to 10^5
Power consumption, V·A	70
Power supply -- from an external source of a sinusoidal or pulsed signal with a frequency of, kHz ..	100-10^3
Voltage of the external sinusoidal signal, V, must be within the limits of	0.5-2.0
Amplitude of pulses of negative polarity, V	1-4

The Signal Frequency Converter ChK5-24 is intended for converting the frequencies of signals which are being compared with respect to the phase and subsequent measurement of phase shifts with the aid of the electronic counting frequency meter Ch3-24 (or a similar device) operating in the frequency ratio measurement mode.

The instrument operates on the principle of transfering phase ratios to a fixed low frequency by frequency conversion and formation of a time interval proportional to the phase shift of the frequencies being converted with its subsequent coding with the aid of an electronic counting frequency meter.

This is a portable desk instrument without a case. It consists of functional assemblies and blocks located in individual folding shielded racks.

The converters set includes: 1) storage box; 2) combination set; 3) technical description; 4) manufacturer's rating certificate.

Basic Specifications

Converted frequency range, MHz	0.1-10
Input voltage level, V	0.01-10
Phase signal conversion level, degrees	0-360
Fundamental error of the conversion of the phase difference of input signals, degrees, not over:	
with equal amplitudes of input signals	±1
with a ratio of the amplitudes of input signals of up to 40 dB	±1.5

The Signal Frequency Converter ChK5-25 is intended for converting the frequency of the signals being compared with respect to the phase and subsequent measurement of phase shifts with the aid of the electronic counting frequency meter Ch3-24 (or a similar device) operating in the frequency ratio measurement mode (Figure 7.5).

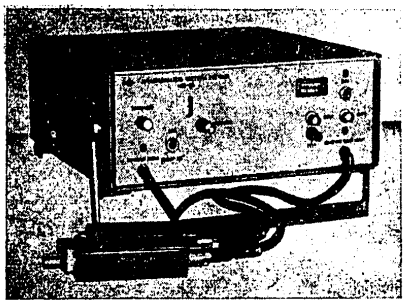

Figure 7.5

The instrument has a two-channel circuit with double frequency conversion. Phase ratios are transferred to a constant intermediate frequency with further formation of a time interval proportional to the phase shift of the signals being converted and filling it with pulses of quantizing frequency. The electronic counting frequency meter operating in the mode of measuring frequency ratios counts the number of periods of these pulses during a constant measuring time.

The instrument is portable, has no case and consists of functional assemblies and units arranged on separate shielded racks.

The converter set includes: 1) storage box; 2) combination set; 3) technical description; 4) manufacturer's rating certificate.

Basic Specifications

Converted frequency range, Hz	$500\text{-}200 \cdot 10^3$
Input voltage level, V	0.1-10
Conversion limit of phase shifts, degrees	0-360
Fundamental error of the conversion of the phase difference of input signals, degrees, in the frequency ranges:	

from 500 Hz to 1 kHz	±1.0
from 1 to 200 kHz (for the input signal ratio 0.9-1.1)	±0.6
from 500 Hz to 1 kHz	±1.5
from 1 to 200 kHz (for an amplitude ratio of up to 40 dB with leveling of signals in the channels)	±1.0

The Frequency Converter YaZCh-41 is intended for widening the range of frequencies being measured with electronic counting frequency meters Ch3-38 and Ch3-39 from 60 to 1000 MHz by converting the frequency of the input signal to the range of frequencies measured by the frequency meter.

The instruments operate at an ambient air temperature from -10 to 50 degrees C. The instrument operates on the principle of discrete heterodyne frequency conversion.

The instrument is designed in the form of a plug-in unit for electronic counting frequency meters Ch3-38 and Ch3-39 (Figure 7.6).

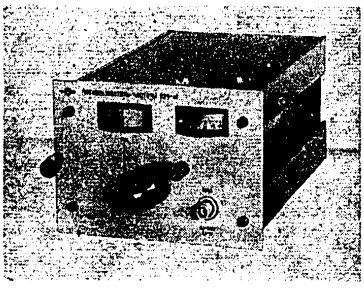

Figure 7.6

The converter set includes: 1) technical description and operation manual; 2) technical record; 3) manufacturer's rating certificate.

Basic Specifications

Input frequency range, MHz	600-1000
Input signal voltage, V	0.05-1
Output frequency range, MHz	1-51
Output signal voltage, V, not less than	0.1
Input resistance, Ohms	50

The instrument is checked according to GOST 9763-67 and checking instructions given in the technical description included in the set.

The Frequency Converter YaZCh-42 is intended for widening the range of measured frequencies by electronic counting frequency meters Ch3-38 and Ch3-39 from 1 to 5 GHz by converting the frequency of the input signal to the range of frequencies measured by the frequency meter. The instrument operates on the principle of discrete heterodyne frequency conversion.

The instrument is designed as a plug-in unit for electronic counting frequency meters Ch3-38 and Ch3-39 (Figure 7.7).

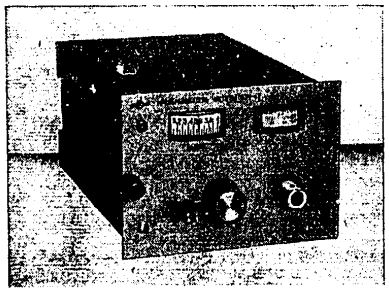

Figure 7.7

The converter set includes: 1) input cable; 2) adapters (2 items); 3) technical description and operation manual; 4) technical record.

Basic Specifications

Input frequency range, GHz	1-5
Input signal voltage, mV	0.2-10
Output frequency range, MHz	1-51
Output signal voltage, V, not less than	0.1
Input resistance, Ohms	50

The instrument is checked according to GOST 9763-67 and checking instructions given in the technical description included in the set.

Frequency Converter Ya34-43 is intended for widening the range of frequencies measured by electronic counting frequency meters Ch3-38 and Ch3-39 from 4 to

12 GHz by converting the frequency of the input signal to the range of frequencies measured by the frequency meter. The instruments operate at an ambient air temperature from -10 to 50 degrees C (Figure 7.8).

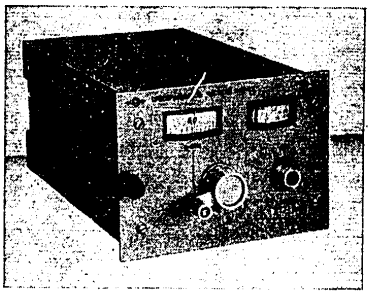

Figure 7.8.

The instrument operates on the principle of discrete heterodyne frequency conversion.

The instrument is designed as a plug-in unit for electronic counting frequency meters Ch3-38 and Ch3-39.

The converter set includes: 1) input cable; 2) adapters (2 items); 3) technical description and operation manual; 4) technical record.

Basic Specifications

Input frequency range, GHz	4-12
Input signal voltage, mV	0.2-5
Output frequency range, MHz	1-51
Output signal voltage, V, not less than	0.1
Input resistance, Ohms	50

The instrument is checked according to GOST 9763-67 and checking instructions given in the technical description included in the set.

7.6. Frequency Synthesizers, Frequency Dividers and Multipliers

The Synthesizing Frequency Multiplier Ch6-2 is intended for multiplying the frequency of a signal of the sinusoidal shape in a range of 25-50 MHz by 2, 4, and 8.

This multiplier is used in radio communication and automatic control devices, spectroscopy, and frequency measuring techniques. It makes it possible to measure the constants of quartz resonators, to tune narrow-band filters and obtain their resonance curves, to calibrate the scales of receivers, transmitters, and various frequency meters with respect to frequency, to evaluate the phase and frequency characteristics of narrow-band radio channels, and to determine the frequency instability and spectral characteristics of sinusoidal-shape signals and other radio signals. The instrument operates at a temperature from 5 to 40 degrees C and a relative humidity of 90-95% at a temperature of 30 degrees C.

A signal of the required frequency at the output of the multiplier is obtained by multiplying the frequency of the reference generator by 2, 4, or 8. The role of the reference generator can be played by any source having an output frequency range of 25-50 MHz and a voltage level of 0.3-1 V at a load of 50 Ohms. The input signal is multiplied by 2 with respect to frequency, then it is amplified by the wide-band amplifier and is delivered to five electronic keys. Depending on the frequency of the input signal, one of the band filters with passbands 50-60, 60-70, 70-80, 80-90, or 90-100 MHz is connected to the output of the wide-band amplifier.

When the frequency is multiplied by 2, the signal from the output of the appropriate filter goes through the output electronic switch to the output connector "output 50-200 MHz". When working with the multiplication factor 4, the signal from the output of the band filters goes to the appropriate frequency doublers and band filters with passbands 100-120 MHz, 120-140 MHz, 140-160 MHz, 160-180 MHz, and 180-200 MHz. The outputs of these band filters are connected with the electronic switch to the output connector "output 50-200 MHz". The output voltage in the range 50-200 MHz is stabilized by the ARU [automatic gain control] system consisting of a detector, a direct-current amplifier, and a controlled attenuator connected in front of the wide-band frequency multiplier.

Further widening of the range of the output frequencies of the instrument is achieved with another frequency doubler. When working with the frequency multiplication factor equal to 8, the signal goes from the band filters of 100-200 MHz to five electronic switches.

Depending on the frequency of the input signal, the switches connect the appropriate frequency doublers and band filters with the passbands of 200-240 MHz, 240-280 MHz, 280-320 MHz, 320-360 MHz, and 360-400 MHz. The operation of all electronic switches is controlled by a logical circuit which receives information about the input frequency of the frequency multiplier and the required multiplication factor.

The frequency multiplier has no case. If necessary, it can be installed in a standard cabinet after adding special angle brackets to the side supports.

The frequency multiplier set includes: 1) connecting cord; 2) signal lamp; 3) safety devices (4 items); 4) connecting cables (5 items); 5) measuring head; 6) high-frequency matching transformer; 7) description, operation manual; 8) manufacturer's rating certificate.

Basic Specifications

The instrument puts out sinusoidal-shape signals in the frequency range, MHz	50-400
Frequency multiplication factors of the input signal	2;4;8
Output signal voltage, V, at an external active load of 50 Ohms in the ranges, not less than	
50-200 MHz	0.5±2 dB
300-400 MHz	0.1
Frequency multiplier maintains its working capacity at a level of the input signal, V, of 25-50 MHz within the limits of	0.3-1
Voltage change in the input signal, V	0.3-1
Change in the output signal, dB, in relation to the level obtained when the input signal is equal to 0.5 V, not more than	±4
Lenth of transient processes, milliseconds, for remote control of the frequency multiplier, not over	1
Short-time frequency instability of the output signal due to the internal noise of the frequency multiplier with an averaging time of 20 milliseconds, does not exceed	$5 \cdot 10^{-8}$
Power supply from an alternating current network:	
with a voltage of, V	220±10%
with a frequency, Hz, of	50±0.5
Power consumption, V·A, not more than	30
Dimensions, mm	490X136X475
Weight, kg	18

The Frequency Multiplier Ch6-35 is intended for multiplying the frequency of sinusoidal signals of 1 or 5 MHz to a frequency of 10 GHz and delivering

sinusoidal signals with frequencies of 10, 100, 1000, and 10,000 MHz (Figure 7.9).

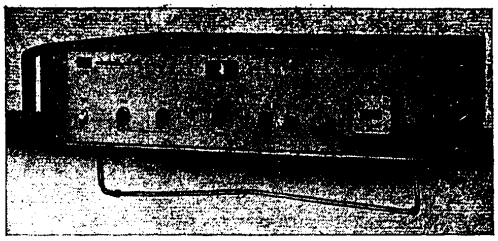

Figure 7.9

According to the operating conditions, the instrument is intended for working at an ambient temperature of from 5 to 40 degrees C and a relative humidity of up to 95% at a temperature of 30 degrees C.

The Ch6-35 instrument consists of a frequency multiplier of 1-100 MHz with an intermediate output of a signal of 10 MHz, three high-frequency amplifiers of 100 MHz, and two frequency multipliers of 100-1000 MHz and 100-10,000 MHz. The input signal with a frequency of 1 or 5 MHz is multiplied successively to a frequency of 100 MHz with an intermediate output of a signal of 1-10 MHz. Then the signal with a frequency of 100 MHz is amplified by the power amplifier of 100 MHz and is distributed to two channels: a channel of frequency multiplication from 100 to 1000 MHz and a channel of frequency multiplication from 100 to 10,000 MHz. Each channel consists of a 100 MHz power amplifier and a diode frequency multiplier. The signal with a frequency of 1000 MHz is delivered to the front panel of the instrument through the decoupling ferrite gate which makes it possible to weaken the effect of the load on the operation of the frequency multiplier. The 10,000 MHz signal is sent to the front panel of the instrument through a matching device which performs the same functions as the ferrite gate. Thus, signals with frequencies of 10, 100, 1000, and 10,000 MHz are present simultaneously at the output of the instrument. The frequency multiplier Ch6-35 is designed as a desk model. The front panel of the instrument has: inputs of the frequency multiplier of 1 and 5 MHz; outputs of the frequency multiplier of 10, 100, 1000, and 10,000 MHz; the "on" button of the instrument; a signal lamp, and a monitoring pointer-type instrument with a switch.

Provisions are made in the design of the frequency multiplier for its operation in a rack. For this purpose, the inputs of the signals of 1 and 5 MHz are also brought out to the back wall.

The set of the Ch6-35 multiplier includes: 1) spare parts and accessories; 2) technical description, operation manual; 3) manufacturer's rating certificate.

Basic Specifications

Input signal frequency, MHz	1 or 5
Frequency instability with its deviation from the nominal frequency, not over	$1 \cdot 10^{-5}$
Input signal voltage, V	0.3-2.0
Multiplication factor when a signal is delivered to the input of the multiplier with frequencies:	
1 MHz	10; 100, 1000, 10,000
5 MHz	2; 20; 200; 2000
Output signal power, W, not less, for frequencies:	
1000 MHz	$1 \cdot 10^{-3}$
10,000 MHz	$50 \cdot 10^{-6}$
Voltage of input signals with frequencies of 10 and 100 MHz at a resistance of 75 Ohms, V, not less than	1
Attenuation of nonharmonic components of the frequency spectrum of the output signal multiples to the input frequency, dB, for signals with frequencies of:	
10 and 100 MHz	60
1000 MHz	20
10,000 MHz	15
Ratio of the signal to noise due to phase fluctuations in the frequency multiplier adjusted to the frequency of the signal of 1 MHz must be in the band of 6 ± 2 Hz, dB, not less, at the analysis frequencies:	
20 Hz	120
50 Hz	122
100 Hz	125
1000 Hz	129
10,000 Hz	134
Power supply from the alternating current network:	
voltage, V	$220 \pm 10\%$
frequency, Hz	$50 \pm 1\%$
Power consumption from network, V·A	25
Dimensions, mm	490X136X475
Weight, kg	15

The instrument is checked for the following parameters: frequency and voltage of the input signals; multiplication factor; voltage of output signals with frequencies of 10 and 100 MHz; power of output signals with freqeuncies of 1 and 10 Hz; weakening of the nonharmonic components of the spectrum of the output signal multiples to the input frequency.

The Frequency Multiplier Ch6-36 is intended for multiplying the frequency of sinusoidal signals of the 25-50 MHz range to the 50-500 MHz range.

The sinusoidal input signal, after preliminary amplification by a two-stage amplifier, goes to the harmonic oscillator which uses a charge-storage diode. The load of the harmonic oscillator is an adjustable coaxial filter. The signal is delivered from the filter to the output of the multiplier through the coupling loop. The tuning of the filter to the harmonics of the signal is done by the maximum deviation of the pointer of the microammeter connected to the output of the multiplier. The instrument is designed as a single unit with a case.

The set of the Ch6-36 multiplier includes: 1) box with spare parts and accessories; 2) technical description, operation and periodic checking manual; 3) manufacturer's rating certificate.

Basic Specifications

Input signal frequency ranges, MHz	25-50; 40-50
Output signal frequency ranges, MHz	50-200; 200-500
Input signal voltage, V, at an input resistance of 50 Ohms	0.4-1
Multiplication factors in the ranges:	
50-200 MHz	2-4
200-500 MHz	2-10
Multiplier output frequency range, MHz	50-500
Output signal voltage, V, at a resistance of 50 Ohms, not less than	0.1
Attenuation of the n-1 and n+1 harmonics, dB, in the output signal, not less than	20
Self-heating time of the instrument, minutes	30
Power used by the instrument, V·A	15

The following parameters are to be checked: the range of the input frequencies; sensitivity of the multiplier; the range of the output frequencies; the voltage of the output signals; attenuation of the n+1 harmonic.

The Frequency Synthesizer Ch6-57 is a generator of sinusoidal electrical oscillations with a frequency range of from 20 Hz to 999999.6 Hz with a discreteness of 0.1 Hz.

A signal with the required frequency at the output of the synthesizer is obtained by a complex conversion of the frequency of the reference quartz generator. In the process of the frequency conversion, the following four arithmetic operations are carried out: addition, subtraction, multiplication, and division. These operations are carried out with the use of mixers, multipliers, and dividers of frequencies. This instrument has no case and, if necessary, it can be installed in a standard cabinet (special angle brackets are added to the side supports).

The Ch6-57 frequency synthesizer consists of a unit of reference frequencies and a frequency synthesizing unit each of which is a separate standardized unit.

The instrument set includes: 1) frequency synthesizer Ch6-57; 2) bunched conductors; 3) high-frequency connecting cables (2 items); 4) connecting high-frequency cable; 5) set of spare parts and accessories which includes: a box, a mixer, a connecting box, a matching high-frequency transformer, a measuring head, a connecting cord, external high-frequency connecting cable and a cable for the BOCh [reference frequency unit], lamps SM-37 (2 items), safety devices VP1-0.5 A (4 items), VP1-1 A (4 items), plugs RPM7-12 Sh-KPA, RPM 7-50 Sh-KPA; 6) technical description, operating manual for the frequency synthesizer Ch6-57 (two parts); 7) technical record for the frequency synthesizer Ch6-57; 8) technical description, operation manual for the reference generator YaZCh-35.

Basic Specifications

Output signal frequency, Hz	20-999999.9
Discreteness, Hz	0.1
Output signal voltage at a load of 50 Ohms, V	1
Weakening of spectral components which are not multiples of the frequency of the output signal, dB ..	70
Adjustment limits of the output voltage (by steps of 10 dB)	0-60
Power consumption, V·A	70

Frequency Synthesizer Ch6-58 is intended for generating a spectrally pure, frequency-stable electrical signal with a frequency in the range of 50-49999999.99 Hz with a discreteness of 0.01 Hz and can be used in radio communication and automatic control systems, stereoscopy and frequency measuring technique (Figure 7.10).

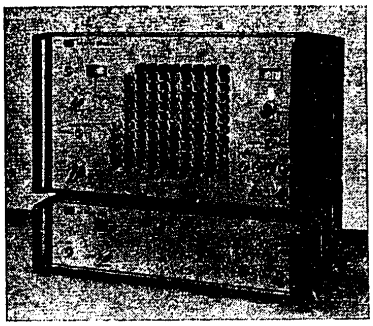

Figure 7.10

This instrument works on the principle of complex conversion of the frequency of the signal of the reference quartz generator YaZCh-35 in the frequency synthesis unit (BSCh) and the reference frequency unit (BOCh).

Structurally, the frequency synthesizer consists of two individual units, BOCh and BSCh, and is divided into a number of functional assemblies; BOCh and BSCh have standard casings.

The instrument set includes: 1) reference frequency units; 2) frequency synthesis unit; 3) set of spare parts and accessories, box, connecting bunched conductors of 3-3.9 MHz, connecting cords (2 items), high-frequency connecting cables (2 items), connecting box, measuring head, high-frequency matching transformer, jack plug; 4) set of spare parts and accessories which includes: box, connecting bunched conductors of 30-39 MHz, connecting cable, mixer, SM-37 lamps (2 items), safety devices VP-1-0.25 A (2 items), VP1-1-1 A (5 items), plugs REM 7-12 Sh-KPA (2 items); RPM7-24 ShCh-KPA, RPM7-50 Sh-KPA (3 items); 5) technical description, operation manual for Ch6-58; 6) manufacturer's rating certificate.

Basic Specifications

Frequency range, Hz	50-49999999.99
Output signal voltage, V, at R_v = 50 Ohms	1
Attenuation of parasitics spectral components, dB, with frequency which are not multiples of the output signal frequency, not less than	70
for network components	60

Power consumption, V·A	120
Power supply from alternating current networks:	
voltage, V	220±10%
frequency, Hz	50±1%; 400±7%
voltage, V	115±5%; 220±5%
frequency, Hz	400±3%
Dimensions, mm:	
BOCh	475X490X135
BSCh	475X490X295
Weight, kg:	
BOCh	20
BSCh	42

The Frequency Multiplier Ch6-62 is intended for multipling the frequency of a sinusoidal signal of 5 MHz to a frequency of 10 GHz and simultaneous presentation of sinusoidal signals with frequencies of 10, 100, 1000, and 10,000 MHz. The instrument can be used for heterodyning and for creating a decade network of reference frequencies. The instrument operates on the principle of direct frequency multiplication. It consists of frequency multipliers of the following ranges: 5-100 MHz, 100-1000 MHz, 1000-10,000 MHz, and a power supply unit. An input signal of 5 MHz from the reference generator goes to the input of the frequency multiplier of 5-100 MHz with the outputs of 10 and 100 MHz. After frequency multipling, the 100 MHz signal arrives at the inputs of the multipliers of frequencies of 1000 Mhz and 10,000 MHz from the outputs of the multipliers of frequencies of 1000 and 10,000 MHz and arrives at the front panel of the instruments. Structurally, the instrument is based on the functional block principle arranged in a standard housing without a case.

The instrument set includes: 1) frequency multiplier Ch6-62; 2) box with spare parts and accessories, semiconductor diode 1A402B, connecting cables (4 items), SM-37 lamps (2 items), waveguide adapter E2-72, waveguide-to-coaxial adapter E2-43A, safety device VP1-1-0.5 A, connecting cord; 3) technical description and operation manual; 4) technical record.

Basic Specifications

Input signal frequency, MHz	5
Signal voltage, V	0.5-1.5
Output signal frequency, MHz	10, 100, 1000, 10,000
Voltage of output signals with frequencies of 10 and 100 MHz at R=50 Ohms, V, not less than	0.5

Frequency instability introduced by the multiplier to the signal in one second, not over	$\pm 1 \cdot 10^{-12}$
Power consumption, V·A	20
Temperature range (limit), degree C	-40 ÷ +50
Dimensions, mm	490X135X474
Weight, kg	12

The Frequency Divider Ch6-63 is indended for converting a signal with a frequency of 5 or 1 MHz to a signal with a frequency of 100 kHz, and in a set with comparator-receivers Ch7-9 and Ch7-10 -- for comparing the frequencies of atomic or quartz signals (measures) with signals transmitted by radio stations. The instruments operate at an ambient air temperature of from -10 to 50 degrees C.

The Ch6-63 instrument consists of two regenerative dividers with division factors of 1/5 and 1/10 connected in series and a power supply unit. The first divider delivers to the input of the second divider a signal with a frequency of 1 MHz which is divided by 10. A 100 kHz signal is delivered to the comparator-receivers as a reference signal.

The frequency divider set includes: 1) connecting cord; 2) connecting cables (3 items); 3) safety devices (3 items); 4) technical description and operation manual; 5) technical record.

Basic Specifications

Input signal frequency, MHz	5 or 1
Input signal level, V	0.5-1.5
Input signal level at a load resistance of 50 Ohms, V, not less than	1
Relative error in comparing frequencies when the length of measurement is not more than:	
24 hours	$\pm 1 \div 10$
1 hour	$\pm 2.3 \div 10$
Weight, kg	5

The instrument is checked according to GOST 9763-67 and checking instructions given in the technical description included in the set.

The Frequency Dividers F5093 are intended for dividing the repetition frequency of electrical signals by the given scaling factors; for forming

signals of reference frequencies, lengths of pulses, time intervals, and the given number of pulses; for working as a meter with presetting.

The instrument is intended for work in enclosed dry heated premises under the conditions of moderate climate at an ambient air temperature of from 10 to 35 degrees C and a relative air humidity of up to 80% in the entire temperature range.

The divider has a wide application area in scientific, technical and industrial activities, such as in developing and manufacturing of frequency-measuring and metering equipment, in automation systems of industrial processes and automatic control, as well as in various electrical and physical laboratory studies.

The division of the repetition frequency of the input signals of the divider is organized on the scaling principle. The instrument is based on two identical preset six-digit counters each of which has an amplifier - shaper of input signals and the necessary number of amplifiers-shapers of output signals. When the digits of the counters reach the state prescribed by means of the switches of channels A and B of the divider, the count is reset to the initial position.

Provisions are made in the instrument for each of the counters to operate in a once-through mode, when, after counting to a preestablished number, a signal appears at the output, and further scaling stops. This makes it possible to use the frequency divider as a program pulse counter. The divider has a constant-temperature quartz generator and quartz frequency dividers for obtaining signals of reference frequencies of 10^3; 10^4; 10^5; 10^6 Hz.

When one of the counters operates in the reference frequency division mode and the second in the mode of a preset counter synchronized by the output signals of the first counter, signals with a calibrated length and a stable repetition frequency are obtained at the output of the second counter.

Moreover, when the divider operates in conjunction with a cinematometer, provisions are made for delivering sinusoidal signals shifted in relation to one another to individual input, their formation with the possibility of doubling or quadrupling the repetiion frequency, and subsequent arrival of the formed pulses to the inputs of the counters.

The frequency divider has two modes of control: manual and remote.

The instrument set includes: 1) frequency divider F5093; 2) set of connecting cables; 3) adapter unit; 4) jumper; clamps; 5) spare safety devices PM0.5; 6) technical description, operation manual; 7) manufacturer's rating certificate.

Basic Specifications

Input frequency range, MHz, for signals:	
sinusoidal	$10 \cdot 10^{-6}+1$
pulsed	$0.1 \cdot 10^{-6}+1$
Range of pulse length and reference time intervals, microseconds	$-1-10^{9}$
Fundamental error of the frequency of the internal quartz generator and its frequency network	$\pm 1 \cdot 10^{-6}$
Power consumption, V·A	60
Weight, kg	11
Dimensions, mm	490X380X130

The F5093 instrument is checked with series-produced measuring devices.

1. The determination of the relative error and frequency instability of the inner quartz generator is done in accordance with the requirements of GOST 13628-68 "High-Stability Generators, Methods and Means of Checking the Frequency of Electric Oscillation."

2. The determination of errors in the frequency division mode is done for each channel separately at minimum voltages of the input signals from the generators G3-7A, G3-47, G5-26 and consists in establishing an arbitrary division coefficient and subsequent checking of the error in frequency division with the frequency meter F5041.

3. The determination of errors in the preset counter mode includes the determination of the following errors: preset pulse counting; formation of the prescribed number of pulses; formation of the time interval in the form of a pulse delay, which is accomplished with the aid of the generators G5-26, G5-15, and frequency meter F5041.

4. The determination of errors in the generator mode is done by sending a signal of one of the reference frequencies of the inner generator to the frequency divider and measuring the length of pulses at the output with the frequency meter F5041.

5. The determination of errors in the cinematometer mode is done by sending sinusoidal signals with a frequency of 10 ± 1 kHz and an amplitude of 3.0 ± 0.5 V and consists in checking with the oscillograph S1-17 of the time spread of the moments of the formation of the edges of the pulsed signals on the jacks "$f_a/2$" and "$f_b/2$" of the divider.

6. The checking of the output of the counting results of input signals through the channel A to the external registering device is done with the aid of the generator G5-26 and oscillograph S1-17.

The Frequency Synthesizer Ch1-51 (Ch6-31) is intended for generating sinusoidal electrical oscillations in the frequency range from 50 to 49999999.99 Hz. Its operating conditions are at an ambient temperature from 5 to 40 degrees C.

The signal of a required frequency at the output of the synthesizer is obtained through complex conversion of the signal frequency of the reference quartz generator. Four arithmetic operations are performed in the process of frequency conversion: addition, subtraction, multiplication, and division.

In order to obtain a spectrally pure output signal, special solution circuits are used in the instrument. The frequency synthesizer consists of two individual units: a reference frequency unit (BOCh) and a frequency synthesis unit (BSCh) connected with one another by means of coaxial cables.

The instrument set includes: 1) box with spare parts; 2) technical description; 3) manufacturer's rating certificate.

Basic Specifications

Frequency range of the output signal, Hz, is regulated by steps of 0.01	50-49999999.99
Signal voltage, V, at a load of 50 Ohms in the ranges:	
50-100 kHz	0.5^{+2}_{-4} db
100 kHz - 50 MHz	0.5 ± 2 dB
Frequency setting error, %, of the final value of the working part of the scale, not over	± 5
Power consumption from network, V·A	105

The interpolation generator must ensure smooth changes in the frequency of the output signal of the synthesizer in ranges of up to 1 MHz.

7.7. Receivers of Standard Frequency Signals and Time Signals

The Receiver of Time Signals Ch7-8 is intended for receiving exact time signals transmitted by shortwave radio stations of the USSR on the frequencies 2496, 2500, 2504, 4996, 5000, 5004, 9996, 10,000, 10,004, 14,996, 15,000, and 15,004 kHz in systems for tying time scales to the exact time signals. It is a superheterodyne receiver with double frequency conversion. The first intermediate frequency is equal to 4 MHz and the second is 0.5 MHz (Figure 7.11).

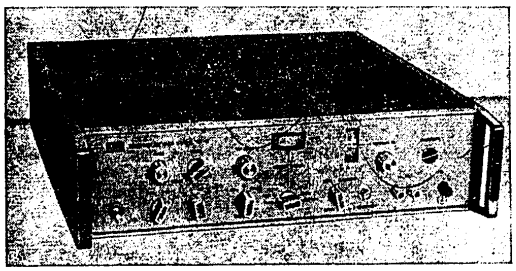

Figure 7.11

The receiver set includes: 1) container with spare accessories which includes: high-frequency connecting cables (8 items), connecting cord, modulator, telephone, coaxial three-branch fittings (2 items), coaxial adapters (2 items), signal lamps (2 items), safety devices (5 items); 2) technical description and operation manual; 3) technical record.

Basic Specifications

Reference signal voltage, V, at a load of 200 Ohms	0.2-1
Reference signal frequency, MHz	1
Frequency instability of the reference signal in 24 hours, not less than	$1 \cdot 10^{-7}$
Sensitivity of the receiver, microvolts, when the signal/noise ratio at the output is not less than 10 dB, not below	5
Maximum level of the input signal at the "Antenna" connection, mV	1
Output signals at the level of the input signal of 5 microvolts, not less than, V:	
at the "Radio Pulse" connector at a load of 100 Ohms	0.4
at the "Video Pulse" connection at a load of 200 Ohms	0.3
at the "Telephone" sockets at a load of 1 kOhm.	0.5

Passband of the receiving channel of the instrument, kHz, at a level of 6 dB depending on the position of the "Band" switch	(3.1±0.2) or (1.5±0.1)
Attenuation of the interference signal, dB, not less than:	
along the neighboring channel	80
along the mirror channel	100
at a frequency equal to the first intermetiate frequency of 4 kHz	80
Delay of the pulse signal, ms, introduced by the receiving channel and measured at a level of 0.5, not more than	1.2

7.8. Frequency, Phase and Time Comparators

The Time Interval Meter I2-22 is intended for measuring time intervals of the microsecond length range.

The instrument operates on the principle of comparing the interval being measured with a reference interval. The instrument has a source of reference time intervals, a delay generator, and an indicating device which ensures the determination of the moment of the coincidence of the beginning and end of the interval (electron-ray oscillographic indicator). The delay generator operates on the principle of selecting the required pulse from a continuous sequence of pulses. The electron-ray indicator is constructed on the basis of an electron-ray tube with a coordinate scale on the inner surface of the screen, which eliminates the parallax error.

The instrument is a desk model and consists of two units which can be installed one on top of the other.

The instrument delivers voltage differences characterizing the results of measurements in the binary-decimal code of 8-4-2-1.

When running idle, the state "0" corresponds to the voltage of not more than 0-0.3 V, and the state "1" corresponds to the voltage of not less than +2.4 V.

The instrument set includes: 1) storage case for the generator; 2) storage case for the indicator; 3) high-frequency connecting cables (9 items); 4) connecting cords (2 items); 5) three-branch fitting; 6) coaxial adapters (7 items); 8) loads (2 items); 9) remote divider 1:10; 10) adapter plate; 11) decade scalers (2 items); 12) draw tube; 13) incandescent lamps (6 items); 14) indication lamps (2 items); 15) safety devices (18 items); 16) technical description and operation manual; 17) manufacturer's rating certificate.

Basic Specifications

The instrument operates in the modes of internal and external synchronization and measures time intervals within a range from 10 ns to 90 ms. The instruments provide nine fixed scanning speeds in a range of 0.002-100 microseconds/division (1 division -- 6 mm).

Time interval measurement error, s, in the modes of:	
internal synchronization	$\pm(1\cdot10^{-5}T_{measur}+5\cdot10^{-9})$
external synchronization	$\pm(\Delta f/f-T+10\cdot10^{-9})$

The steepness of the studied signal in the area of the points between which the measurements are taken is 3 V/ns (here, $\Delta f/f$ is the relative error of the external synchronizing signal).

External synchronization can be accomplished by sinusoidal signals:	
with frequencies, kHz	$100; 1\cdot10^3; 5\cdot10^3$
with an amplitude of, V	1-30
Repetition period of the triggering delayed output pulses, microseconds	$10-100\cdot10^3$
The error in the period adjustment does not exceed.	$1\cdot10^{-5}\ T_{adjust}$
The adjustment of the measuring levels by steps at 0.1 of the size of the image at an amplitude of the studied signals, V	10-200
The passband of the amplifier of vertical deflection included in the instrument	10 Hz to 20 MHz
Sensitivity of the amplifier, V/division	0.02-10
Power supply of the instrument from an alternating current network:	
with a voltage, V, of	$220\pm10\%$
with a frequency, Hz, of	50 ± 0.5
Power consumption, V·A	210
Dimensions, mm:	
delay generator	240X360X475
indicator	200X360X375
Weight, kg:	
delay generator	19

indicator	17
Instrument sensitivity, V, does not exceed	0.3
Dynamic range of input voltages, V, in the attenuator position 1:1	0.3-4

The Time Comparators Ch7-7 are intended for determining the time position of the time marks formed by local clocks in relation to the exact time radio signals received by a radio receiving device or exact time signals of some other source.

The instrument operates at an ambient temperature from 5 to 40 degrees C and a relative humidity of up to 95% at a temperature to 30 degrees C.

The comparator is intended for operation in conjunction with an electronic clock of the Ch6-37 type and an oscillograph of the S1-48A type or other instruments with analogous parameters.

Time signals from clocks traveling with frequencies of 1 kHz and 1 Hz arrive through the input shaper to the descrete delay line. The delay time can be changed discretely (after 1 ms) with a delay switch from 0 to 999 ms. Thus, the output pulse of the delay line can shift in a one-second interval. This pulse triggers the scanning generator of the comparator whose sawtooth voltage is delivered to the horizontal plates of the oscillograph. A radio signal (exact time signal) arrives at the vertical plates of the oscillograph. The measured interval (the time interval between the pulse of 1 Hz from the clock and the radio signal) is equal to the delay value set by the discrete delay switch if the radio pulse coincides with the beginning of scanning. The accuracy of the coincidence of the radio pulse with the beginning of scanning is insufficient at the length of scanning of 1 s. The accuracy of coincidence is increased to 100 microseconds by introducing four scanning ranges of 1000, 100, 10, and 1 ms and brightness marks (ten on each scan). Further improvement of the accuracy of measurement was achieved by introducing marks of 20 microseconds into the instrument.

Ch7-7 is designed as a desk instrument; provisions were made for the possibility of installing the instrument in a standard rack.

The instrument set includes: box, case, connecting cables (6 items), safety devices (5 items), connecting cord, description, operation manual; manufacturer's rating certificate.

Basic Specifications

Range of measured time intervals, sec	0-1
Resolution in comparing exact time signals, microseconds	10

Pulse frequency, Hz	1
Pulse delay in relation to input pulses is accomplished in the range, microseconds	0-999
Switching descreteness, ms	1
Pulse length, microseconds, not less than	25
Amplitude, V	8±2
Polarity	positive
Time comparison by the instrument is ensured when it receives from the clock pulsed signals	
with a frequency, Hz, of	1
with a length, microseconds, of not less than	10
with a frequency, kHz, of	1
with a length, microseconds, of not less	15
sinusoids or meanders with a frequency, kHz, or	10, 100
Amplitude of input signals in the interval, V	3-20
Voltage of sinusoidal input signals, V	0.4-20
Input resistance, Ohms, not less than	2.2
The instrument produces:	
sawtooth scanning voltage with an amplitude of, V, not less than	20
meander voltage of an amplitude of, V	30±5
Dimensions, mm	490X480X136
Weight, kg	10

The Receiver-Comparator Ch7-9 is intended for determining frequency deviations of quartz or atomic frequency measures from the standard frequencies transmitted by radio stations of the superlong wave range.

The instrument operates at an ambient air temperature from -5 to 50 degrees C.

The receiver-comparator Ch7-9 operates on the principle of automatic following the changes in the phase of a local generator of an atomic or quartz frequency measure in relation to the phase of a standard-frequency radio signal.

The receiver is designed in the form of a portable desk instrument and can be installed in a standard rack.

The set of the receiver includes: 1) loop antenna; 2) connecting cords; 3) connecting cables (6 items); 4) safety devices (2 units); 5) signal lamps (3 items); 6) adapters (5 items); 7) connecting boxes (2 items); 8) plates (2 items); 9) earphones; 10) tripods; 11) technical description, operation manual with manufacturer's rating certificate; 12) technical record.

The instrument is checked in accordance with GOST 9763-67 and checking instructions given in the technical description included in the set.

Basic Specifications

Range of frequencies received, kHz, in steps of 0.1 kHz	10-29.9
Sensitivity, microvolt	1
Relative measurement error of frequency deviations, not over, for the measuring time:	
24 hours	$\pm 5 \cdot 10^{11}$
1 hour	$\pm 1 \cdot 10^{-9}$
Weight, kg	24

The Receiver-Comparator Ch7-10 is intended for determining frequency deviations of quartz or atomic frequency measures in relation to the frequency of signals of standard frequency transmitted by radio stations of the long-wave range. The instrument operates at an ambient air temperature from -5 to 50 degrees C.

The receiver-comparator Ch7-10 operates on the principle of automatic measurement of the phase of a local generator of the atomic or quartz frequency measure in relation to the phase of a standard frequency radio signal.

The receiver is designed as a portable desk instrument and can be installed in a standard rack.

The receiver set includes: 1) loop antenna; 2) connecting cord; 3) connecting cables (6 items); 4) safety devices (20 items); 5) signaling lamps (3 items); 6) adapters (5 items); 7) connecting boxes (2 items); 8) plate; 9) tripod; 10) technical description and operation manual with manufacturer's rating certificate; 11) technical record.

Basic Specifications

Frequencies received, kHz	66.6 and 200
Sensitivity, microvolts	1

Relative measurement error of frequency deviation, not more than, for the measurement time:	
24 hours	$\pm 5 \cdot 10^{-11}$
1 hour	$\pm$ -- 10^{-9}
Weight, kg	24

The instrument is checked according to GOST 9763-67 and checking instructions given in the technical description included in the set.

The Phase Comparator Ch7-17 is intended for comparing the phases of signals of two highly stable generators. They are used in developing and checking quartz and quantum-mechanical measures of frequency. The instrument operates at an ambient air temperature from 5 to 40 degree C.

The instrument operates on the principle of proportional dependence of the constant output voltage on the changes in the difference of the phases of signals at the input.

The instrument is designed as a separate unit in a rigid supporting frame.

The comparator set includes: 1) feeder cable; 2) technical description and operation manual; 3) technical record.

Basic Specifications

Frequency of input signals, MHz	0.001-1
Working section of phase difference measurement, rads	0.2-1.8
Input signal voltage, V	0.5-1.5
Input resistance of channels, kOhm, not less than.	1
Dimensions, mm	114X120X308
Weight, kg	3

The instrument is checked according to GOST 9763-73 and checking instructions given in the technical description included in the set.

The Frequency Comparator Ch7-12 is intended for measuring the frequency and phase instability of highly stable sources of signals. When used in combination with an electronic counting frequency meter, a spectrum analyzer, a recording microammeter, and a frequency deviation meter, it can be used: to measure the frequency difference of two signals and frequency instability; to evaluate the distribution of the spectral density of the phase fluctuations of oscillations; to measure frequency deviation in a particular frequency band; to adjust the frequency of signal sources by a standard or atomic measure.

The instrument operates at an ambient air temperature from 5 to 40 degrees C.

The instrument operates on the principle of increasing the resolution of measurements of frequency instability of output signals by the method of the multiplication of the difference of their frequencies.

The comparator is designed as a portable desk model and can be installed in a standard rack.

The comparator set includes: 1) unit of phase detectors; 2) converter unit; 3) connecting cables (13 items); 4) signal lamp; 5) safety devices (5 items); 6) connecting cords (2 items); 7) technical description and operation manual; 8) technical record.

Basic Specifications

Relative frequency instability $\Delta f/f$ introduced by the comparator with the interval of the averaging time of, respectively, 100 and over; 1; 0.1; 0.01, and 0.001 is equal to $2 \cdot 10^{-13}$; $1 \cdot 10^{-12}$; $1 \cdot 10^{-11}$; $1 \cdot 10^{-10}$; $1 \cdot 10^{-9}$.

Input signal frequency, MHz	1 and 5
Weight, kg	15

The instrument is checked according GOST 9763-67 and checking instruction given in the technical description included in the set.

7.9. Synchronometers

The Synchrnonometer Ch7-20 (Figure 7.12) is intended for: measuring time intervals between pulses coming from two different sources; measuring the length of pulses and poses between pulses from two different sources; displaying measurement results on a digital chart; delivering signal coding to an external registering device; delivering quartz-frequency voltages.

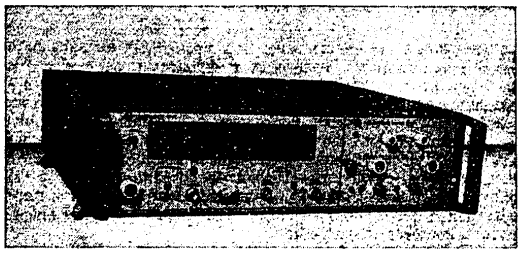

Figure 7.12

The instrument's operating conditions are: operating temperature range from +5 to +40 degrees C; relative air humidity up to 90-95% at an ambient temperature of up to +30 degrees C; atmospheric pressure 96-104 kPa. The instrument can also measure the average speed at a segment of a trajectory known in advance, distance, exact time, the fact of occurrence of some event, and other physical values if they are converted to pulses. The instrument simplifies the adjustment, tuning, and testing of various pulsed radio equipment requiring exact measurements of time intervals and length of pulses and pauses between pulses.

The instrument is based on the method of consecutive counting which consists in the following. The automatic control device forms a gate pulse from the variable interval being measured which goes to the selector. During the operation of the gate pulse, quartz-frequency pulses go through the open selector to the counting unit; these time markers are counted by the counting unit. The length of the gate pulse is equal to the length of the time interval being measured.

The instrument set includes: 1) synchronizer Ch7-20; 2) time interval unit YaZCh-30 in a storage box; 3) set of spare parts which includes; box, connecting cords (2 items); connecting cables (10 items), plates (2 items), lamps INS-1 (2 items), lamp IP-12A, safety devices VP1-1-1A (5 items), VP1-2 A (5 items), plugs RPM7-50 Sh-PB-A (3 items); 4) technical description and operation manual for Ch7-20; 5) technical record for Ch7-20; 6) technical description and operation manual for YaZCh-30; 7) technical record for YaZCh-30; 8) technical description and operation manual for YaZCh-36; 9) technical record for YaZCh-36.

The instrument is checked in accordance with GOST 9763-67.

Basic Specifications

Time interval range, s ..... 10^{-7}-10

Instrument sensitivity in channels C and D, V 0.3

(Relative error of the measurement of time intervals and lengths with input pulses with edges of not over 4 ns per one V is not more than the total error $\delta_T = \pm \delta_o \pm \tau_o/T_{meas} = \pm \delta_o \pm \delta_1$; δ_o -- relative error due to the noncoincidence of the phases of the pulse determining the beginning and the end of the counting time and pulses of the quartz frequency of filling ($\pm$1 count unit); τ_0 -- repetition period of pulses of quartz frequency of filling; T_{meas} -- time interval being measured. Relative error of the frequency of the output signal of the quartz generator after self-heating:

in the course of one month, not over ..... $\pm 1.5 \cdot 10^{-7}$
in the course of six months, not over ..... $2.5 \cdot 10^{-7}$

The reading of the error is done from the moment of the establishment of the actual value of the frequency with a relative error, not over ..... $\pm 2.0 \cdot 10^{-8}$

In the mode "With Blocking", the instrument measures time intervals only in the presence of an external signal "Removal of Blocking". The "Removal of Blocking" signal is a pulse of negative polarity with an amplitude of 6-10 V. There is a possibility of distance control with the switch "Time Markers" and the button "Reset"; it puts out information with a decimal points to the recording device in the binary-decimal code 8-4-2-1 with the following voltage levels, V, at a load of 18 kOhm:

level "0", not less than	-4
level "1", not more than	-0.8

Information output is accompanied by reference voltages, V, at a load of 18 kOhm:

level "0"	$-4 \pm 10\%$
level "1"	$1 \pm 10\%$

Power consumption, V·A at a nominal network voltage, not over 80

CHAPTER 8

INSTRUMENTS FOR MEASURING PHASE DIFFERENCE AND GROUP DELAY TIME

8.1. Devices for Checking Phase Difference Meters and Group Delay Time Meters

The Phase Calibrator F1-1 is intended for checking, graduation, and certification of electronic phase meters at fixed frequencies of 30, 500, and 1000 Hz under laboratory and workshop conditions.

The principle of the reproduction of phase shifts with the use of phase-measuring devices based on electron-ray tubes is based on the fact that the appearance of identical positions of single and multiple Lissajous figures occurs at strictly determined phase increments of voltages of multiple frequencies which are established by a circularly graduated phase shifter in a phase-variable channel.

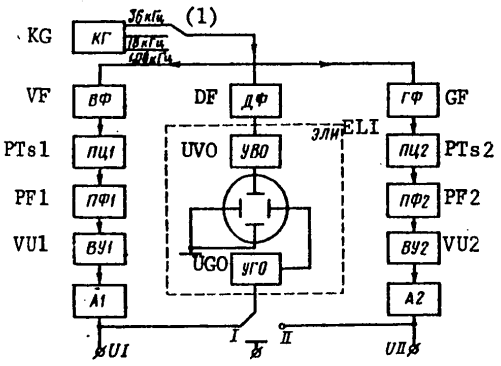

Figure 8.1

Key: 1. kHz

The block diagram of the instrument (Figure 8.1) consists of a KG -- quartz generator; VF -- auxiliary phase shifter; GF -- graduated phase shifter; PTs1, PTs2 -- recalculation circuits; PF1, PF2 -- band filters; VU1, VU2 -- output amplifiers; A1, A2 -- attenuators; UVO, UGO -- amplifiers of vertical and horizontal deviations in the channel of the electron-ray indicator ELI.

Voltages with the frequencies of 1.08, 18, and 36 kHz from the master KG oscillator enter one frequency-division channel through the auxiliary phase shifter VF, and the other through the graduated phase shifter GF which ensure the change of the output voltages from 0 to 360 degrees and through the recalculation circuits PTs1 and PTs2 and band filters PF1 and PF2 to the output amplifiers VU1 and VU2. Attenuators A1 and A2 measure the output signals in the channels.

The electron-ray indicator (ELI) is used for monitoring the phase shift and its establishment of the zero value. The additional phase shifter DF is turned on in the ELI channel for working in a single-channel mode.

The phase calibrator is designed as a desk-type laboratory instrument.

The instrument set includes: 1) phase calibrator with a built-in power supply cord; 2) SM-37 lamps (2 items); 3) cable for connecting to phase meter KPF; 4) connecting cable for repairs KSR; 5) "crocodile"-type clamp; 6) set of safety devices PM-0.5, PM-1, PM-2 (2 items each); 7) set of operational documentation and a document certifying the checking of the instrument.

The checking is done not less than once a year in accordance with the methods given in the operational documentation for the instrument.

Basic Specifications

Phase shift measuring range, degrees	0-360
Operating frequencies, Hz	30, 500, 1000
Frequency adjustment error, %	± 1
Relative frequency instability, %	$2 \cdot 10^{-5}$
Error of phase shift increment, degrees	0.1
Coefficient of nonlinear signal distortions in each channel, %	1
Output voltage levels, V	0.1-10
Output resistance, Ohms, not over	150
Power supply from an alternating current network:	
voltage, V	$220 \pm 10\%$
frequency, Hz	$50 \pm 1\%$

Dimensions	560X344X342
Weight, kg	30

The Phase Calibrator F1-2 is intended for checking, calibration and certification of electronic phase meters on fixed frequencies of 5, 10, 20, 50, 100, 200 kHz (Figure 8.2). The instrument can operate under shop and laboratory conditions corresponding to the second group of GOST 9763-67.

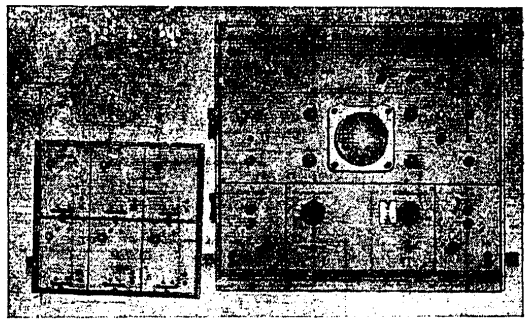

Figure 8.2

The instrument operates on the principle of setting the phase shift angle from 0 to 360 degrees with an inaccurate (series) phase shifter on one frequency (200 kHz) and measuring this shift angle with an accurate phase shifter with the aid of the Lissajous figures and subsequent division of the frequency of 200 kHz in two channels.

The principle of the reproduction of phase shifts with the use of a phase measuring instrument using an electron-ray tube is based on the fact that the appearance of identical positions of multiple Lissajous figures occurs after strictly definite phase increments which are established by the circular phase shifter in a phase-variable channel.

Phase shift increments are monitored with a phase measuring device with an electron-ray tube by multiple Lissajous figures with a frequency ratio of 1:36.

The functional diagram of the instrument is shown in Figure 8.3.

Voltage with a frequency of 7.2 MHz from the alternating current unit BPN goes to the inputs of the frequency divider DCh1 with a scaling factor of 36. Simultaneously, a signal is delivered from the alternating voltage unit to the vertical deflection amplifier UVO of the electron-ray tube. From the output of the frequency divider, DCh1, a voltage with a frequency of

200 kHz is sent to the main phase shifter OF and additional phase shifter DF. The main phase shifter OF with the limits from 0 to 360 degrees measures phases of the voltage arriving at the "variable phase" channel.

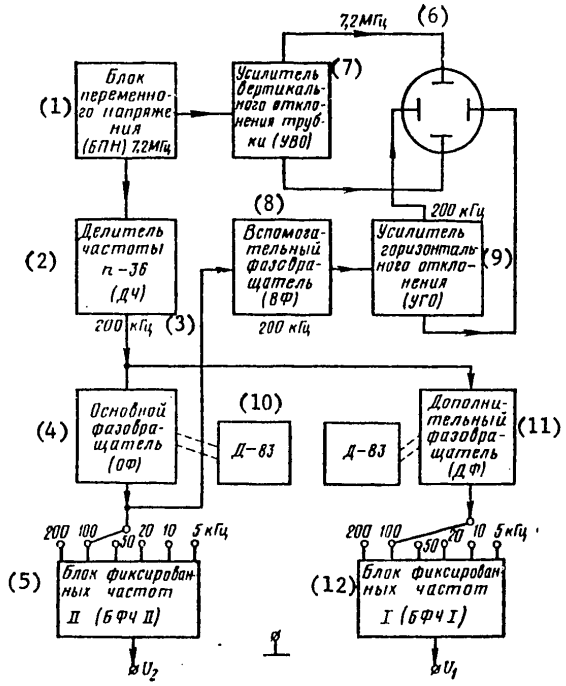

Figure 8.3

Key: 1. Alternating voltage unit (BPN), 7.2 MHz
2. Frequency divider, n-36, (DCh)
3. kHz
4. Main phase shifter (OF)
5. Fixed frequency unit II (BFCh II)
6. MHz
7. Amplifier of the vertical deflection of the tube (UVO)
8. Auxiliary phase shifter (VF)
9. Amplifier of horizontal deflection (UGO)
10. D-83
11. Additional phase shifter (DF)
12. Fixed frequency unit I (BFCh I)

The additional phase shifter DF serves for adjusting the phase of the voltage arriving at the "reference phase" channel. The use of the additional

phase shifter eleminates the parasitic "invasion" of the phase in both channels. From the output of the main phase shifter OF, through the phase shifter ("phase adjustment") VF with the regulation limits of ±360 K (where K = 7.2 MHz/200 kHz = 36 is the frequency multiplicity factor), the signal goes to the amplifier of horizontal deflection UGO, and further to the ELT [electron-ray tube]. Phase ratios are established by the main phase shifter and are measured by the Lissajous figures on the ELT. The exact unit of phase shift is the transition of one figure from "closed" to "open" and then again to "closed". The increment of the phase shift at a frequency of 200 kHz from one closed Lissajous figure to another corresponds to an angle of 5 degrees.

From the outputs of phase shifters DF and OF, the signals go to the fixed frequency units BFCh1 and BFCh2 which generate the remaining frequencies -- 100, 50, 20, 10, and 5 kHz.

The fixed frequency units BFCh1 and BFCh2 have output amplifiers which amplify the voltage signal to 5 V of 200 kHz and to a level of 8 V frequency signals of 100, 50, 20, 10, and 5 kHz.

The phase calibrator of the F1-2 type is designed as a table-type laboratory instrument.

The instrument consists of removable units. Electrical contact among them is accomplished through plug and socket units.

Basic Specifications

Phase shift measurement range, degrees	0-360
Frequency range is determined by the series of the following discrete values, kHz	5; 10; 20; 50; 100; 200
Fundamental frequency on which phase shifts are set and monitored, kHz	200
Frequency instability of the quartz resonator during proportional adjustment of the thermostat within the limits of 60±2 degrees C for one hour of operation .	$2 \cdot 10^{-5}$
Error in the phase shift increment on frequencies of up to 200 kHz, degrees	0.1
Nonlinear distortion coefficients, %	1.5
Output voltage levels, V, for frequencies:	
200 kHz	0.05-5
for remaining frequencies	0.08-8

Output resistance, Ohms, not over	1000
Power supply from alternating current network:	
voltage, V	220±10%
frequency, Hz	50±1%
harmonic content, %	5

The following parameters are checked: absolute frequency value, frequency instability, nonlinear distortion factor, output voltage, and error in the phase shift increment.

The determination of the absolute frequency value is done by measuring it on the output clamp of the first channel of the instrument with the aid of a Ch3-30-type frequency meter (error of 10^{-8}).

Frequency instability is checked by measuring the frequency with the aid of a Ch3-30-type frequency meter.

The nonlinear distortion factor is checked at the output of two channels of the instrument with the aid of a S6-5-type nonlinear distortion meter in the range from 5 to 200 kHz.

Output voltage is checked by successively connecting a voltmeter of the V7-15-type (fundamental error of 2.5%) to the output of each channel of the instrument.

The error in the phase shift increment for instruments of the second class is checked by the method of independent checking.

The Phase Shift Calibrator F5125 is intended for tuning, adjustment and checking of electronic phase-metering instruments and can be used as a generator of a number of quartz freqeuncies, as well as a two-channel generator with a calibrated delay in one channel.

The calibrator is designed on the principle of two-channel structure with the use of very stable phase devices using triggered scaling circuits. The sinusoidal-shape output signal is formed by means of a piecewise stepped approximation of the function describing the output signal. Structurally, the calibrator consists of a base unit with a set of printed plates, a front panel unit, and a power supply unit.

The instrument set includes: 1) phase shift calibrator F5125; 2) connecting cables (5 items); 3) transition unit; 4) clamps (4 items); 5) spare safety devices PM-0.5 (3 items); 6) spare lamps KM24-35 (2 items); 7) box for accessories; 8) technical description and operation manual; 9) manufacturer's rating certificate.

Basic Specifications

Frequency range, Hz	$1 \div 20 \cdot 10^3$
Discreteness of the setting of the phase shift increment, degrees	1
Error in the setting of phase shift increments, degrees, not over	0.2
Maximum output voltage, V	10
Adjustment of output voltage within the limits, dB.	0-55

The error in the setting of phase shift increments $\Delta\psi$ is checked by multiplying $\Delta\varphi$ by 36 with the aid of the phase shift multiplier F5166 developed by the plant "Tochelektropribor" with subsequent measuring of the above value by a F2-13 phase meter. Other technical characteristics are checked in accordance with GOST 12691-67.

8.2. Phase Difference Meters

The Combination Phase Difference Meter FK2-12 is intended for measuring phase differences of sinusoidal signals and their voltage levels, as well as for measuring transmission coefficients of quadripoles and S-parameters of high-frequency transistors. The instrument operates on the principle of stroboscopic conversion of frequency with automatic phase adjustment of frequency.

The instrument set includes: 1) matched loads (2 items); 2) attenuators 75/50 Ohms (2 items); 3) three-branch fittings (4 items); 4) dividers 1:10 (2 items); 5) diodes (8 items); 6) power supply cables; 7) tester adapters (4 items); 8) tester constants (10 items); 9) safety devices (5 items); 10) coaxial cable; 11) three-branch fittings of the tester; 12) technical description and operation manual; 13) technical record.

Basic Specifications

Input frequency range, MHz	1-1000
Phase difference measurement limits, degrees	$-180 \div +180$
Input voltage limits, V:	
without divider	10^{-4}-1
with external divider	up to 10
Input impedance, kOhm, shunted by a capacitance of 3 pF	100
Dimensions, mm	480X473X160

The Phase Difference Meter F2-13 is intended for measuring phase differences between two continuous sinusoidal signals of the same frequency and is used for various radio engineering measurements. The instrument operates at an ambient air temperature from 5 to 40 degrees C. It operates on the principle of converting the phase difference being measured to a time interval with subsequent measurement by a pointer-type instrument of the constant component of the current pulses whose length is equal to that interval.

The phase meter is designed as a unipolar triggered two-channel circuit whose measuring and reference channels are identical.

The special characteristic of its circuit is the use of high-speed triggers and level discriminators using tunnel diodes.

The meter set includes: 1) testers (2 items); 2) adapters (2 items); 3) cables (2 items); 4) "crocodile" clamps (2 items); 5) repair plates (3 items); 6) safety devices (8 items); 7) neon lamps (2 items); 8) manufacturer's rating certificate.

Basic Specifications

Measurement range of phase shifts in the operating frequency range, degrees	-18÷+18; -36÷+36 -90÷+90; -180÷+180
Operating frequency range of the instrument, kHz	0.02-1000
Overlapped by two subranges	0.02-20; 20-1000
Input voltage range, V	0.1-1;
Overlapped by two subranges	0.1-1; 1-10

The permissible fundamental error of the measurement of phase differences with the instability of the signal frequency is not over 10^{-3} in 10 minutes and does not exceed the values given in Table 8.1.

Table 8.1

(1) Частота, кГц	(2) Погрешность, град., при относительной разности уровней сигналов	
	(3) не более 10%	(4) свыше 10%
От 0,02 до 0,2 (5)	$\pm(0{,}015\varphi_x+0{,}3)$	$\pm(0{,}015\varphi_x\pm0{,}3+2A)$
Свыше 0,2 до 200 (6)		$\pm(0{,}015\varphi_x\pm0{,}3+0{,}75A)$
Свыше 200 до 1000 (7)	$\pm(0{,}02\varphi_x+1)$	$\pm(0{,}02\varphi_x+1+0{,}15A)$

Note: A -- input voltage drop, dB, at input voltages from 0.1 to 10 V; φ_x -- phase difference being measured.

Key: 1. Frequency, kHz
2. Error, degrees, at a relative difference of signal levels
3. Not over 10%
4. Over 10%
5. From 0.02 to 0.2
6. Over 0.2 to 200
7. Over 200 to 1000

Effective input resistance of the instrument at a frequency of 100 kHz, not less than MOhm	1
Input capacitance, pF, not over	15
Power consumed by the instrument from the network at a nominal voltage, V·A, does not exceed	50
Dimensions, mm	360X160X300
Weight, kg	+5

The Combination Phase Difference Meter FK2-14 is intended for measuring the phase difference and amplitude ratio of signals of the radio frequency range.

The meter is a two-channel superheterodyne receiver and consists of: a frequency converter which converts the frequency of the input signals to the intermediate frequency (PCh) of 20 MHz; a base measuring unit serving for tuning the harmonic oscillator and maintaining a constant PCh, measuring the ratios by the readings from the step attenuator and second conversion to the display frequency; a pointer-type indicator which measures and indicates the phase differences of the signals and the signal level in the channel being tested; a decoupled three-branch connector used for setting the instrument to zero and measuring complex transmission factors of the quadripoles.

The instrument set includes: 1) meter; 2) high-frequency unit; 3) conbination set containing: frequency converter, coaxial adapters (6 items); 4) attenuators (8 items); 5) connecting cord; 6) connecting cables (3 items); 7) technical description and opertion manual; 8) technical record.

Basic Specifications

Frequency range, GHz	0.11-7.0
Measurement limits of the phase difference of signals, degrees	0±180

Subranges	-6÷+6; -18÷+18 -60÷+60; -180÷+180
Measurement limit of level ratios, dB	0-60
Permissible absolute measurement error of the phase difference $\pm(1+0.03\ \psi_{limit}+0.075\ A_x)$, (but not over 3 degrees, where ψ_{limit} is the scale limit; A_x -- attenuation of the studied signal, dB).	
Permissible absolute error of measurements of level ratios from $\pm(0.5+0.03\ A_x)$ up to 50 dB (but not over ± 4 dB, where A_x is the value being measured, dB).	
Instrument sensitivity in the measuring channel, W	10^{-9}
Resolution in measuring the phase difference of signals, degrees	± 0.2
Resolution in measuring the ratio of levels, dB	± 0.2
Power supply of the instrument from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50±1%
Power consumption, V·A	100
Dimensions, mm:	
meter	215X475X499
frequency converter	75X 220X240
high-frequency unit	135X475X490
Weight, kg	37.7

The instrument is checked in accordance with GOST 9763-67 and checking instructions given in the technical description and operation manual included in the set.

The Digital Phase Meter F5126 is intended for measuring the average phase shift between two periodic continuous voltages with a frequency of 1-150 MHz in developing, checking, tuning, and adjusting phase-sensitive radio engineering devices, electronic devices, communication devices, and in other areas of the national economy (Figure 8.4).

The phase meter is based on the compensation method of measuring phase shifts with the use of a multiple-valued measure of phase shift constructed on the

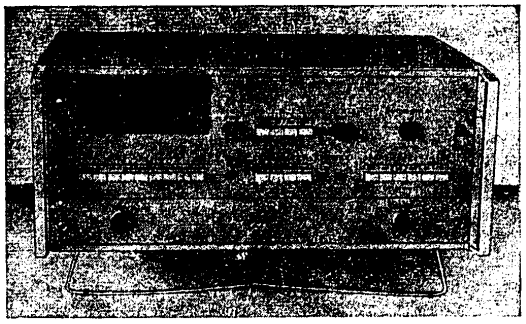

Figure 8.4

basis of discrete phase shifters with trigger-action scaling circuits. The phase shift being measured is compared with the compensating phase shift with the aid of a double low-frequency converter and a statistical zero-element.

In order to measure input voltages in the operating frequency range, the spectra of input voltages are transformed into the area of low frequencies with the aid of an automatic two-channel stroboscopic frequency converter.

In order to reduce the amplitude-phase error of measurement, the levels of input signals are stabilized with the aid of amplifiers with automatic gain control.

Structurally, the phase meter consists of the following units: basic unit with a set of printed-circuit cards, front panel unit, power supply unit.

The instrument set includes: 1) digital phase meter F5126; 2) high-frequency cables (2 items); 3) special high-frequency cables (2 items); 4) remote testers (2 items); 5) 40-contact adapter unit; 6) 30-contact adapter unit; 7) voltage dividers 1:10 (2 items); 8) matched loads (2 items); 9) resistors UNU-III-0.25-50 Ohms (2 items), UNU-III-0.25-75 Ohms (2 items); 10) three-branch fitting; 11) adapters (2 items); 12) spring probes (2 items); 13) clamps (4 items); 14) spare safety devices PM-0.5 (4 items); 15) spare lamps KM-24-35, IN-12B; 16) spare diodes DK512A (8 items); 17) plug; 18) technical description and operation manual; 19) manufacturer's rating certificate.

Basic Specifications

Frequency range, MHz	1-150
Input voltage level range, V	0.01-1

Phase shift measurement limit, degrees	0-359.9
Phase difference measurement error, degrees:	
at equal signal levels	±0.3
at a level drop of 20 dB	±0.5
Effective input resistance of the phase meter at each of the inputs, kOhm, not less than	100
Input capacitance, p/F, not over	5

The phase measurement error is checked by the method of comparing with the natural measure of phase shift (self-checking method) which makes it possible to eliminate the error from the coupling between channels through the signal source. The checking is done with the aid of uncalibrated phase shifters on low frequency of the operating range and with the aid of controlled delay lines M5-2 on upper frequencies. The checking of the amplitude-phase error is done by an indirect method through determining this error on a low intermediate frequency with the aid of an F5125 phase shift calibrator and by measuring the coupling between channels by the intermediate frequency during the delivery of high-frequency signals to the input of the phase meter.

8.3. Group Delay Time Meters

The Group Delay Time Meter F4-3 is intended for measuring nonuniformities of frequency characteristics of the group delay time (GVZ), and attenuation of communication lines and quadripoles in the frequency range of 0.2-20 MHz. The operating temperature range is from 5 to 45 degrees C.

The GVZ measurements with the aid of the instrument is based on the Nyquist principle: if oscillations of a high frequency ω are delivered to the input of the object being studied and amplitude-modulated by oscillations of frequency Ω, then the envelope of the modulated signal at the output of the object acquires a phase shift of $\Delta\varphi$ which is proportional to the delay time on the carrier frequency ω, $\Delta\varphi = \tau(\omega)$.

During such measurements, not the absolute phase shift of the low-frequency oscillation is determined but the phase increment depending on the change of the high frequency, i.e., the nonuniformity of the frequency characteristic of the group delay time is measured.

Structurally, the instrument consists of three units: transmitting and receiving devices and an oscillographic indicator. the basis of the structure of the instrument's units is a normalized caseless frame 200 mm high.

The instrument set includes: 1) set of operational documentations; 2) set of spare parts and accessories; 3) manufacturer's rating certificate.

Basic Specifications

Operating frequency range, MHz	0.2-20
Measurement limits of GVZ nonuniformities, microseconds	±(0.015-7.5)
Measurement limits of nonuniformities of the frequency characteristics of attenuations, dB	±(0.75-13)
Permissible fundamental error of GVZ measurements %	±2.5
Permissible fundamental error of attenuation measurements, %	±3.5
Power consumption, V·A	220
Input and output resistance, Ohms	75

The Group Delay Time Meter F4-4 is intended for measuring frequency characteristics of group delay time (GVZ) and amplitude-frequency characteristics (AChKh) symmetrical and asymmetrical in relation to the quadripoles and high-frequency channels of transmission systems in the range from 10 to 2100 Hz.

According to the Nyquist principle, the measurement of GVZ amounts to the isolation of the envelope at the output of the object being studied and its comparison with the reference oscillations. In this case, the changes of the phase shift between the envelope and the reference oscillations, depending on the frequency of the carrier, are proportional to the nonuniformity of the GVZ characteristic in the carrier frequency range being studied. The result of the measurements is presented in the form of an image of the frequency characteristic on the screen of the oscillographic indicator. Having passed the object being studied, the testing signal acquires, besides a phase shift, amplitude changes in accordance with the amplitude-frequency characteristic of the object. The information about the AChKh of the object being studied is carried by the envelope of the low-frequency oscillation which is observed on the screen of the oscillographic indicator.

The instrument consists of three units: measuring device, receiving-transmitting device, power supply unit, and quartz oscillator. The instrument has a normalized caseless body.

The instrument set includes: 1) measuring device; 2) receiving-transmitting device; 3) power supply unit and quartz oscillator; 4) set of spare parts and accessories; 5) operational documentation; 6) manufacturer's rating certificate.

Basic Specifications

Operating frequency range, kHz	10-2100
Measuring limits of GVZ nonuniformities, microseconds	10; 50; 100; 200; 500
AChKh measuring limit, dB	2·8.7
Fundamental error of GVZ measurements, microseconds, does not exceed	±0.5
Fundamental error of attenuation measurements, dB, does not exceed	±0.05·8.7
Input and output resistance, Ohms	75±5%
Power consumption, V·A	250

The checking of the instrument includes the following operations: 1) checking of the nominal frequency value of the quartz oscillator; 2) determination of the error in the setting of the nominal frequency value of the quartz oscillator; 3) determination of the frequency correction limits of the quartz oscillator in relation to the nominal value; 4) checking of the frequency range; 5) checking of the initial and final frequency of the operating range of the instrument; 6) checking of the limits of the adjustment of the frequency swinging (deviation) range: 7) checking the frequency axis scale; 8) checking of the maximum output voltage; 9) checking of the coefficient of nonlinear distortion of the output signals; 10) checking of the image dimensions of the coordinate scale; 11) checking of the coefficient of the amplitude modulation of the output signal; 12) checking of the calibration of the GVZ measurement limits; 13) calibration of the AChKh measurement scale; 14) nonuniformity of the GVZ natural frequency characteristic: 15) nonuniformity of the instrument's natural AChKh; 16) power consumption.

The Group Delay Time and Amplitude-Frequency Characteristic Meter IVA is intended for measuring relative frequency characteristics of the group delay time (GVZ) and nonuniformities of the amplitude-frequency characteristics (AChKh) of audio-frequency channels and quadripoles in the frequency range from 0.3 to 3.4 kHz.

The main purpose of the meter is to measure GVZ and AChKh of audio-frequency channels in the process of their tuning and operation. The meter can be used by scientific research and industrial laboratories for tuning and monitoring various electrical and radio devices (filters, amplifiers, phase circuits, correctors, etc) operating in the frequency range from 0.3 to 3.4 kHz.

AChKh and GVZ measurements are done by comparing the amplitudes (phases) of a signal on the frequency being measured with the amplitude (phase) of the reference signal.

Measurement of the frequency characteristics of communication channels presupposes the presence of two territorially separated measuring instruments: a receiver and transmitter.

The reception of information about the amplitude (AChKh) and phase (GVZ) of the reference signal in the IVA meter is accomplished without the use of any additional or reverse channel. For this, the operation cycle of the instrument is divided into two parts: operating and reverse motion of frequency oscillation.

During the reverse motion, a reference-frequency signal (0.8 kHz for AChKH and 1.9 kHz for GVZ) is sent to the channel from the transmitter and its measurements are done. The receiver stores the amplitude (AChKh) or the phase of the envelope (GVZ) of this signal

When the instrument is operating, a measuring signal whose frequency changes according to a prescribed law enters the channel. The receiver measures the parameter (amplitude or phase) of the signal which passed through the object being studied, compares it with the values stored in the memory, and the resulting (difference) signal is sent to the measuring device calibrated in the appropriate values (decibels or milliseconds).

The instrument performs measurements in the modes of periodic and manual frequency oscillation, as well as on twenty-one fixed frequencies.

The emitter forms frequency marks which make it possible to determine frefrequency at the characteristic point being measured when working with external recording devices (recorder, oscillograph) in the mode of periodic and manual oscillation.

The meter is designed as a standard table model and can be installed either directly at the work place or on the movable stand which is included in the set.

The control, switching and monitoring devices are located on the front panel of the instrument, while the switching and monitoring elements which are not operational are on its back wall. The instrument is designed on the basis of the functional assembly method in the form of blocks connected into a common circuit with the aid of small plug and socket units. The circuit elements of the blocks are on printed-circuit plates. For checking or repairs, any block can be removed from the instrument and connected with a meter with the aid of a special repair plate.

The IVA meter does the following: measures AChKh and GVZ with a pointer-type microammeter; records the results of measurements on external recording

devices; provides panoramic observation of the characteristics on the screen of the external oscillograph. The input and output of the meter are symmetrical.

The meter delivers the results of measurements to external recording devices (recorders and oscillographs): voltage of vertical deflection proportional to the indications of the microammeter; voltage of horizontal deflection proportional to the frequency of the input signal.

With respect to the climatic and mechanical requirements, the meter belongs to Group II of GOST 9763-67 with a broader range of operating temperatures from +5 to +40 degrees C.

The meter set includes: 1) IVA meter; 2) stand; 3) power supply cord; 4) grounding cord; 5) measuring cords (9 items); 6) repair plates (9 items); 7) repair cord; 8) handle; 9) safety devices (12 items); 10) manufacturer's rating certificate; 11) recording millivoltmeter N39.

Basic Specifications

Frequency range of the meter, kHz	0.24±0.24÷3.50 ±0.05
Oscillation zone, kHz, not less than	3.17
Frequency oscillation periods, seconds	40±10 and 70±18
Deflection of fixed frequencies from the monimal values, %, not over	2
Error of frequency marks, not over	±(2% f ±15 Hz)
Range of measured levels, dB	-40÷+2
Dynamic measurement ranges with the microammeter of the meter, dB	-20÷+2; -6÷+1

The fundamental error of AChKh measurement in relation to the amplitude on a frequency of 0.8 kHz is not over ±(0.04 A + 0.2) dB(A -- relative amplitude at the point being measured, dB).

GVZ measurement range, ms	-20÷+20
Measurement limits, ms	0±0.2; 0±2 0±5; 0±20

The fundamental error of GVZ measurement is not more than ±(0.03 T±10) microseconds (T -- finite value of the measurement limit, microseconds).

Output level of the measuring signal, dB, at a load of 600 Ohms (regulated in steps every 2 and 10 dB)	-40-0
Error of output level adjustment, dB, does not exceed	±0.5
Asymmetry attenuation, dB, not less than	40
Modulus of the input and output resistance, Ohms	600±12
Power consumption from the network, V·A, not over	100
Power supply of the instrument -- from an alternating current network:	
voltage, V	220 +10% -15%
frequency, Hz	50
Dimensions, mm:	
table-model instrument	480X338X425
stand	589X116X500

The IVA meter is checked in accordance with the section "Maintenance" of the manufacturer's rating certificate for the meter.

The checking of the basic technical characteristics of the instrument is done with the use of the measuring instruments given below or with analogous instruments: 1) digital voltmeter V7-16; 2) audio-frequency signal generator G3-104; 3) pulse generator G5-35; 4) spectrum analyzer S4-48; 5) frequency meter Ch3-38; 6) oscillograph S1-65; 7) stopwatch.

The frequency range and the oscillation zone are checked with the aid of a frequency meter connected to the output sockets of the meter loaded to a resistance of 600 Ohms. The frequency meter is used to measure the boundary (lower and upper) frequency of the output signal in the operation mode of periodic frequency oscillation when the switch "Period" is set in position "X2".

Frequency oscillation periods are checked with a stopwatch by which the lengths of the working and reverse strokes are marked. They are monitored by the "on"-time of the indication lamps of the working and reverse strokes. The period is determined by summing up the measured values. Measurements are done at two positions of the switch "Period" -- "X1" and "X2".

The deviation of fixed frequencies from the nominal values are checked with the frequency meter connected to the output sockets of the meter loaded to 600 Ohms. Measurements are done at all positions of the switches (kHz).

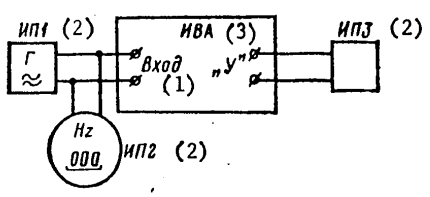

Figure 8.5

Key: 1. Input
2. IP
3. IVA

The frequency of marks is checked according to the scheme (Figure 8.5). While smoothly changing the frequency of the generator IP1, frequency at which an amplitude mark appears on the screen is determined by the oscillograph IP2 connected to the sockets "U" of the meter. Measurements are done at all positions of the switches "kHz".

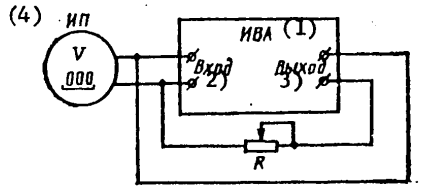

Figure 8.6

Key: 1. IVA
2. Input
3. Output
4. IP

The dynamic range and the fundamental error of AChKh measurement is done according to the scheme (Figure 8.6) by comparing the indications of the microammeter of the meter and the reference voltmeter IP. The pointer of the microammeter of the meter is set to the marks of the AChKh scale by adjusting the out voltage of the meter with the aid of its output attenuators and by adjusting the potentiometer R (see Figure 8.6). Measurements are done at two measurement limits -20 and -6 dB at two positions of the switches kHz; 0.5 and 3.2.

The limits and the fundamental error of GVZ measurements are checked according to the following method: the input and output of the meter are connected and the setting of the pointer of the microammeter of the meter to the "0"

mark of the GVZ scale is checked. The pulse generator operating in the single-triggering mode is connected to the sockets "HVZ Check" and the pulse formed by the generator performs the phase shift (time shift) of the envelope of the GVZ measuring signal. Adjusting the pulse length of the generator, the pointer of the microammeter of ~~the meter is set to the marks of~~ the meter is set to the marks of the GVZ scale which are being checked, and the obtained error is determined by the indications of the pulse-length switches of the generator. Measurements are done at all GVZ measurement limits with the switches "kHz" set in position "1.9".

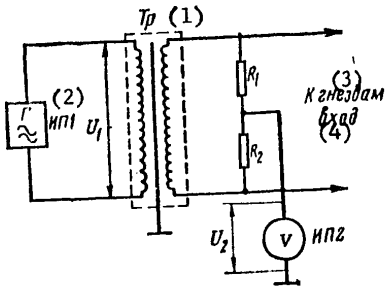

Figure 8.7

Key: 1. TR
2. IP
3. to sockets
4. Input

The error of the setting of the output level is checked with the digital voltmeter connected to the sockets "Output" of the meter loaded to a resistance 600 Ohms. Measurements are done at all positions of the output attenuators with the switches "kHz" set in position "0.8".

The input asymmetry attenuation is checked according to the scheme of (Figure 8.7) on frequencies of 0.3 and 3.4 kHz.

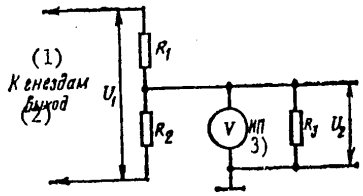

Figure 8.8

Key: 1. to socket
2. Output
3. IP

The output asymmetry attenuation is checked according to the scheme of (Figure 8.8) with the switches "kHz" set in positions "0.3" and "3.4".

Asymmetry attenuation is determined by the formula $a_A = 20 \lg\left(\frac{U_1}{U_2}\right) - 6,$

a_A -- asymmetry attenuation, dB; U_1 -- output voltage of the generator (meter), V; U_2 -- voltage in the symmetrization circuit, V.

The input and output resistance moduli are checked by the comparison method which consists in obtaining identical voltage drops at a known effective resistance R_o and unknown resistance Z_x being measured when they are simultaneously connected in series in a common circuit. Measurements are done by changing the value of R_o until an identical voltage drop is obtained for both resistances. At that time $Z_x = R_o$.

CHAPTER 9

INSTRUMENTS FOR MONITORING, MEASURING, AND STUDYING SIGNAL AND SPECTRUM FORMS

9.1. Multipurpose Oscillographs

The Oscillograph S1-40 (Multifunctional, with Changeable Units) is a multifuctional laboratory instrument for general use and is intended for visual studies of the voltage shapes of periodic and pulsed processes.

The oscillograph has the following main assemblies: a vertical deflection channel consisting of a preamplifier for precision measurements; a preamplifier; an indicator unit with a delay line, a terminal amplifier, a switching device, and a high-voltage source; a horizontal deflection channel consisting of a sweep generator with synchronization circuits, a horizontal deflection amplifier, a generator of switching pulses, and a delayed scanning unit; a calibrator for delivering voltages for calibrating the oscillograph; a pulse generator for monitoring the parameters of the transient characteristic of the oscillograph; a control unit; a power supply unit.

The instrument set includes: 1) extension tester; 2) extension feelers (2 items); 3) power supply cord; 4) cable with a high-frequency connector; 5) cable with a jack plug; 6) cable with an adapter; 7) high-frequency connecting cable; 8) connecting cord; 9) 75 Ohm matching attachment; 10) coaxial adapters (4 items); 11) draw tube: 12) filters (25 items); 13) light filter-scale; 14) polyethylene cover; 15) electron tubes (8 items); 16) screwdriver; 17) signal lamps (18 items); 18) terminals (6 items); 19) "crocodile"-type clamps (6 items); 20) safety devices (18 items); 21) preamplifier (at customer's request); 22) delayed scanning unit (at customer's request); 23) pulse generator; 24) dolly (may be excluded at customer's request); 25) photographic attachment (at customer's request); 26) technical description, operation and periodic checking manual; 27) manufacturer's rating certificate.

The instrument with a set of changeable units No 40-01 and No 40-02 belongs to the precision class I of GOST 9810-69, with other changeable units -- to precision class III.

Basic Specifications

Minimum scanning frequency, Hz	200
Passband of the vertical deflection channel, MHz	0-20
Sensitivity of the vertical deflection channel, pulse/V, with preamplifiers:	
No 40-01	0.6-200
No 40-02	1-100
Measuring error of rectangular-shape pulsed voltage with a length of 60 ns to 100 ms and sinusoidal signals with frequencies from 200 Hz to 2 MHz, %, not over	2
Power supply of the instrument -- from the alternating-current network:	
voltage, V	220±10%
frequency, Hz	50±0.5
Power consumed from the network at a nominal voltage, V·A, not over	950

The Multipurpose Oscillograph S1-7 in combination with adjacent units 1P11, 1P71 in the horizontal deflection channel and 1U11, 1U13, 1U71 in the vertical deflection channel is intended for studying periodic and single electrical signals through visual observation and photographing. The instrument operates at temperatures from 5 to 40 degrees C and a relative humidity of 95% at a temperature of 30 degrees C.

Electrical signals being studied are amplified by the changeable vertical deflection unit and are delivered through the delay line to the input of the output amplifier U. The output amplifier amplifies this signal to a level necessary for the excitation of vertical deflecting plates of the electron-ray tube ELT. From the changeable horizontal deflection unit, the signal is delivered to the input of the output amplifier Kh and is amplified by the latter to a value necessary for the excitation of the horizontal plates of the ELT. The signal can also be delivered to the input of the amplifier Kh through the connector "Kh Input".

The oscillograph S1-70 is a single-unit instrument of the table-rack type.

The oscillograph set includes: 1) basic unit of the oscillograph; 2) changeable units with a ZIP [kit of spare parts, tools, and accessories] set; 3) cover; 4) connecting cords (2 items); 5) draw tube; 6) high-frequency connecting cables; 7) adapters (2 items); 8) T-joint; 9) safety devices (14 items); 10) technical description and operation manual; 11) technical record.

Basic Specifications

Passbands, MHz, with units:	
1U11	0-50
1U13	0-10
1U71	0-3.5
Minimum deflection factors, mV/division, with units:	
1U11	10
1U13	0.5
1U71	5
Noise level,mV	5
Scanning length ranges, ns/div, with units:	
1R11	10-15
1R71	$0.1 \cdot 10^{-9} \div 5 \cdot 10^{-6}$
Permissible errors in the deflection and scanning factors with units:	
1U11, 1U13, 1R11	4
1U71, 1R71	7
Power consumption, V·A	200
Dimensions, mm	200X480X420
Weight, kg	20

The multipurpose oscillograph S1-67 is intended for studying shapes of electrical signals through visual observation and changes in the time intervals from 0.4 microseconds to 0.2 second and amplitudes in the range from 30 mV to 140 V.

The oscillograph is based on a generally accepted block diagram. The signals being studied are intensified in the preliminary and terminal amplifiers of the vertical deflection channel and are delivered to the vertical plates of the ELT. The preamplifier channel has a delay line which makes it possible to observe the leading edges of the pulses being studied.

The sweep generator generates sawtooth voltage for the time scanning of the ELT beam. The sweep generator can work in the slave sweep mode and in the automatic-triggering and single-triggering modes.

Periodic control of the sensitivity of the vertical deflection channel and calibration control of the scanning length are done with the amplitude and scanning length calibrator.

The oscillograph set includes: 1) a set of spare parts; 2) technical description and operation manual; 3) manufacturer's rating certificate.

Basic Specifications

Passband of the vertical deflection channel, MHz ..	0-10
Nonuniformity of the AChKh [amplitude-frequency characteristic], not over, dB	3
Build-up time of the transient characteristic must not exceed, ns	3.5
The error in the measurement of the amplitudes of pulsed signals when the pulse lengths are over 0.1 microsecond and the size of the signal image is from 4 to 7 divisions must not exceed, %:	
for sinusoidal signals in the frequency range 0-2 MHz	10
for time intervals in the range from 0.4 microsecond to 0.2 second for a signal in the horizontal direction from 4 to 10 divisions	5
Weight, kg	9

The Multipurpose Oscillograph S1-65 is intended for studying the shapes of electrical signals and measuring their amplitudes and time parameters under the workshop, laboratory, and field conditions of operation.

The signals being studied are delivered to the "Input" jack of the vertical deflection amplifier. The input attenuator is used to determine the dimensions of the signal image which is convenient for examination on the screen of the electron-ray tube. The signal is amplified by the preamplifier and the terminal vertical deflection amplifier. The symmetric delay line delays the signal for a time compensating the delay of the signal in the synchronization, scanning, and bright-up units, which makes it possible to observe the leading edges of short pulses.

The horizontal-scanning generator generates sawtooth voltage for time scanning. This voltage is amplified to the necessary value by the horizontal deflection amplifier and goes to the horizontally deflecting plates of the electron-ray tube. Provisions are made in the horizontal deflection amplifier for increasing the scanning rate ten-fold. The scanning generator can operate in the slave sweep mode, in the triggering mode, and in the single triggering mode.

Provisions are made for the possibility of delivering an external signal to the horizontally deflecting plates through the horizontal deflection amplifier when the signal is delivered to the "Input" jack.

Provisions are made for the possibility of delivering an external signal to the input of the amplifier for obtaining brightness time marks.

Periodic checking of the sensitivity of the vertical deflection channel and checking of the scanning length calibration are done with the amplitude and scanning length calibrator.

The instrument set includes: 1) set of accessories; 2) incandescent lamps (3 items); 3) safety devices (4 items); 4) 1:10 divider with a changeable attachment; 5) divider; 6) clamps (3 items); 7) connecting cable; 8) adapter cable; 9) cables (4 items); 10) rack; 11) adapters; 12) light filter; 13) T-joint; 14) draw tube; 15) feeler; 16) cover; 17) storage box; 18) technical description and operation manual.

Basic Specifications

Passband, MHz	0.35
Minimum deflection factor, mV/div	5
Amplitude measurement error, %	5
Frequency measurement error, %	5
Scanning length range, microsecond/div	0.02-50
Dimensions, mm	300X180X420
Weight, kg	16

The oscillograph is checked in accordance with GOST 9810-69.

The Oscillograph S1-64 is intended for visual studies of electrical processes by measuring the amplitude and time parameters of the signal; simultaneous presentation of two signals in one scanning; detailed studies of any part of a complex signal by means of retarded scanning.

Structurally, the instrument is composed of the following units: electron-ray tube (ELT); input attenuator of channel 1; input attenuator of channel 2; preamplifier of channel 2; diode switch; vertical deflection amplifier with a delay line; switching multivibrator; synchronization preamplifier; synchronization circuit A; scanning circuit A; brightening amplifier A; single scanning triggering circuit A; synchronization circuit B; scanning circuit B; brightening amplifier B; delay comparator; horizontal deflection amplifier; amplifier; ELT power supply circuit; power supply unit; amplitude and scanning length calibrator.

Amplitude measurements are done by the method of reading from the calibrated scale on the ELT screen. Two methods can be used for measuring time intervals: measurement of intervals by the calibrated scanning length with the aid of calibrated scanning delay.

The instrument set includes: 1) storage box; 2) set of accessories; 3) technical description and operation manual; 4) manufacturer's rating certificate.

Basic Specifications

Working part of the screen of the oscillograph, mm:	
vertically	48 (6 divisions)
horizontally	80 (10 divisions)
Beam line thickness, mm, not over	0.8
Minimum scanning recurrence rate, Hz	200
Fundamental error of the measurement of the amplitude of pulsed signals in the range from 20 mV to 60 V for lengths of pulses from 50 ns to 10 s is, %, not over, in the image sizes:	
from 4 to 6 divisions	±5
from 2 to 6 divisions	±7
in measuring with the aid of a remote divider	10
Measurement error of time intervals in the range from 40 ns to 10 s, when the measured size of the image is from 4 to 10 divisions, does not exceed, %	5
Calibrated deflection factor of channels 1 and 2 is set in steps from 0.005 to 10 V/division and is regulated smoothly with an overlap of not less than of 2.5 times.	
Amplitude characteristic nonlinearity of the amplifier, %, does not exceed	10
Maximum permissible total constant and variable voltage delivered to the output, V	200
Input parameters of vertical deflection amplifiers of channels 1 and 2 with open input:	
resistance, MOhm	1+2%
capacitance, pF	25±10
Signal of inner source of calibrated voltage:	
square pulses with an amplitude of, V	0.1-1
with frequency, Hz	2
Error in setting the required values of the amplitude and frequency of the calibrator, % does not exceed	±1

Range of calibrated A sweep length is 1 s/div ±0.1 microsecond/div, of B sweep -- 50 ms/div ± 0.1 microsecond/div.	
A and B sweep lengths are regulated smoothly at each range with an overlap factor, not less than..	1:2.5
Nonlinearity of A and B scanning within the limits of the working scanning section, %, does not exceed	10
Range of regulated scanning delay, seconds	$1 \cdot 10^{-6}$-10
Error of delay regulation (changing) within above limits, %, not more than	±2
The instrument is operated from an alternating current network:	
voltage, V	220±22
frequency, Hz	50±5
voltage, V	115 and 220
frequency, Hz	400±7%
with a harmonic content, %	5
Power consumption by the instrument, V·A	150
Dimensions, mm	348X220X490
Weight, kg	19

Periodic checking of the sensitivity of the vertical deflection amplifiers of both channels and checking of the length calibration is done by the amplitude and scanning length calibrator.

9.2. High-Speed and Stroboscopic Oscillographs

The Two-Channel Stroboscopic Oscillograph S7-5 is intended for studying one or two electric processes of nanosecond length through visual observation, photographing, and recording with a two-coordinate recorder.

The instrument satisfies the requirements of GOST 9763-67 and belongs to group II of that standard with respect to the operational conditions.

The instrument is designed on the basis of the stroboscopic method. Essentially, it consists in sequential time measurements of instantaneous values of electrical signals by means of short gate pulses automatically shifting in relation to the repeated signal.

The instrument has the following functional units: gate generator; synchronization and automatic shift device; generator of "fast" sawtooth voltage;

generator of "slow"stepped sawtooth voltage; stroboscopic converter (5 PS-1 or 5 PS-2 -- changeable); amplitude and length calibrators; power supply unit.

The instrument is designed in the form of three individual units: oscillographic, power supply, and delay units; the units are installed on a cart.

The instrument set includes: 1) replaceable units (2 items); 2) storage box with a set of accessories; 3) technical documentation: 4) manufacturer's rating certificate.

Basic Specifications

Range of signals:	
with the 5 PS-1 unit:	
length, microseconds	$1.5 \cdot 10^{-3}$-50
voltage, V	$20 \cdot 10^{-3}$-2
with the 5 PS-2 unit:	
length, microseconds	$0.5 \cdot 10^{-3}$-50
voltage, V	$10 \cdot 10^{-3}$-1.6
Input resistance:	
with the 5 PS-1 unit, kOhm	100±10%
with the 5 PS-2 unit, Ohms	50±3%
Calibrated deflection coefficient with an error of ±5%:	
with the 5 PS-1 unit, mV/cm	20-200
with the 5 PS-2 unit, MV/cm	10-200
Calibrated scanning factor with an error of ±5%, ns/cm	$0.1\text{-}10 \cdot 10^3$
Root-mean-square value of the noise level, mV, not over:	
with the 5 PS-1 unit	2
with the 5 PS-2 unit	1

The Stroboscopic Oscillograph S7-8 is intended for studying the form of one or two synchronous repeating electrical signals through visual observation, photographing and recording with a two-coordinate recorder or memorizing on the screen of the electron-ray tube.

These instruments satisfy the requirements of GOST 9763-67 and belong to group II of that standard with respect to their stability against climatic and mechanical effects.

The instrument is based on the stroboscopic principle of converting the spectrum of the signal being studied. The input of the vertical channel

has a diode mixer which is opened periodically by the gating pulse automtically shifting in time in relation to the signal being studied. Thus, instantaneous values of the signal are read successively at the moments of the diode triggering. Modulated gate pulses are amplified with respect to the amplitude, are expanded with respect to the length and arrive at the pulsed demodulator where the envelope which is an analog of the studied signal is isolated.

The vertical channel has two identical mixers and two demodulators, which makes it possible to study two synchronous signals.

The indicator is a bistable electron-ray storage tube which operates in the oscillographic mode, storage mode, and a storage mode with automatic erasing. The instrument has pulse generators of calibrated amplitude and time marks.

Structurally, the instrument consists of a basic part which includes power supply units, calibrators, tube assembly, and replaceable units in vertical and horizontal channels. The ventilation of the instrument is natural.

The irstrument set includes: 1) high-frequency cables and cords (9 items); 2) dividers with high-resistance inputs (2 items); 3) extension divider; 4) coaxial adapters (11 items); 5) T-joint; 6) attenuators; 7) draw tube, photographic attachment; 8) keys (3 items); 9) diodes (3 items); 10) transistor; 11) safety devices (14 items); 12) technical description and operation manual; 13) manufacturer's rating certificate.

Basic Specifications

Input signal amplitude, V 0.02-1.2

Length of input signals, microseconds ..... $0.2 \cdot 10^3 \div 50$

Parameters of the transient response of the vertical channel (for both channels) are given in Table 9.1.

Calibrated deflection factor of the vertical tract is 10-200 mV/division (the coefficient is increased by the dividers by 4, 10, 20, and 40 times).

Table 9.1

Параметры (1)	Значения параметров (2) для входов	
	низкоомного (3)	высокоомного (4)
Время нарастания, нс (5)	0,3	0,8
Время установления, нс (6)	0,9	2,4
Выброс, % (7)	10	15
Неравномерность установившегося значения, % (8)	5	5

(cont'd on page93)

(Continuation of Table 9.1)

Key: 1. Parameters
2. Parameter values for inputs
3. Low-resistance
4. High-resistance
5. Build-up time, ns
6. Transient time, ns
7. Overshoot, %
8. Nonuniformity of stable-state value, %

Time of Continuous reproduction of the image on the screen after memorization, minutes, not less than	10
Manual or automatic erasing with a minimal frequency, Hz	2
Normalized measurement of the amplitudes of pulses and time intervals, does not exceed, %	5
Supply voltage, V	220±10%
Power supply for a network of 220 V ± 10% with a frequency of 50 Hz.	
Power consumption, V·A	300
Dimensions, mm	490X296X545
Weight, kg	38

The Stroboscopic Oscillograph S7-9 is intended for studying and measuring the parameters of the shape of one or two synchronously connected repeating electrical signals with a length from 0.3 ns to 100 microseconds and an amplitude from 60 mV to 1.6 V through one or two independent channels by visual observation, photographing, recording on a two-coordinate recorder, and for measuring the amplitude and time parameters of signals with a readout in a digital form and recording of the measurement results on a digital typewriter.

The instrument operates on the principle of using stroboscopic conversion of repeating signals. It is designed on the functional-block principle.

The instrument is a set of basic indicator with a set of changeable units and an analog-digital converter. There are three changeable conversion units (with different passbands) and a scanning unit which is installed in the indicator unit, and an ATsP [analog-digital converter] unit which is conneted with a cable.

The instrument set includes: 1) stroboscopic oscillograph set; 2) analog-digital converter; 3) storage box with a set of accessories; 4) description, operation manual; 5) manufacturer's rating certificate.

Basic Specifications

Range of calibrated vertical deflection factors, mV/division	10-200
Range of calibrated scanning speeds, s/div	$0.1 \cdot 10^{-9} \div 10 \cdot 10^{-6}$
Error of amplitude and time measurements $\pm(4+\Delta)\%$, (Δ -- addend depending on the measuring mode).	
Synchronization frequency range, Hz	$50 \div 1000 \cdot 10^{6}$
Passbands, GHz, depending on the addend of the unit used	$0 \div 700 \cdot 10^{-3}$; 0-2; 0-6

The Stroboscopic Oscillograph S7-11 is intended for studying the shape of one or two synchronously repeating electrical signals of the microsecond, nanosecond, and picosecond duration ranges through visual observation, photographing, and recording on a two-coordinate recorder or storage oscillograph (Figure 9.1).

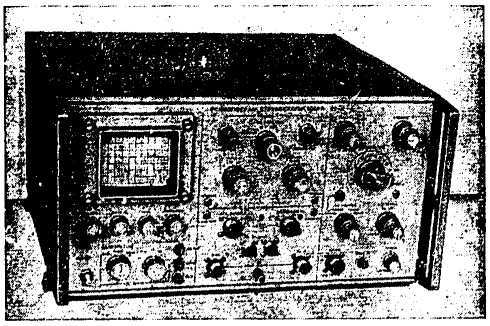

Figure 9.1

The signals which are being studied are sent directly or through external devices to the inputs of channels A and B of the stroboscopic converters.

Simultaneously, triggering signals which are rigidly related in time with the signals being studied and which are ahead of them by the value of the delay "X" of the channel are delivered to the input of the scanning synchronization unit. If necessary, the scanning of the oscillograph is triggered by the signal being studied.

Synchronization is done with part of the energy of the signal being studied which is picked up by a special transformer. In this case, the signal is delivered through a delay line built into the instrument.

Provisions are made in the instrument for measuring pulse amplitudes with a direct-current calibration voltage generator whose amplitude is stabilized.

The Oscillograph S7-11 is a single-unit instrument of the table-rack type.

The instrument set includes: 1) 90 ns delay line; 2) photographic attachment; 3) ring; 4) draw tube; 5) bracket; 6) active probes with connecting devices (2 items); 7) sets of dividers with connecting devices (2 items); 8) attenuators D2-35 (8 items); 9) pulse shapers (2 items); 10) absorber; 11) split socket; 12) T-joints (2 items); 13) 50-75 Ohm adapter; 14) coaxial adapters (11 items); 15) 50-Ohm load; 16) connecting cords (3 items); 17) connecting cables (17 items); 18) electron tubes (2 items); 19) semiconductor diodes (10 items); 20) safety devices (12 items); 21) bulbs (4 items); 22) keys (5 items); 23) screwdrivers (3 items); 24) technical description and operation manual; 25) technical record.

Basic Specifications

The instrument makes it possible to study the shape of one or two synchronously repeating electrical signals with the following paramters:	
amplitude, V	$1 \cdot 10^{-3}$-1
duration, microseconds (at an input resistance of 50 Ohms):	
of a low-resistance matched channel	$0.2 \cdot 10^{-3}$-100
of a high-resistance input	$2 \cdot 10^{-3}$-100
Signal repetition frequency, MHz:	
pulsed	$5 \cdot 10^{-5}$-100
sinusoidal	1500
with the use of an external synchronizer	$5 \cdot 10^{3}$
Vertical Deflection Amplifier:	
Deflection coefficients, mV/div, for the low-resistance matched input (50 Ohms) with a calibration error of 5%	5-200
Internal noise level, mV, not over	3.5
Passband which for a low-resistance matched input (50 Ohms) must be, GHz, not less than	5
Passband when the internal delay line is connected, MHz, must be not less than	700

Passband for a high-resistance input with an active tester, MHz, not less than	700
Horizontal Deflection Scanning Unit:	
17 fixed lengths, microseconds	$0.05 \cdot 10^{-3} \div 10$
Scanning nonlinearity, %, not over	10
Time calibrators (sinusoidal voltage):	
frequency, MHz	100
error, %	3
The instrument is operated from an alternating current network:	
voltage, V	$220 \pm 10\%$
frequency, Hz	$50 \pm 1\%$
with a harmonic content, %	up to 5
Power consumed by the instrument at a nominal voltage, V·A	160
Dimensions, mm	480X240X475
Weight, kg	33

High-Speed Oscillograph S7-15 is intended for studying single rarely repeating and periodic pulsed signals of the picosecond and nanosecond ranges by visual observation and photorecording at a recording speed of not less than 40,000 km/s at a scale of 1:1.

The application areas of the instrument are: nuclear physics, controlled thermonuclear fusion, seniconductor physics, laser techniques, electronic computer engineering, measuring technique, and other areas of science and technology.

The appearance of the oscillograph is shown in Figure 9.2.

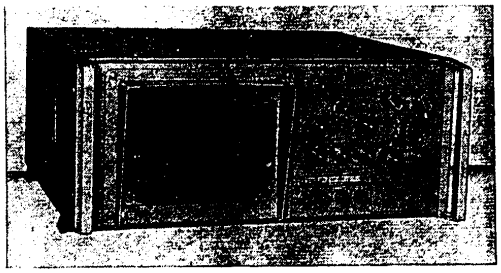

Figure 9.2

The instrument operates on the principle of converting electrical signals with the aid of an electron-ray tube to a visible light image.

Structurally, the instrument consists of the following functional assemblies: ELT; input trigger signal converter; time base with devices for its triggering and blocking; shaper of beam-brightening pulses; calibration of the time channel; raster assembly: horizontal and vertical; sources of low-voltage and high-voltage power supply.

The instrument has provisions for light and remote triggering of scanning, and its transit triggering is possible.

The instrument is designed as a single-block unit. It is based on the front and rear frames connected at the corners by four brackets. The assemblies of the time channel calibrator, the source of high-voltage power supply, the delay line, and the photographic clamping device are designed as a complete unit.

The instrument has a cart with a delay line fastened in it.

Operating conditions:	
environmental temperature, degrees C	10-35
relative air humidity (at a temperature of 20 degrees C)	80

The instrument set includes: 1) high-speed oscillograph S7-15; 2) cart with delay lines; 3) photographic clamping device; 4) carriage; 5) rubber draw tube; 6) optical converter; 7) coaxial condenser; 8) connecting cables (various types) (5 items); 9) connecting cords; 10) elements for high-frequency connectors (adapters, loads, T-joints, plugs -- 13 units); 11) technical description and operation manual; 12) technical record.

Basic Specifications

Vertical Channel	
Passband, GHz	0-5
Input resistance, Ohms	50
KSVN [Voltage Standing Wave Ratio] for bands, not over:	
0.5-1.5 GHz	1.7
1.5-3.0 GHz	2.3
3.0-5.0 GHz	3.0
Deflection coefficient, V/mm, not over	1.2
Triggering and Scanning Channel	

Amplitude of the studied or external pulsed signal, V	1-300
Repetition frequency of triggering signals in the slave sweep mode of scanning triggering from single pulses, kHz	10
Triggering instability, ns, not over	100
Delay in scanning triggering, ns, at a coefficient of 0.1 ns/mm, not more than	40
Scanning range, ns/mm (nine calibrated values)	0.1-50
Frequency error, %, four coefficients:	
1-50 ns/mm	10
0.1-0.5 ns/mm	20
Electron-Ray Indicator	
Working field, mm	15±40
Width of the beam line in the center of the screen, micrometers, not more than	85
Error of the time and amplitude calibrated signals of the calibrator, %, not more than	1
Power supply of the instrument from an alternating current network:	
voltage, V	220
frequency, Hz	50
Power consumption, V·A, not over	300
Dimensions, mm	490X345X814
Weight, kg, not over	60

The instrument is checked by using series-produced checking devices.

9.3. Storage Oscillographs

The storage oscillograph S8-9A is intended for studying the shapes of low-frequency periodic and single signals by storing, subsequent visual observation or photographing of the image from the ELT [electron-ray tube] screen.

The instrument satisfies the requirement of GOST 9763-67 and GOST 9810-69 precision class III, and belongs to Group II of GOST 9763-67 with respect to the operating conditions.

The instrument has the following assemblies: vertical deflection amplifier consisting of a preamplifier, a delay line, and a terminal amplifier; synchronization amplifier; sweep generator; brightening pulse unit; reproducing and erasing control unit; amplitude calibrator; length calibrator; unit of automatic erasing and scanning preparations; low-voltage and high-voltage supply unit; electron-ray indicator.

The instrument set includes: 1) incandescent lamps (6 items); 2) safety devices (4 items); 3) remote dividers (2 items); 4) connecting cable; 5) connection blocks for connecting to the plates (2 items); 6) "crocodile"-type clamps (8 items); 7) terminals (2 items); 8) power supply cord; 9) dustproof cover; 10) photographic attachment; 11) description and operation manual; 12) manufacturer's rating certificate.

Basic Specifications

Maximum speed of recording on the screen, km/s	100
Time of reproduction of the recorded process in the "off"-state, hours, not less than	12
Passband, MHz	2
Nonuniformity of frequency characteristic, dB, not over	3
Maximum sensitivity, mm/mV, not lower than	0.1
Time interval measurement error, %, not over	10
Scanning is triggered by pulses of any polarity:	
with buildup time, microsecond	0.2
length, microsecond, not less than	1
with repetition frequency from single impulsing, kHz	10
with amplitude, V	1-50

Double-Trace Storage Oscillograph S8-11 is intended for simultaneous study of two synchronous single or periodic signals in a frequency band from a direcc current of up to 1 MHz.

Provisions are made for a special mode of intensifying the brightness of the image during the oscillographing of pulse signals of short duration with a low repetition frequency.

The instrumnets work at a temperature from 5 to 40 degrees C and a relative air humidity of up to 95% at a temperature of 30 degrees C.

The oscillograph is designed in the form of a basic unit and individual functional units plugged into the instrument. The basic unit is a frame

structure consisting of two cast frames and bracing brackets. The vertical deflection amplifiers have opened and closed inputs.

The function units which have control elements, a display unit, differential amplifiers, and a calibrator, are removable, are inserted and fastened in the front frame.

The printed plate of the terminal amplifiers and the scanning amplifiers are located in the rear part of the instrument, below and on top respectively.

Units are connected by means of plug and socket units.

The instruments set includes: 1) storage box; 2) remote dividers (2 items); 3) distributors (2 items): 4) cables (5 items); 5) high-frequency cables (3 items); 6) power supply cord; 7) filters (8 items); 8) draw tube; 9) cover; 10) electron tubes (4 items); selected in pairs; 11) clamps (6 items); 12) jumpers; 13) casings (8 items); 14) safety devices (9 items); 15) incandescent lamps (4 items); 16) neon lamps (2 items); 17) photographic attachment; 18) ring; 19) technical description and operation manual; 20) manufacturer's rating certificate; 21) technical description and operation manual for the photographic attachments; 22) manufacturer's rating certificate for the photographic attachment.

Basic Specifications

Minimum scanning frequency which ensures the observation of the maximally fast signal being studied, Hz	10
Recording speed in the storage mode (line thickness is not over 1 mm and the reproduction time is not less than 30 minutes), km/s, not less than	5
Maximum permissible sum of the amplitudes of the direct and alternating voltages at a closed input, V	400
Passband of the vertical deflection channels at an open input from direct current, MHz	1
Nonuniformity of the amplitude-frequency characteristic, dB, in the range from 50 Hz to 300 kHz, not more than	1
Buildup time of the transient characteristic of the vertical deflection channels, ns, not more than	420

Nonuniformity of the peak of the transient characteristic in relation to the steady value, %, not more than	2
Sensitivity of the vertical deflection channels, mm/mV, not less than	1
Error in the setting of calibrated values of deflection coefficients, not more than $\pm(3+12/n)$% (n--dimensions of the image in the working section of the screen in the divisions of the scale).	
Measurement error of the input signal amplitudes, %, not more than	$\pm$10
Scanning nonlinearity in the working section, %, not more than	10
Measurement error of time intervals, %, for time intervals in the range from 2 microseconds to 250 seconds when the dimensions of the image of the time interval are from 4 to 10 divisions of the scale in the horizontal direction, not over	10
Minimal duration of the time interval being studied, microseconds	2
External triggering and stable scanning are ensured by:	
pulsed signals of both polarizations	
with a length of, microseconds	from 0.2
with an amplitude of, V	1-50
sinusoidal signals	
with a frequency of, Hz	$1\text{-}10^6$
with an amplitude of, V	1-25
With internal synchronization, the minimal size of the image of the studied signal, mm	3
The instrument is operated from an alternating current network	
with a voltage of, V	220 ± 1 %
with a harmonic content of, %	up to 5
Power consumed by the instrument, V·A	700
Weight, kg	50

The instruments are checked by means of standard reference instruments used in checking general-purpose oscillographs. The checking mechods are given in the technical description included in the set and in GOST 9810-69.

9.4. Special Oscillographs

Combination Display Device KIU-1 is intended for joint operation with a differential characteristic meter (IDKh), a frequency-response characteristic meter (IChKh), a frequency deviation meter, and a sound subcarrier channel meter (ITPZ). The instrument provides an oscillographic display of the measured characteristics making it possible to study two characteristics simultaneously, and is a two-channel low-frequency display device with the image size 100X160 mm. The switching device in the KIU-1 unit makes it possible to connect effectively four different instruments to it. The linear amplifier of vertical deflection has two channels switched by an electronic switch and makes it possible to observe two characteristics simultaneously. The scanning is done both by an external signal, and by a signal from the internal sweep generator. The electron-ray tube has a large rectangular screen. Provisions are made in the instrument for the brightness modulation of the beam. Signals from the measuring instruments operating jointly with KIU-1 arrive at the group of inputs (ABCD) which are switched to the KIU-1 circuit by means of a switching unit. This makes it possible to work effectively with four instruments.

The instrument set includes: 1) combination display device KIU-1; 2) set of spare parts; 3) set of tools and accessories; 4) set of operation documents; 5) storage box; 6) manufacturer's rating certificate.

Basic Specifications

Nonuniformity of the frequency characteristic of the vertical deflection channel (KVO) in the band 0-4 kHz must not be, db, over	1
Maximum KVO sensitivity, mm/mV, not less than	2
Scaling factor error of the input divider, %, not over	5
Nonlinearity of the amplitude characteristic of KVO, %, not over	± 5
KVO input resistance, kOhm, not less than	30
Input capacitance, pF	250
Voltage ensured by the KVO sensitivity calibrator, V	0.05; 0.5; 5

Error, %, not over	±10
Horizonal scanning of the beam is effected: by an external sinusoidal signal (from the instruments IDKh, IChKh, IDCh, ITPZ),	
with a frequency of, Hz	50
with an amplitude of, V	1
by a signal from the internal generator	
Frequency characteristic nonuniformity of the horizontal deflection channel (KGO) in the frequency band from 0 to 500 Hz, not over, dB	3
Image size, mm	100X160
Brightness modulation is effected by pulses of positive polarity:	
with a length of, ms	0.2-30
with an amplitude of, V, not less than	5

KIU-1 is checked by means of standard measuring instruments.

Nonuniformity of the frequency characteristic is checked by means of the generator G3-35, voltmeter V3-40, direct current source V5-11, and voltmeter V2-19. A signal from the generator and the direct current source is delivered to the input and its value is monitored by the voltmeter. The nonuniformity of the KVO frequency characteristic is determined by the size of the image on the screen depending on the frequency of the delivered signal in relation to a signal of 100 Hz.

Sensitivity of the KVO is determined by the preceding method with the aid of G3-35 and voltmeter V3-40. A signal with a frequency of 400 Hz, whose value corresponds to 100 mm of the image, is sent to the input.

The error of the input amplifier is checked by the method described above at three positions of the switch "divider". Nonlinearity of the amplitude characteristic of the KGO is checked with the aid of the direct current source B5-11. By changing the signal from B5-11 from 100 mV to 0 through 10 mV, the changes in the beam deflection on the ELT are registered. The input parameters are measured with the aid of the bridge Ye2-4.

Climatic and mechanical tests and tests for electric strength are done in accordance with GOST 9763-69.

The Semiconductor Television Oscillograph S1-57 is intended for visual observation of pulsed and periodic electrical signals, measurements of the amplitudes and lengths of signals, and detailed studies of television signals with a display of the section of the raster being examined.

The signal being studied is delivered to "Input I" or to "Input II" of the vertical deflection amplifier located, respectively, on the front and back panels of the instrument. There is a switch for switching the inputs. Amplified voltage from the amplifier of the vertical deflection of the beam is delivered to the vertically deflecting plates of the ELT.

The vertical deflection amplifier can be adjusted by the degree of sensitivity and the vertical position of the beam. The studied signal is taken in the section from the preamplifier to the delay line for triggering the line discrimination unit (BVS) and the scanning unit. The gating pulse which may be in phase with any line or its part within the limits of the entire frame of the television raster is isolated by the BVS.

The unit is triggered either by a complete video signal or by the pulses of the frequency of the lines and the frequency of the fields which are delivered from the outside to the input emitter followers and further to the BVS.

The scanning unit produces sawtooth voltage whose duration can be controlled both in steps and smoothly within wide limits, which makes it possible to examine video signals from a part of the line to a whole frame on the screen of the oscillograph.

The sweep generator can operate both in the periodic mode and in the slave sweep mode. Scanning can be synchronized by: a gating pulse produced by the BVS; any periodic signal being studied; an external synchronizing signal.

In addition to sawtooth voltage, the sweep generator produces brightening pulses for the ELT and the video control unit (VKU). The duration of the pulses is equal to the sweep interval. Sawtooth voltage goes from the output of the sweep circuit to the horizontal deflection amplifier and then to the modulator of the ELT for brightening the working scanning motion.

When a sweep multiplier is used, the length of calibrated sweeps decreases to one fifth. The expansion is done to the left and to the right from the center of the ELT screen.

The sensitivity of the vertical amplifier and sweep lengths are calibrated, which makes it possible to measure the amplitude and time intervals quickly and accurately.

The BVS unit ensures stable phase coincidence of the sweep with any line or its part within the limits of a complete frame or simultaneously in the even and odd field, as well as the triggering of scanning with frequency fixation of the lines of the fields.

The scanning delay in the BVS can be regulated by not less than 70 microseconds by turning the "delay" handle from one stop to the other.

Provisions are made in the oscillograph for obtaining brightness time marks when an external signal is delivered to the jack "Input Z".

Channel "Z" makes it possible to observe bright marks when sinusoidal voltage in the frequency band from 100 Hz to 5 MHz, as well as pulsed signals of both polarities with a duration from 0.2 to 5 microseconds and an amplitude from 1 to 5 V, are delivered to its input.

The oscillograph is designed in two variants: bench type and bay type. The bay-type oscillograph, unlike the bench type, has special side brackets and does not have the legs and handles on the side which serve for carrying the instrument.

The instrument set includes: 1) 1:10 divider; 2) light filter; 3) connecting cord; 4) conducting wire; 5) cables (2 items); 6) network cord; 7) "crocodile" clamp; 8) draw tube; 9) T-joint; 10) safety device (4 items); 11) incandescent lamps (3 items); 12) storage box; 13) frame; 14) technical description and operation manual; 15) manufacturer's rating certificate.

Basic Specifications

Size of the working part of the oscillograph screen, mm/div:	
vertically	48/6
horizontally	80/10
Thickness of the beam line, mm, does not exceed	0.8
Parameters of rectangular pulses of the inner source of calibration voltage:	
on-off time ratio	2±20%
frequency, kHz	1±2%
amplitude, V	0.2±2%; 1±2%

Nominal values of the calibration deviation factor (sensitivity): 0.01 V/div (800 mm/V); 0.02 V/div (400 mm/V); 0.05 V/div (160 mm/V); 0.1 V/div (80 mm/V); 2 V/div (4 mm/V); 5 V/div (2 mm/V).

Deviation factor is regulated smoothly with overlap coefficients, not less than	1; 2; 5
Nonlinearity of the amplitude characteristic of the vertical deflection amplifier, %, does not exceed	5

The error in the measurement of signal amplitude is 5% with the lengths of pulses from 0.08 microsecond to 0.2 second and frequency of sinusoidal signals from 0 to 3 MHz in the range of input voltages from 0.03 to 30 V of the amplitude and an image size from 3 (24 mm) to 6 (43 mm) large divisions. The passband of the vertical deflection amplifier is 0-15 MHz with a nonuniformity of not over 3 dB when signal delivered to the open "Input I" (at

that time the nonuniformity of the frequency characteristic in the range from 100 kHz to 7.5 MHz does not exceed 5% in relation to the level on a frequency of 1 MHz and 10% at frequencies of up to 10 MHz). The passband of the vertical deflection amplifier is 0-7.5 MHz when the signal is delivered to the open "Input II" from 0 to 7.5 MHz with a nonuniformity of 5%.

Duration of calibration scans: 20; 10; 5; 2; 1; 0.5; 0.2; 0.1 ms/div. 50: 20; 10; 5; 2; 1; 0.5; 0.2; 0.1 microseconds/div.

Scanning length on each subband is regulated smoothly with overlapping coefficients of not less than 1; 2; 5.

Measurement error of time intervals: 5% (without exapnsion), in the range from 0.4 microsecond to 0.2 second with the image size in the horizontal direction from 4 to 10 large divisions.

Measurement error is 5% in expanded ranges of scanning from 0.08 microsecond to 32 ms when the image size in the horizontal direction is from 4 to 8 large divisions and the beginning and the end of the time interval being measured is symmetric in relation to the center of the screen.

Horizontal deflection amplifier

Passband, MHz	0-3
Nonuniformity of the frequency characteristic, 3 dB	
Deflection factor, V/div:	
without expansion, not more than	1
with expansion, not more than	0.2
Power consumption, V·A	110
Dimensions, mm:	
bench model	480X160X475
bay model	520X160X510
Weight, kg	25

The Oscillograph S9-1 is intended for: visual observation of pulse-type and periodic signals; measuring the amplitudes and lengths of studied signals; detailed studies of television signals with a display of the raster section being examined; measuring differential amplification, differential phase, and characteristics of the color subcarrier.

The oscillograph S9-1 has a standardized casing and consists of the following main devices: input attenuator; vertical deflection amplifier; rf filter circuit; circuit for clamping the video signal by the level of synchropulses; input emitter followers; synchronizer; sweep generator; amplifier

"X"; amplifier "Y"; electron-ray tube; amplitude and length calibrator; power supply unit; matching filter.

For the triggering and synchronization of scanning, it is possible to use the studied signal from the amplifier of vertical deflection of the beam with internal synchronization.

The instrument set includes: 1) divider; 2) clamp; 3) cables (4 items); 4) casings; 5) conducting wire; 6) light filter; 7) T-joint; 8) draw tube; 9) network cord; 10) incandescent lamps (5 items); 11) protective devices (4 items); 12) storage case; 13) technical description and operation manual; 14) technical record.

Basic Specifications

Passband of the amplifier of vertical deflection from direct current, MHz	up to 20
Nonuniformity of the band when the signal is delivered to the open input, dB, not over	3
Frequency characteristic nonuniformity, %, does not exceed:	
in relation to the level on a frequency of 1 MHz	3
in the frequency range	10
Passband of the horizontal deflection amplifier, MHz, with frequency characteristic nonuniformity of 3 dB	3
Build-up time of the transient response of the vertical deflection channel, ns, does not exceed	18
Nonlinearity of the amplitude characteristic of the vertical beam deflection channel, %, does not exceed	5
Measurement of pulse signals:	
amplitude range, V	$30 \cdot 10^3 \div 40$
pulse length, ns	80
Fundamental measurement error, %, with the image dimensions on the screen:	
3-6 cm	± 5
6-8 cm	± 3
Power consumed by the instrument from the network at a nominal voltage, V·A	110

The Special Oscillograph S9-2 is intended for visual observation of pulsed and periodic electrical signals, measurement of amplitudes and lengths of the signals being studied, detailed studies on television signals on the VKU of the raster section being examined.

The main area of application is in studying and measuring the parameters of video signals in the instrument rooms of television centers, in laboratories, and workshops.

The oscillograph is based on the classical schematic and consists of a vertical beam deflection amplifier, a sweep generator, a horizontal beam deflection amplifier, a synchronization unit, a line discrimination unit, an electron-ray tube, and power supply unit. The signal being studied arrives at the input of the vertical deflection amplifier, is amplified to the necessary value, and is delivered to the vertically deflecting plates of the ELT.

Part of the signal arrives at the synchronization unit which forms pulses for triggering a sawtooth voltage. The latter effects the scanning of the signal along the time axis. The line discrimination device delays the triggering of the scanning until the moment when a pulse synchronous with a definite number of the television line is formed. The selection of the line is accomplished with the aid of a special delay circuit. The number of the selected line is displayed with the aid of a display board on the "Nixie"-type tubes. The oscillogram of the selected line is reproduced on the ELT screen on which the measurements of the amplitude and time parameters are made.

The instrument has a standardized casing. The presence of conversion frames in the set makes it possible to use this instrument not only as a bench model but also as a bay model.

The television line selection unit ensures a stable phasing of scanning with any line number within the limits of a complete frame. The filters built into the vertical beam deflection channel make it possible to isolate the following from a complete color video signal: brightness signals; color signals; high-frequency component of 4.43 MHz; high-frequency component of 1.2 MHz.

The instrument set includes: 1) oscillograph S9-2; 2) technical description and operation manual; 3) technical record; 4) 1:10 divider; 5) clamp; 6) cables (3 items); 7) frame; 8) conducting wire; 9) light filter; 10) 75 Ohm load; 11) draw tube; 12) network cord; 13) set of spare parts; 14) storage box; 15) manufacturer's rating certificate.

Basic Specifications

Working part of the screen, mm	80X100
Beam line thickness, mm	0.8
Passband of the vertical beam deflection amplifier, MHz	0-20
Frequency characteristic nonuniformity, %, in relation to a level of 1 MHz in the ranges:	

from 0.1 to 7.5 MHz, not over	±3
from 7.5 to 10 MHz, not over	±5
Build-up time of the transient response, ns, does not exceed	18
Overshoot on the pulse image, %, does not exceed	3
Nonuniformity of the pulse image time, %, does not exceed	15
Stabilization time of the transient response, ns, not over	50
Input resistance on jacks:	
"Input I"	75 Ohms
"Input II"	1 MOhm (35 pF)
Range of calibrated deflection coefficients, V/cm	0.01-5
Fundamental error of the deflection coefficient, %, for image dimensions:	
3-6 cm	4
6-8 cm	2
Range of calibrated sweep factors, microsecond/cm	$0.1\text{-}50\cdot10^3$
Fundamental error of calibrated sweep factors, %	±4
Error of the source of calibrated voltage, %, both with respect to frequency and the amplitude	±1
Synchronization range	$20\pm25\cdot10^3$
Power supply voltage from an alternating current network:	
voltage, V	220±22
with frequency, Hz	(50-60)±0.5
Power consumed by the instrument, V·A	130
Dimensions, mm	160X360X430
Weight of the instrument, kg	18

The special oscillograph S9-2 is checked according to the method given in the section "Checking Instructions" of the technical description. The oscillograph has to be checked at least once a year.

The following items are checked: 1) its outward appearance; 2) insulation resistance; 3) amplitude and frequency error of the calibrator; 4) fundamental errors of the deflection and scanning coefficients; 5) passband; 6) built-up time of the transient response; 7) overshoot on the conversion frame; 8) steep slope of the pulse vertex; 9) lock for the sweep; 10) proper operation of the BVS unit.

The following instruments are used for checking: pulse generators G5-40, G5-6A; signal generators G4-93, G3-56, G4-68; frequency meter Ch3-30; V1-4 unit; alternating current voltmeters V3-24, V3-25; oscillograph S1-67 GOST 9810-69; inductance and capacitance meter Ye7-5A; volt-kilohmmeter V7-16; generator G6-8; multipurpose disruptive discharge unit UPU-1P.

9.5. Amplitude Modulation Factor Meters

Amplitude Modulation Factor Meter S2-10. The S2-10 instrument (modulation meter) is intended for measuring the depth of amplitude modulation (AM) of weak signals and for checking internal modulation meters of generators of standard signals and generators of signals in the laboratory and workshop conditions.

The instrument satisfies the requirements of GOST 9763-67 and GOST 10086-68 for modulation meters of Class 3.0.

The instrument measures the amplitude modulation factor on the principle of two voltmeters one of which ("carrier adjustment") is replaced with a highly effective system of automatic stabilization of the average level of the carrier, and the scale of the other is calibrated directly in the percentages of modulation depth. Thus, the principle of amplitude modulation measurement is based on a direct determination of the ratio of the amplitude of the positive and negative half-period of the modulating signal to the average level of the carrier whose constant value is stabilized by the system of automatic level stabilization (ASU).

A high-frequency AM [amplitude modulated] signal arrives at the conversion unit (BS-1, BS-2, or BS-3) from which the intermediate frequency voltage released by the concentrated selection filter arrives at the wide-band amplifier intended for amplifying the AM voltage in the frequency range from 15 kHz to 20 MHz to a value necessary for linear detection in the semiconductor carrier detector.

The wide-band amplifier together with the carrier detector are in the ring of the ASU whose operating principle is based on comparing the reference voltage with the voltage proportional to the mean value of the carrier obtained at the output of the carrier detector. The voltage difference is amplified by the direct current amplifier and is delivered to the screen grids of the first three stages in the form of an amplifier for adjusting the amplification.

After detection, the envelope of the high-frequency signal is sent through the cathode follower and peak voltmeter measuring its average value by the galvanometer whose scale is calibrated in the values of modulation depth.

For covering the range of 800 kHz-1500 MHz at the selective input, the instrument has three removable units each of which contains a mixer with a concentrated selection filter, a heterodyne, and an objective adjustment circuit with an electron-optical indicator for widening the dynamic range.

The entire instrument is designed on the basis of a block system. The instrument does not have a common casing. Structurally, the front panel is not the load-carrying element.

The S2-10 instrument is delivered in the following variants with replaceable units:

1	2	3	4	5	6
BS-1	BS-2	BS-3	BS-1, BS-2, BS-3	BS-1, BS-2	BS-2, BS-3

Basic Specifications

Operating range of the carrier frequencies of the signals being measured, MHz	0.015-1500
Operating range is covered by:	
aperiodic input of the instrument, kHz	$25 \div 20 \cdot 10^3$
replaceable unit BS-1	$800 \div 25 \cdot 10^3$
replaceable unit BS-2	$20 \div 340 \cdot 10^3$
replaceable unit BS-3	$325 \div 1500 \cdot 10^3$
Calibration error of frequency scale, %, not over	3
Range of modulating frequencies, Hz, of measured signals when working on the selective input with the units:	
BS-1	$30\text{-}15 \cdot 10^3$
BS-2	$30 \div 300 \cdot 10^3$
BS-3	$30 \div 500 \cdot 10^3$
Range of modulating frequencies, Hz, when working at:	
aperiodic input	$30 \pm 0.02\ f_{carrier}$
section of a carrier frequency range	$15 \cdot 10^3 \div 100 \cdot 10^3$
remaining range	$30 \div 3 \cdot 10^3$
Range of modulating frequencies, Hz, in which separate measurement is ensured of the depth modulation coefficient M, %, for half-periods of various polarities:	
at aperiodic input, Hz	$30 \div 10^3$
with BS-1 unit	$30 \div 4 \cdot 10^3$

with BS-2 unit	$30 \div 100 \cdot 10^3$
with BS-3 unit	$30 \div 150 \cdot 10^3$
Amplitude modulation measurement limit, %	5-100
Fundamental measurement error, %, on modulation frequencies of 400 and 1000 Hz in measuring the depth of modulation from 5 to 95%:	
on " $\triangle$ M %" scales, not more than	$\pm 1.5 \cdot 10^{-2}$
on the "0-100%" scanning scale	5
The parasitic frequency deviation of the signal being measured, kHz, at which the fundamental measurement error of the instrument is guaranteed does not exceed (at a 30-% depth of amplitude modulation) in the frequency ranges:	
800 kHz - 35 MHz, does not exceed	$2 \cdot 10^{-5}+250$
20 kHz - 340 MHz, does not exceed	$2 \cdot 10^{-5}+2$
340 kHz - 1200 MHz, does not exceed	$2 \cdot 10^{-5}+8$
Instrument sensitivity, Mv, at the selective input in the frequency ranges:	
200 kHz - 1000 MHz	50
800 kHz - 200 MHz	30
1000 kHz -1500 MHz	70
At aperiodic input	10
Additional errors at modulation frequencies from 30 Hz to 500 kHz is eliminated with the aid of a correction chart separately for each input. Error in the determination of corrections, %	$6 \cdot 10^{-2}$
The dynamic range of the input signal necessary for the normal operation of the instrument at the periodic and selective inputs against the sensitivity value indicated in the rating certificate is, dB	$10\% \pm 3$
The coefficient of nonlinear distortions introduced by the instrument to the envelope of the AM signal, %, at the modulating frequency of 1000 Hz at the modulation depth from 30 to 70%, not over	3
Power supply of the instrument from alternating current networks:	
voltage, V	$220 \pm 10\%$
frequency, Hz	50
voltage, V	$115 \pm 3\%$
frequency, Hz	$400 \pm 3\%$

Power used from the network, V•A	400
Dimensions, mm	240X600X360
Weight, kg	46

Provisions are made in the instrument for the output of the voltage of the envelope to the oscillograph or a nonlinear distortion factor meter.

The amplitude modulation factor meter is checked in accordance with the requirements of GOST 13024-67.

The Meter of Quality Indexes of AM Broadcasting Transmitters SK2-13 is intended for measuring the basic quality indexes of broadcasting transmitters: amplitude modulation depth; frequency characteristic; noise and background components; coefficient of the harmonics and the level of low-frequency signals.

The meter consists of the following instruments and units: amplitude modulation factor meter with whose aid it is possible to register the frequency characteristic and indicate the overmodulation of radio transmitting devices; nonlinear distortion meter intended for measuring the harmonic coefficient, the background and noise components, as well as of effective values of alternating voltage; low-frequency generator intended for ensuring the modulation of transmitters by a low-frequency signal; oscillograph intended for observing the shape of low-frequency signals and amplitude-modulated oscillations; switching unit intended for achieving the necessary interconnection among the instrument set, as well as with one of the ten transmitters; matching device intended for matching high-frequency cables connecting the transmitting devices with the SK2-13 equipment.

All main units of the set are designed structurally and electrically as independent instruments. Each instrument has a built-in power supply unit and can be turned on or off independently from one another.

The instrument set can be used for measuring ten transmitters.

The circuits of control switching buttons provide for all the necessary interconnections of the instruments of the set.

The instrument set includes: 1) amplitude modulation factor meter; 2) low-frequency generator; 3) nonlinear distortion meter; 4) oscillograph; 5) switching unit; 6) spare part unit; 7) network filter; 8) cabinet; 9) matching device; 10) high-frequency cables (5 items); 11) connecting wire bundle; 12) cord; 13) various cables (7 items); 14) description, operation manual, and manufacturer's rating certificate.

Basic Specifications

Carrier frequency range, MHz	0.15-30
Minimum high-frequency input signal, V	10
Permissible absolute error in measuring the amplitude modulation, %	± 3
Modulating frequency range in measuring the frequency characteristic, Hz	$50 \div 10 \cdot 10^3$
Permissible measurement error of the frequency characteristic, %	4.8
Measurement limits of the background and noise components, dB	-70
Permissible measurement error of these components, %	± 4

The instrument set ensures the modulation of transmitting devices by a low-frequency signal at fixed frequencies: 30; 50; 60; 100; 120; 200; 400; 800; 1000; 2000; 4000; 5000; 6000; 7000; 8000; 8500; 10,000; 12,000; 15,000; 20,000 Hz. The instrument gets its power supply from an alternating current network:

voltage, V	220±10%
with a frequency, Hz, of	50-60
with a harmonic content, %, of	5

Power consumed by the instrument set from the network, V·A	260
Dimensions, mm	630X1880X750
Weight, kg	270

The instruments in the bay set are checked as independent units with the following normative documents: GOST 13024-67; GOST 13473-68; GOST 8118-74; instructions 200-64 "Checking Nonlinear Distortion Meters", GOST 12691-67, and instructions on methods No 246 "On Checking General-Purpose Oscillographs".

The checking methods are also explained in the technical descriptions of the devices included in the set.

9.6. Frequency Deviation and Heterodyne Meters

The Instrument K4-13/1 is intended for use in conjunction with frequency deviation meters having an external heterodyne input, as well as an independent source of signals with a small parasitic frequency deviation.

The heterodyne has two circuits with a grounded grid using a TM-1 triode. The feedback is the structural capacitance (pin) -- S13.

The anode-grid circuit is a three quarter-wave section of the coaxial line. The retuning of the anode-grid circuit is done with a noncontact plunger of the choke-cup type with a fixed structural capacitor placed at the input of the plunger. The fixed capacitance is formed by a section of a low-resistance coaxial line and serves for reducing the length of the anode-grid circuit.

The cathode-grid circuit is a quarter-wave section of the coaxial line. The retuning of the cathode-grid circuit is done with a contact plunger. The retuning of the heterodyne with the "tuning" handle simultaneously retunes the anode-grid and cathode-grid circuits, corrects the mode of the oscillator tube by variable resistor and corrects mechanically the level of the output power by the changes in the coupling of the pickup with the circuit. The "Fine Tuning" handle serves for changing smoothly the frequency of the heterodyne.

The power supply unit is a separate unit built into the instrument. Structurally, the heterodyne consists of the following parts: bicoaxial circuit, driving gear, scale mechanism, built-in power unit, and a case.

The instrument set includes: 1) heterodyne K4-13/1; 2) connecting cable; 3) connecting cord; 4) safety devices PM-0.5 (5 items); 5) description, operation manual, and manufacturer's rating certificate.

Basic Specifications

Frequency range, MHz	650-1000
Error in frequency reading, % of scale indication, not over	0.5
Parasitic frequency deviation, Hz, not over	5
Frequency band, Hz	$30 \div 15 \cdot 10^3$
Frequency trim within the limits of, kHz, not less than	50
Output signal power, mW, at a load of 50 Ohms, not less than	1
Output power nonuniformity, dB, not over	9
Heterodyne frequency instability 10 min after one hour of heating, not over	$3 \cdot 10^{-5}$

Power consumed from the network, V·A, not more than	28
Average time of faultless operation, hours	1000
Dimensions, mm	540X251X493
Instrument weight, kg, not over	27

The frequency range is checked by means of the frequency meter Sh2-8, matching transformer E1-19G, and a high-frequency connecting cable.

The power level of the output signal is checked by means of the thermistor power meter M3-1A, a high-frequency connecting cable and the matching transformer E1-19G.

The level of parasitic frequency deviation of the output signal of the heterodyne is checked by means of the frequency deviation meter S3-21A with an external heterodyne at a frequency of 1000 MHz.

The Spectrum and Frequency Characteristic Analyzer SK4-26 is intended for measuring the spectra of periodic processes, relative measurements of stationary noise, and for studying amplitude-frequency characteristics in the audio frequency range.

In the spectrum analysis mode, the instrument operates by the method of sequential analysis. The circuit is designed as a heterodyne-type circuit. The elements of the section are quartz filters ensuring a high resolving power of the analysis channel. For studying frequency characteristics, the instrument has an internal beat-frequency oscillator consisting of a sweep-frequency heterodyne and a quartz heterodyne. Results of measurements are displayed on the electron-ray tube with a long afterglow.

Frequency sweeping of the heterodyne is brought about by the changes in the capacitance of a straight-line frequency or logarithmic precision variable capacitor by means of a built-in electric motor which ensures a high degree of even rotation.

Scanning along the frequency axis is done by a precision linear potentiometer which is mechanically connected with a capacitor of variable capacitance. This makes it possible to ensure a high degree of accuracy in measuring frequency intervals by reading directly from the frequency scale on the screen of the tube.

Measurements of the ratio of the components of the spectrum under study are done with the aid of the built-in calibrator.

The instrument has three modes of operation: automatic continuous frequency sweep in the scanning zone, single automatic passage of the scanning zone and manual frequency adjustment within the limits of the scanning zone.

The analyzer set includes: 1) divider; 2) electric motor; 3) manufacturer's rating certificate of the electric motor; 4) 10 kOhm potentiometer; 5) draw tube for "Zenit" photographic camera; 6) safety devices (2 items); 7) incandescent lamps (6 items); 8) connecting cable with an adapter; 9) housing with a replaceable coordinate scale; 10) assorted diodes (4 items); 11) assorted stabilitrons (4 items); 12) storage box; 13) technical record.

Basic Specifications

Frequency range, Hz	$20 \div 20 \cdot 10^3$

Margin of range coverage is not less than $\pm(0.02\ f+12\ Hz)$ (f -- frequency indicated on the limb of the scale "Frequency, kHz".)

Error in the linear frequency graduation of the instrument's scale, not more than $\pm(0.01\ f + 6\ Hz)$.

Error in frequency determination in a logarithmic scale by the limb "Frequency, kHz" with the aid of the conversion table, is not more than $\pm(0.02\ f + 6\ Hz)$.

Calibration error of the logarithmic frequency scale of the ELT is not more than $\pm(0.15\ f + 6\ Hz)$ (f -- frequency indicated by the coordinate scale of the ELT).

The instrument has the following scanning zones, Hz, in the frequency scale:

in linear	200, 1000, 4000, 20,000
in logarithmic	0-20,000

Absolute error in determining frequency intervals between spectral components by the ELT screen in the linear frequency scale with passbands (f -- scanning zone):

5 Hz	$\pm(0.02\ f + 6\ Hz)$
30 Hz	$\pm(0.02\ f + 10\ Hz)$
130 Hz	$\pm(0.02\ f + 50\ Hz)$

Voltage at the heterodyne frequency at the socket "Heterodyne", mV, on a load consisting of a resistance of 50 kOhms and parallel capacitance of 25 pF 500

Error in the reading of ratios of amplitudes, %, by the coordinate scale along the Y axis:

in linear scale, does not exceed	5
in logarithmic scale, dB:	
up to 40 dB, not more than	3
up to 60 dB, not more than	6

Instrument's output parameters:	
resistance, kOhms	50 ± 5
with external divider, MOhms	4 ± 0.4
capacitance, pF	150 ± 30
Maximum low-frequency voltage on the "Output" socket, V, on a load of 600 Ohms	10
Adjustment error of low-frequency output voltage,%, in the ranges:	
10-0.1 V, does not exceed	4
0.1-1 mV, does not exceed	6
Power supply from alternating current network:	
voltage, V	$120\pm10\%$
frequency, Hz	$50\pm1\%$
with harmonic content, %	5
voltage, V	$220\pm5\%$
with frequency, Hz	$400^{+7}_{-3}\%$
with harmonic content, %	5
Power consumed by the instrument, V·A	150
Dimensions, mm	480X485X468
Weight, kg	50

The Frequency Deviation Meter IDCh (Figure 9.3) is intended for measuring the transconductance of the modulators in radio relay and satellite communication systems with frequency modulation which have an intermediate frequency of 70 MHz, as well as for monitoring the deviation in these systems. The instrument can be used for measuring the frequency of nonmodulated signals within the range of 55-85 MHz.

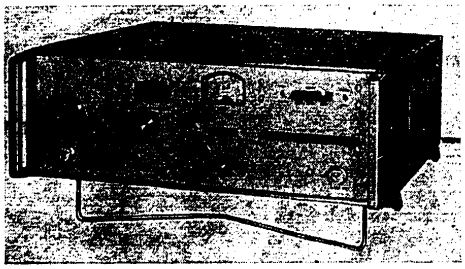

Figure 9.3

The operating principle of the instrument is based on the frequency detection method in combination with the comparison method. With this method, the signal being measured and the signal from the calibrated wide-band generator come alternately (with the aid of an electronic switch) to the ChD [frequency discriminator], as a result of which a curve corresponding to the frequency modulation law being sought and a horizontal line corresponding to the frequency of the calibrated generator appear on the screen of the oscillograph connected to the output of the ChD.

Setting the horizontal line at the required level in relation to the curve observed on the screen, the frequency corresponding to this level is read on the scale of the generator. Bringing the line into coincidence with the maximum curve, the total amplitude of the deviation of the measured signal is determined.

The instruments are designed to be set up one on top of the other sufficiently steadily which is ensured by the appropriate arrangement of the legs of a special shape.

The instrument set includes: 1) frequency deviation meter; 2) set of operational documentation; 3) set of spare parts and accessories; 4) tubes, NSM-10-55-2 (2 items); 5) safety devices VP-1-05a (2 items); 6) socket RP; 7) 75-Ohm load; 8) cable connectors (6 items); 9) network cord; 10) storage box (for ZIP [kit of spare parts, tools, and accessories]); 11) storage box; 12) packing materials.

Basic Specifications

Limit of measured deviation, MHz	0.2-15
Modulation frequency range (but not over 10 MHz) from 50 Hz to 40/A MHz (A -- deviation being measured, MHz).	
Fundamental error of deviation measurements, %, on a modulation frequency of 1 kHz with the limits of the deviations being measured:	
0.2-1 MHz	$\pm(1+4/A)$
1-10 MHz	$2[\pm(2.5+2.5/A)]$
10-15 MHz	$3[\pm(25-220/A)]$
Additional frequency error of frequency deviation measurement, %, at modulation frequencies of:	
up to 1.5 MHz	5
up to 5 MHz	7
up to 10 MHz and less than 1 kHz	10
Error in tuning the instrument to the frequency of the carrier of 70 MHz	± 20

Limit of the input levels of the signal being measured V	0.1-1
Working temperature interval, degrees C	5-40
Average time of faultless operation, hours	1000
Weight, kg	20

The instrument is checked in accordance with GOST 14016-68 and the chapter of the technical description "Checking Instructions".

9.7. Spectrum Analyzers

The Spectrum Analyzers S4-27, S4-28 are intended for studying the spectra of repeating radio pulses and continuous periodic signals under laboratory and workshop conditions (Figure 9.4).

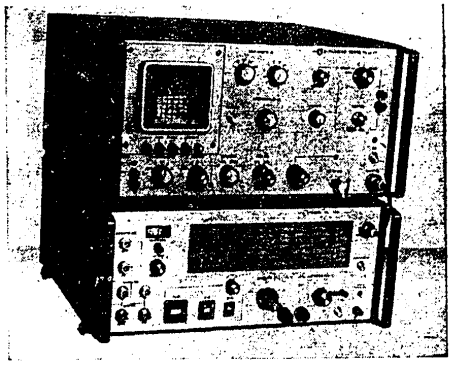

Figure 9.4

They are superheterodyne receivers with triple frequency conversion and automatic frequency retuning within the limits of the scanning zone from 0 to 80 MHz. The studied frequency signal of 0.01-39.6 GHz is converted in the first mixer to an intermediate frequency signal of 160-40 MHz. In the second mixer, the spectrum of the signal in the band from 120 to 200 MHz or in any part of this band is successively transferred to the frequency of 75 MHz by automatic retuning within the limits of 235±40 MHz. After amplification, the signal is converted in the third mixer to a signal of 8.16 MHz to which the filters in the passband of 1 kHz, 3-70 MHz and 300 kHz are tuned. These

filters determine the resolving power of the analyzer. The 8.16 MHz frequency channel has a reference attenuator whose attenuation can be regulated within the limits of 0-49 dB in steps every 1 dB which makes it possible to conduct relative measurements of the amplitudes of the spectrum components of the signal being studied. After detection and amplification, the signal arrives at the vertically deflecting plates of the ELT. The horizontal scanning of the ELT beam is done by the sawtooth voltage generator which simultaneously controls the sweep generator. This makes it possible to observe on the ELT screen the signal spectrum in the amplitude-frequency coordinates.

The spectrum analyzer S4-28, unlike S4-27, has a synchronizer (as a separate unit) in its set for stabilizing the frequency of a microwave heterodyne.

Structurally, the analyzers consist of the following units: microwave analyzer of the intermediate-frequency spectrum, synchronizer SCh-28.

Each analyzer set includes: 1) microwave unit; 2) intermediate-frequency spectrum analyzer; 3) synchronizer (only for SCh-28); 4) coaxial adapter; 5) waveguide-to-coaxial adapter; 6) connecting cables (2 items); 7) waveguides (14 items); 8) adjuster bolts (15 items); 9) semiconductor devices (18 items); 10) electrovacuum devices (3 items);11) signal lamp; 12) attenuator; 13) screwdriver; 14) key; 15) manufacturer's rating certificate.

Basic Specifications

Frequency range, GHz	0.01-39.6
Subranges, GHz	0.01-2; 2-12; 12-17; 17-26; 26-39.6

Error of the adjustment of the instrument to the operating frequency, not over $\pm(2 \cdot 10^{-2} f_p + 1$ MHz) (f_p -- operating frequency).

Error of frequency intervals, 0.1 and 10 MHz, not over $\pm(0.01 F_k + \triangle f)$ (F_k -- frequency interval; f -- established passband).

The entire scanning zone, MHz, is regulated smoothly within the limits from 0 to 5 (scanning zone at a level of 3 dB is regulated smoothly from 3 to 70 MHz and has a fixed value of 1 and 300 KHz).

Sensitivity of the instrument, W, to a sinusoidal signal at a minimum weakening of the inner attenuators must be, at a signal amplitude on the ELT screen of 70 mm, within the limits of ..... 10^{-5}-10^{-7}

Power supply of the instrument from an alternating current network:	
voltage, V	220
frequency, Hz	50
Power consumption, V·A	200

The Spectrum Analyzer S4-29 is intended for analyzing the spectrum of continuous periodic oscillations and stationary noise under laboratory and workshop conditions. It makes it possible to record signals manually or automatically with the aid of a recorder.

The analyzer is based on the method of sequential analysis with shifting of the spectrum to the zero frequency. The signal being studied is delivered to the input of the analyzer unit. The divider limits it, after which the signal goes to the low-pass filter with a cutoff frequency of 150 Hz and to the mixer, where the heterodyne converts it to an intermediate-frequency signal of 600 Hz. The latter arrives at the synchronous detectors of the quadrature-phase filter which perform narrow-band signal selection.

The instrument consists of two units: a spectrum analyzer and a heterodyne.

The analyzer set includes: 1) recorder N-110 with a ZIP [kit of spare parts, tools and accessories] box; 2) movement transmitter; 3) cables (11 items); 4) signal lamps (2 units); 5) protective devices (7 items); 6) description, operation manual, and manufacturer's rating certificate.

Basic Specifications

Frequency range, Hz	0.5-100
Fundamental error of frequency measurement is $\pm(0.01\ F + \Delta f)$ (F -- tuning frequency; Δf -- passband).	
Passbands at a level of 3 dB, Hz	0.2; 1; 5±20%
Voltage measurement limits, V	0.1; 0.3; 1, 3, 10, 30, 100
Fundamental error in sinusoidal voltage measurements, %, at a frequency of 55-60 Hz within the limits from 3 mV to 100 V, does not exceed	10
Frequency characteristic nonuniformity, dB, not over	2
Power consumed by the instrument at the nominal voltage of the network, V·A, does not exceed:	
spectrum analyzer	100
heterodyne	75

The Spectrum Analyzers S4-30, S4-31, S4-32 are intended for studying the spectra of repeating radio pulses and continuous periodic signals under laboratory, field, and workshop conditions (Figure 9.5).

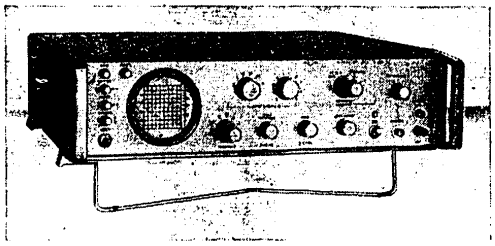

Figure 9.5

Operating conditions: ambient temperature from -30 to 50 degrees C and relative humidity -- 95-98%.

The instruments work by the method of sequential spectrum analysis and are superheterodyne receivers with single conversion and automatic frequency adjustment within the limits of the scanning zone. The input signal, through the regulated attenuator with a maximum attenuation of 50 dB, arrives at the band filter with a passband equal to the maximum scanning zone of 6 MHz. The band filter attenuates the signals in the mirror and the adjacent channels which could create spurious responses on the screen of the indicator. The filtered signal is mixed with the voltage of the frequency-modulated heterodyne in the ring mixer.

The band filter, the mixer, and the heterodyne, as well as the generator of the calibrator form a unit which is called converter. Depending on the operating frequency, there are three modifications of the converter which differ in the tuning frequencies of the band filter, the heterodyne, and the generator of the calibrator.

The detected signal is amplified by the paraphase amplifier and is delivered to the vertically deflecting plates of the ELT of the indicator. The horizontal scanning of the beam and the synchronous retuning by the frequency of the frequency-modulated heterodyne is accomplished by the sawtooth voltage generator. The calibrator produces frequency marks with an interval of 0.1 or 1 MHz which are used for calibrating the frequency scale of the horizontal scanning. The power unit produces stabilized voltages of 80, -20, 12.6 V, as well as a filament and high voltages for feeding the ELT.

The analyzer set includes: 1) high-frequency cable; 2) semiconductor diodes (4 items); 3) storage box; 4) manufacturer's rating certificate.

Basic Specifications

Fixed operating frequency, MHz, for the instruments:	
S4-30	30
S4-31	60
S4-32	26
Passband, kHz, at a level of 3 dB is regulated within the limits	from 3 to 40
Scanning zone, MHz	0-6
Error in tuning to the operating frequency, %	±1
Sensitivity to a sinusoidal signal, microvolts, with a signal amplitude on the ELT screen of 50 m, not less than	100
Nonuniformity of the amplitude-frequency characteristic, dB, not over	1
Power supply -- from alternating current networks:	
voltage, V	220±10%
with a frequency, Hz, of	50
voltage, V	220±5%
with a frequency, Hz, of	400
Power consumption, V·A	50
Weight, kg	20

The Spectrum Analyzer S4-46 is intended for visual observation and relative measurement of the spectral components of the spectra of continuous periodic signals and shape of the spectrum of stationary noise under laboratory and workshop conditions (Figure 9.6).

The spectrum analyzer can be used for measuring nonlinear distortions and studying the spectral characteristics of highly stable sources of signals on frequencies in the vicinity of the carrier frequency.

The spectrum analyzer consists of two functional units each of which is of a bench-rack type and is in a frame without a casing. In order to reduce the interference from external fields and simplify the installation, all assemblies have independent power supply cables.

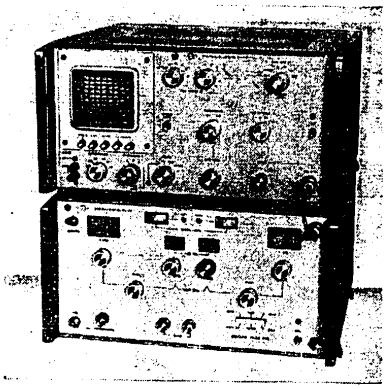

Figure 9.6

The instrument is based on the method of sequential analysis of the spectrum. The analyzer is a superheterodyne receiver with multiple frequency conversion and automatic retuning in the scanning zone. The spectrum is analyzed on the intermediate frequency of 10±0.025 MHz. The signal being studied arrives at the input of the instrument and further through the input attenuator to the mixer which simultaneously receives voltage from the first heterodyne synchronized in the frequency range of 106.5-166.5 MHz at intervals of 1 MHz by means of an automatic phase frequency control system. The converted signal arrives at the input of one of the three intermediate frequency amplifiers (UPCh) tuned to 106.5, 56.5, and 6.5 MHz. The passband of each one of them is not less than 1 MHz at level of 0.95. The use of these amplifiers, with the aid of one heterodyne retuned from 106.5 to 166.5 MHz, makes it possible to cover the frequency range of the studied signal from 0.1 to 160 MHz in the direct channel and from 113 to 273 MHz in the mirror channel. From the outputs of the UPCh-1 and UPCh-2, the signal arrives to the second and third mixers. Voltage from the heterodyne comes simultaneously to the second mixer at a frequency of 100 MHz, and the third mixer receives voltage at a frequency of 50 MHz from the frequency amplifier of 1-100 MHz.

The converted signals of 6.5 MHz, through a low-pass filter, arrive alternately at the UPCh-3, and then at the fourth mixer, which receives simultaneously the voltage from the second heterodyne synchronized at intervals of 100 kHz in the frequency range of 16-17 MHz with the aid of the automatic phase frequency control system. Smooth overlapping in the range of 100 kHz is accomplished with the aid of the interpolation oscillator of the second

heterodyne. The converted signal of 100 MHz arrives through the buffer stage at the amplifier of 10 MHz of the spectrum analyzer unit. Thus, the handles of the first heterodyne are used for tuning at intervals of 1 MHz, and the second heterodyne is used for tuning at intervals of 100 kHz within the limits of 1 MHz, while the handles of the interpolation oscillator are used for smooth tuning within the limits of 100 kHz.

The spectrum analyzer unit is the spectrum analyzer proper with double frequency conversion. The automatic retuning of the instrument in the scanning zone of 0.1-50 kHz is accomplished with the aid of the frequency-modulated heterodyne which has a central frequency of 9.4 MHz and is controlled by the sawtooth voltage of the scanning unit. The deviation of the frequency-modulated heterodyne is overlapped smoothly within the limits of 0.1-50 kHz by two subranges: 0.1-2 and 2-50 kHz. The signal with a frequency of 10 MHz from the output of the amplifier of 10 MHz arrives at the mixer which simultaneously receives the voltage of the frequency-modulated heterodyne. The converted signal of 600 kHz arrives at the UPCh-4 and then at the mixer which simultaneously receives a voltage of 728 kHz from the quartz crystal controlled oscillator.

The converted signal with a frequency of 128 kHz is amplified in the UPCh-5 and arrives at one of the four switchable quartz filters having the passbands of 5, 30, 150, and 1200 Hz respectively which performed necessary frequency selection. From the output of such a filter, the signal with a frequency of 128 kHz goes to the attenuator, after which it goes to two operational amplifiers ensuring the logarithmic, linear, and quadratic scales of indication and detection of the signal.

The horizontal deflecting plates of ELT receive voltage from the sweep oscillator which is amplified by the horizontal deflection amplifier and ensures the scanning of the beam whose frequency scale is established with the aid of the calibrator. The carrier frequency of the calibrator is 10 MHz. In order to average the amplitudes of the responses on the ELT screen in the presence of a fluctuation noise of the components, an integrating circuit is connected whose time constant is changed by means of a switch.

The levels of internal noise and modulation interference with frequencies which are multiple of the frequency of the supply network are measured by a generator for 100 MHz.

The instrument set includes: 1) container; 2) high-frequency connecting cables (3 items); 3) connecting cords (2 items); 4) coaxial adapters (4 items); 5) matching device; 6) T-joint; 7) safety devices (22 items); 8) semiconductor diodes (4 items); 9) packing boxes (2 items); 10) manufacturer's rating certificate; 11) technical record.

Basic Specifications

Frequency range, MHz	0.1-270

Error in measurements of frequency intervals within the limits from 50 Hz to 50 kHz, not over $\pm(0.05\ f_y+10\ Hz)$, where f_y -- set scanning zone.

Error in measuremnts of the input signal frequency, not over $\pm(10^5\ f_{input} + 5\ kHz)$, where f_{input} -- frequency of the input sinusoidal signal.

Scanning zone, Hz (smoothly regulated)	$100 \div 50 \cdot 10^3$
Passband, Hz	5; 30; 150 and 1200
Relative level of internal noise in the passband, dB:	
with a signal mismatch of not less than by 50 Hz	-65
in a passband of 150 Hz with a signal mismatch of not less than by 2 kHz	-70
Initial response, dB, must be balanced at a minimum sensitivity to a value of not less	-20
Error of each of the indicating attenuators, dB for relative measurements of levels of the spectrum components does not exceed	$\pm$0.5
Maximum permissible effective voltage, V, of the instrument, not over	2.5
Instrument has the linear, logarithmic, and quadratic scales of the indicator.	
Power consumed from the network at a nominal voltage, V·A, does not exceed:	
converter	75
spectrum analyzer	70
Dimensions, mm:	
spectrum analyzer	255X490X487
converter	255X490X487
Weight of the analyzer and converter, kg	35

The Spectrum Analyzer S4-47 is intended for the observation and relative measurement of the spectra of radio pulses and continuous signals in real time under the laboratory and workshop conditions.

The instrument operates on the principle of using the special characteristics of signal propagation in dispersion delay lines in which spectral decomposition of signals in time is performed. When measuring spectrum, the analyzer is started at the moment of the arrival of radio pulses at its

input. The spectrum of each radio pulse arriving at the input is reproduced on the screen of the analyzer.

When measuring the spectra of continuous signals, the analyzer works in the periodic mode. The screen of the analyzer shows the spectra of sequential samples (sections) of the signal.

The instrument set includes: 1) storage box; 2) combination set; 3) technical description and operation manual; 4) technical record.

Basic Specifications

Maximum scanning zone, MHz, in the mode of the analysis of radio pulse spectra	10±1
Central frequency, MHz	157±1.5
Maximum scanning zone, MHz, in the mode of the analysis of continuous signal spectra	3±0.4
Central frequency, MHz	160±1
Maximum sensitivity of the instrument, mm/microvolt, from the 150 MHz input in analyzing a sinusoidal signal, not less than	0.2
Level of the internal noise of the instrument, microvolts, brought to the input, not over	50
Nonuniformity of the amplitude-frequency characteristic in the mode of the analysis of continuous signals, %, in a scanning zone of 3 MHz in the mode of the analysis of the spectra of radio pulses in the scanning zone of 10 MHz, not over	3
Frequency scale of the instrument's scanning, MHz/division, changes in steps, and at a sweep length of 100 mm assumes the values of	0.1; 0.2; 0.3; 0.5; 1
Error in setting the frequency scale, %, against the set value, not over	±15
Duration range of analyzed pulses, microseconds	0.4-6
Power consumed from the network, V·A, not over	220
Dimensions, mm	480X295X604
Weight, kg	35

9.8. Nonlinear Distortion Meters

The Nonlinear Distortion Meter S6-4 is intended for measuring nonlinear distortion coefficients of alternating voltages, as well as for measuring background and noise levels.

The instrument is used for studying, controlling, and monitoring radio broadcasting channels, television sound channels, and is used in the sets of instruments for monitoring the quality indexes of ultrashort-wave, frequency-modulated, and amplitude-modulated transmitters and communication lines.

The instrument operates normally in a temperature range of 5-50 degrees C, and corresponds to Group II of GOST 9763-67 with respect to its stability against mechanical influences. The nonlinear distortion coefficient is measured by the method of comparing the entire voltage under study with the voltage of higher harmonic components.

The studied voltage arriving at the instrument's input is amplified by the input device and is adjusted in order to have a constant value of voltage.

Then the voltage is delivered to the block of filters in which the filter of the analyzed frequency is turned on; it suppresses the fundamental frequency, and the voltage of only higher harmonics arrives at the input of the voltmeter.

Due to the quadratic characteristic of the voltmeter, the instrument will indicate the effective value of voltage of the higher harmonic components regardless of their amplitude and phase ratio.

With appropriate calibration of the voltmeter, it is possible to obtain the reading of the nonlinear distortion coefficient K in percentages or in decibels.

The instrument is designed in the form of two separate units in a frame without a case (a unit of the nonlinear distortion coefficient meter and a unit of filters).

The instrument is produced as a bench model (S6-4) and as a rack model (S6-4/1).

The instrument set includes: 1) Power supply cable: 2) interunit connection cable (5 items); 3) socket; 4) cable socket; 5) electron tube; 6) electromagnetic relay; 7) safety device; 8) technical description, operation manual, and manufacturer's rating certificate.

Basic Specifications

The nonlinear distortion coefficient is measured by the instrument on eight fixed frequencies of 30, 60 (50), 120 (100), 400, 1000,

2000, 5000, 7000 Hz. The inputs of the instrument are symmetric and nonsymmetric.

Range of measured values of the nonlinear distortion coefficient, %, with input levels of 0.2-15 V	0.2-30
Fundamental absolute error of measurements of the nonlinear distortion coefficient, %, on frequencies (K_{fv} -- value of the upper limit of the scale):	
30, 60, 120 Hz	0.1 K_{fv}+0.15%
400, 1000 Hz	0.05 K_{fv}+0.1%
2000, 5000, 7000 Hz	0.1 K_{fv}+0.1%
1000 Hz (in the presence of noise)	0.1 K_{fv}+0.3%
Input resistance of the instrument, Ohms, at the input:	
nonsymmetric	$50 \cdot 10^3$
symmetric	600
Instrument measures the background and noise level up to -70 dB in relation to the input level of 0.775 V with an error, dB, of not over	1
Voltmeter of effective values measures alternating voltages within a frequency range from 30 Hz to 100 kHz within the limits of 0.0003; 0.001; 0.003; 0.01; 0.03; 0.1; 0.3; 1; 3; 10; 30 V.	
Fundamental error of the voltmeter, %	4
Power supply -- from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50
Dimensions of units, mm:	
nonlinear distortion coefficient meter	215X490X475
filters	135X490X475
Weight of units, kg:	
nonlinear distortion coefficient meter	25
filters	19

This meter is checked in accordance with GOST 13473-68 and Instruction 222-65 "On Checking Electronic Voltmeters at Frequencies of Up to 1000 MHz", Instruction 200-64 "On Checking Nonlinear Distortion Meters" and in accordance with the technical description, operation manual, and manufacturer's rating certificate included in the set.

The Nonlinear Distortion Meter S6-5 is intended for measuring harmonic coefficients of signals in the frequency range from 20 Hz to 200 kHz. The built-in voltmeter makes it possible to measure alternating current voltage both of a sinusoidal and of a distorted shape within the limits from 0.0001 to 100 V in the frequency range from 20 Hz to 1 MHz.

Moreover, the instrument can be used for measuring voltage ratios.

The principle of measuring the harmonic coefficient in the instrument is based on separate measurements of the root-mean-square value of the voltage of the total signal and the root-mean-square value of the voltage of the higher harmonics. The harmonic distortion factor of the signal under study is measured by the method of comparing the entire voltage being studied with the voltage of the higher harmonics, i.e., it is determined from the expression:

$$\kappa_l = \sqrt{\sum_{i=2}^{i=n} U_i^2} \Big/ \sqrt{\sum_{i=1}^{i=n} U_i^2}.$$

where U_i -- root-mean-square value of the voltage of the i-th harmonic.

For the realization of this principle, the instrument includes the following assemblies: matching device; input attenuator; input amplifier; amplifier with a rejection filter; voltmeter; converter of the root-mean-square voltage value; calibrator; power supply unit.

The nonlinear distortion meter S6-5 is designed in the form of an individual instrument in a caseless frame.

The instrument set includes: 1) matching device; 2) spare parts; 3) filter at the customer's request; 4) technical description and operation manual; 5) technical record.

Basic Specifications

Frequency range of the fundamental harmonic of voltages under study, Hz, at the inputs:	
nonsymmetric	$20 \div 200 \cdot 10^3$
symmetric	$20 \div 20 \cdot 10^3$
Fundamental instrument error of the upper limit of the scale, %:	
0.02% of signal distortions at frequencies of up to 20 kHz	0.05
0.1% of signal distortions on frequencies from 20-200 kHz	0.1

Input voltage range, V, of the instrument	0.1 - 100
Root-mean-square voltage, V	$0.1 \cdot 10^{-3} \div 100$
Fundamental maximum permissible error of the voltmeter on frequencies:	
up to 100 kHz	± 0.04
up to 1 MHz	± 0.1
Input resistance, kiloohms, not less than	100
Power supply from alternating current networks:	
voltage, V	$220 \pm 10\%$
frequency, Hz	50
voltage, V	$115 \pm 5\%$
frequency, Hz	400
Power consumed from the network, V·A	40
Dimensions, mm	490X135X355
Weight, kg	14

The fundamental instrument error in the frequency range up to 20 kHz is checked according to Instruction 200-64 "On Checking Nonlinear Distortion Meters".

The fundamental error in the frequency range from 20 Hz to 200 kHz is checked by an indirect method determining the amplitude-frequency characteristic of the entire measuring channel of the instrument and determining the level of the internal background, noise, and harmonics of the instrument.

The built-in voltmeter is checked according to GOST 8118-74.

CHAPTER 11

INSTRUMENTS FOR MEASURING PULSE SIGNALS

11.1. Time Interval Meters

Time Interval Meters I2-17 are intended for measuring the intervals of periodic processes of the microsecond duration range synchronized by triggering pulses.

The instrument conforms with the requirements of GOST 9763-67 and is intended for operation at the ambient temperature from 5 to 50 degrees C, an atmospheric pressure of (10-40) Pa and a relative humidity of up to 98% at a temperature of 30 degrees C.

The instrument is based on the compensation method of measuring time intervals which, essentially, is the comparison of the interval being measured with the reference interval.

The instrument includes a source of reference time intervals (delay generator) and a device for comparing the measured interval with the reference interval (electron-ray oscillographic zero indicator) which thereafter will be referred to as "generator" and "indicator". The generator is connected in the triggering circuit of the indicator, and the signal being studied is sent to the input of the vertical deflection system of the indicator. The beginning of the measured time interval (leading edge of the measured pulse, when its length is being measured) is brought into coincidence with the sight on the screen of the indicator. Then, due to the changes in the triggering delay of the indicator, the end of the measured interval (the trailing edge of the measured pulse) is put into coincidence with the same sight.

The instrument set includes: 1) storage box with spare parts and accessories; 2) technical description, operation manual and instructions for periodic checking; 3) manufacturer's rating certificate.

Basic Specifications

Time interval measurement range, seconds ..... $10 \cdot 10^{-9} \div 10^{-3}$

Measurement range, pulse parameters, sec ..... $10 \cdot 10^{-9} \div 2 \cdot 10^{-3}$

Measurement error, seconds, not over 10^{-4} $T_{measurement} \div 1 \cdot 10^{-9}$
($T_{measurement}$ -- the value of measured interval at a steepness of the leading edges of the studied signals in the area of points between which measurements are taken, not less than 6 V/ns).

Amplitude of input signals, V, not over 150

Minimum amplitude of input signals is determined by the minimum permissible size of the image on the screen of the electron-ray tube (approximately 1-5 mm) depending on the parameter being measured.

Sensitivity of the vertical deflection channel of the plates, tube, mm/mV, not less than 0.25

Parameters of Output Triggering and Delaying Pulses of Positive or Negative Polarity

Pulse duration, microsecond, at the level of a 0.5 amplitudes 0.15-0.3

Pulse edge length, microsecond, not over 0.13

Pulse amplitude, V, at a load of 75 Ohms with a parallel capacitance of not more than 20 pF regulated smoothly 2-10

Pulse amplitude, V, at a load of 150 Ohms with a parallel capacitance of not over 20pF regulated smoothly 2-15

Pulse repetition period $T_{setting}$, microseconds, from 10 to 100:
with discreteness of setting, microsec 10
with error of setting, microsec ..... $\pm(10^{-4} T_{setting} + 0.1)$

The Instrument Can Be Synchronized by An External Sinusoidal Voltage

Frequency, MHz ..... $10 \pm 0.01\%$
Amplitude, V 1-10
Frequencies of synchropulses, MHz ..... 5 and 10

Amplitudes of synchropulses, V, not less than ..... 1.8 and 5
(at a load of 150 Ohms with a parallel capacitance of not over 20 pF)

Power supply of the instrument is from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50±0.5
with a harmonic content, %, of	5
Power consumption, V·A:	
delay generator	75
indicator	450
Dimensions, mm:	
delay generator	570X370X310
indicator	300X663X450
Weight, kg:	
delay generator	28
indicator	35

The Meter of Time Parameters of Integrated Logic Circuits L2-35. This instrument is intended for monitoring ILS [integrated logic circuits] by the parameters of t^{01}_{z} -- the delay time of the output pulse in relation to the input pulse when the output voltage changes from the state "log.0" to the state of "log.1"; t^{10}_{z} -- delay time of the output pulse in relation to the input pulse when the output voltage changes from the state of "log.1" to "log.0"; $t^{01}_{z.r}$ -- the delay time of the spread of information in the logical element when the output voltage changes from the state "log.0" to the state "log.1"; $t^{10}_{z.r}$ -- the delay time of the spread of information in the logical element when the output voltage changes from the state "log.1" to the state "log.0"; $t^{0.1}_{p}$ -- the switching time from the state "log.0" to the state "log.1"; t^{10}_{p} -- switching time from the state "log.1" to the state "log.0".

The meter can also be used in the mode of the classification and output of the results of measurements on a digital printer and with the use of the outer unit for programming. The instrument can measure the ILS parameters with a number of inputs of up to 18 which are distributed for their purposes in the following way: inputs -- 9, outputs -- 4, power supply -- 3, framework -- 1, additional input -- 1.

The instrument satisfies the requirements of GOST 9763-67 with respect to its stability against climatic and mechanical influences.

The meter consists of five units: conversion unit, indicator, mode unit, and two power supply units.

The instrument set includes: 1) contact head; 2) intermediate panels (3 items); 3) shaper; 4) loads (2 items); 5) connecting cords (12 items); 6) cables (6 items); 7) hands (2 items); 8) relays (3 items); 9) plugs (30 items); 10) resistors (4 items); 11) incandescent lamps (2 items); 12) signal lamps (5 items); 13) safety devices (6 items); 14) set of operating documents.

Basic Specifications

Measuring range of time parameters, ns	3-1000
Amplitude of input and output signals, V	$\pm$(0.5-10)
Fundamental measurement error of time parameters of the ILS $\delta_o = \pm(15+100/t_x)\%$, ($t_x$ -- measured time interval, ns).	
Input resistance of the meter, MOhm	1
Power supply -- from an alternating current network:	
voltage, V	220$\pm$10%
with a frequency, Hz, of	50$\pm$1
with a harmonic content, %, of	up to 5
Power consumed by the instrument from the network, V·A	up to 400
Instrument weight without packaging, kg	130

The Time Parameter Meter of Integrated Logic Circuits L-235 is intended for the sorting of logical systems (ILS) by the parameters: t^{01}_z -- delay time of the output pulse in relation of the input pulse when the output voltage changes from the state "log.0" to the state "log.1"; t^{10}_z -- delay time of the output pulse in relation to the input pulse when the output voltage changes from the state "log.1" to the state "log.0"; $t^{0.1}_{z.r}$ -- delay time of the spread of the information in the logical element when the output voltage changes from the state "log.0" to the state "log.1"; $t^{10}_{z.r}$ -- delay time of the spread of information in the logical element when the output voltage changes from the state "log.1" to the state "log.0"; t^{01}_p -- switching time from the state "log.0" to the state "log.1"; t^{10}_p -- switching time from the state "log.1" to the state "log.0".

The instrument can work in the mode of classification and presentation of results to a digital printer.

The instrument can measure ILS parameters with a number of outputs of up to 18 which are distributed in the following way with respect to their purposes: inputs -- 9, outputs -- 4, power supply -- 3, framework -- 1, additional input -- 1.

The instrument satisfies the requirements of Group II of GOST 9763-67 with respect to its stability against climatic and the mechanical influences.

The instrument consists of an ILS time parameter meter (L2-33) and a programming unit.

The L2-33 meter in the L2-35 instrument performs all measuring functions. It ensures the delivery of supply voltages, voltages of static states and test pulses to the tested integrated logic circuit connected to it, the switching of the output of the integrated circuit being tested, the setting of the voltages of the reading levels at transient process signals of the ILS being tested, conversion of the measured values to a code, comparison of the measured time parameters with the prescribed permissible values, visual indication of the results of measurements and classification, and internal control of the processes of measurement and classification.

The L2-33 meter delivers to its output connector signals controlling the programming unit, signals for digital registration of the results of measurements and classification, as well as signals for controlling an external automatic loading device.

The programming unit programs the controlling of L2-33 (and thus the operation of L2-35). It gives the switching sequence of the outputs of the ILS being studied which are not covered by the test pulses, the signal shape at the input and the output of the tested ILS, the operation range of the meter and nominal values of the tolerance limits for each time parameter being measured. The programming unit changes the information delivered to the L2-33 meter when special control signals arrive from it.

The instrument set includes: 1) connecting cords (2 items); 2) set of spare parts and accessories in a case; 3) punched card blanks (30 items); 4) program preparation cards (30 items); 5) device for punching holes; 6) set of operational documentation.

Basic Specifications

Range of the measured delay time, ns	3-1000
Power supply from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50±1
harmonic content, %	5
Power consumed by the instrument from the network, V·A	450
Dimensions of each unit in the L2-33 and the programming unit, mm	480X420X240
Weight, kg	158

The Time Shift Source I1-8. This instrument (Figure 11.1) is intended for defining the time coordinate and operation within meters of time intervals of the oscillographic type.

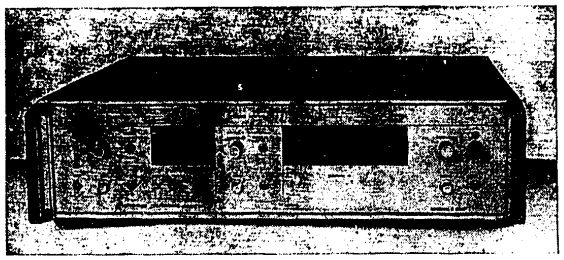

Figure 11.1

It works in the mode of internal and external triggering, produces the reference and delayed pulses, and ensures delay changes in a range of 0-1 sec.

The inner source of the reference sequence produces a pulse with the repetition frequency of the quartz generator of 10 MHz. In order to remove phase distortion in the packet of pulses in the case of external triggering, prelininary frequency multiplication of up to 20 MHz is used before selection, and then, division again to a frequency of 10 MHz. Small time shifts of up to 100 ns are obtained with the use of the delay line (discreteness 0.1; 1; 10 ns).

The principle of obtaining large time shifts (over 10 ns) is based on the method of feeling frequency dividers with a regulated preliminary setting by reference sequence pulses.

The instrument must operate in the modes of external and internal triggering.

The I1-8-(IVS) instrument is designed with the use of semiconductors and microcircuits. It uses printed wiring. The instrument consists of the following complete assemblies: delay line; 15 switching devices; quartz generator units; power transformer; plate with diodes and control jacks; printed wiring plate.

The instrument set includes: 1) time shift source I1-8; 2) technical description of the instrument; 3) kit of spare parts, tools, and accessories which include: cables, plates, and a mixer.

Basic Specifications

Changes in the time position (τ shift) of the delayed pulse in the range of, seconds:	
with external triggering	0-1
with internal triggering	0-0.9998

Setting error, seconds, τ_{shift}, not over:	
in the course of 30 days	$\pm(5\cdot10^{7}\ \tau_{shift} + 5\cdot10^{-9})$
in the course of a year	$\pm(1\cdot10^{-5}\ \tau_{shift} + 0.5\cdot10^{-9})$
Repetition period of output pulses, microseconds:	
with internal triggering	10 microsec-10^{6}
with external triggering	over 100
Error, not over	$\pm5\cdot10^{-7}\ T_{repetition}$
Amplitude, V, at a load resistance of R_1=50 Ohms ..	2-10
Instrument weight, kg, not over	10
Average operation time for 1 failure, hours	700

The relative component of the setting error $\tau_{shift} \leq \pm5\cdot10^{-7}$ [τ_{shift} is determined by the frequency error of the quartz generator].

The absolute error component $\tau_{shift} = \pm0.5$ is not determined with the aid of an IVI [time interval meters] of the type of I2-17 with the use of the frequency period of 100 MHz as a reference measure and with the use of the calibrator K-763.

The main means of checking are the following instruments: Ch3-34, S1-70, I2-17, G5-53, K-763, G4-65A.

11.2. Pulse Counters

The Single-Channel Counter PSO2-2eM is intended for counting the number of stochastic or evenly distributed pulses in the course of a prescribed time interval (exposure); measurement of the time during which the prescribed number of input pulses arrive; delivery of command pulses controlling the work of external instruments and devices; measurement of the repetition frequency of electrical pulses or a sinusoidal signal.

Stability of the instrument's parameters to climatic and mechanical influences must correspond to the requirements of Group II of GOST 9763-67.

The instrument operates on the principle of counting and storing by the scaling decades the number of pulses delivered to the input of the instrument during the time of prescribed exposure with subsequent information output in the digital form to a digital readout printer.

The instrument is checked in accordance with the requirements of GOST 14346-69 and checking methods given in the technical description included in the set.

The instrument set includes: 1) storage boxes (4 items); 2) technical record; 3) technical description; 4) manufacturer's rating certificate.

Basic Specifications

Counting capacity	10^6 pulses
Resolution time of the instrument for double pulses of both polarities, seconds, not over	$2.5 \cdot 10^{-6}$
Frequency range of the input sinusoidal signal, kHz	10^{-3}-400
In the pulse counting mode, the instrument ensures the possibility of prescribing exposures, seconds	1, 3, 10, 30, 100, 300, 1000

Fundamental error of the result of the counted number of pulses not over $\pm(8 \cdot 10^5 N + 7 \cdot 10^{-5} N/t + 1$ unit of count), where N -- counted number of pulses; t -- prescribed exposure.

Fundamental measurement error of the time necessary for accumulating the prescribed number of pulses is $\pm(8 \cdot 10^{-5} t_{measurement}$ $t_{measurement}/Np + 2 \cdot 10^{-4})$ seconds, where N_p -- prescribed number of pulses; $t_{measurement}$ -- time interval being measured, seconds.

Additional error due to temperature changes, not more than one-half of the fundamental error per each 10 degrees C.

Weight, kg	6

The Buffer Storage Device BZU2-90 is intended for recording, storing, and reading numbers given in a parallel code.

The buffer storage device BZU2-90 is a unit of registers (32 numbers 16 digits each).

The electrical circuit of the device is designed with six plates of three types: output plate (1 item); memory plates (4 items); input plate (1 item).

The BZU2-90 unit consists of: memory registers; synchronization unit, conversion circuits; shaping assembly: decoding and control.

The front panel has 17 connectors of the SP50-73F type, and the back panel of the unit has two connectors of the GRPM-2-46G02 type. The design of the unit makes it possible to install and remove plates from the connectors easily during tuning and repairs.

The unit is protected by screens on both sides, as well as from the bottom and the top.

The instrument set includes: 1) storage box; 2) buffer storage device BZU2-90; 3) manufacturer's rating certificate.

Basic Specifications

Input resistance, Ohms, of inputs 1-16, "Recording"	50±5%
Minimum recording time, ns, does not exceed	100
Length of recording signal, ns, not over	50
Resolving time on the recording signal edge and code signal drop, ns, not over	50
Minimum length of recording and code signals, ns, not over	50
Minimum reading time, ns, through the "Output" connector does not exceed	100
Reading length, ns, not over	50

Recording of codes is done through matched inputs 1-16 "Recording", but through unmatched inputs of the "input" connector. The unit ensures the recording, storage, and readout of 32 numbers 16 digits each.

Parameters of Signals of Matched Inputs

Input current, mA, for signals:	
"log.0"	2-20
"log.1"	-12÷+36
Pulse buildup and decay time at a minimum amplitude, ns	15
Minimum pulse length, ns, at a level of 0.5	50

Parameters of Unmatched Signals

Input voltage for circuits, V:	
"log.0"	0-8
"log.1"	2-5
Input current, mA, not more than, for circuits:	
"log.0"	1.6
"log.1"	0.04

Output voltage, V, (at a capacitance of 50 pF) for circuits:	
"log.0"	2.4-5
"log.1"	0-0.5
Output current, mA, for circuits:	
"log.0"	0.6
"log.1"	16
Pulse buildup and decay time, ns, not over	15
Time of long continuous work, hours	8
Power supply of the unit from a direct current source with a voltage of, V	6
Dimensions, mm, not over	100X239X366
Unit weight, kg, not over	3.5 ± 0.2

Operating conditions of the unit conform with the requirements of Group II of GOST 9763-67.

Characteristics checked: work with the data channel, minimun recording time.

Instruments necessary for checking: reference instruments -- control unit BKTs2-94, pulse generator G5-44, frequency meter Ch3-24, oscillograph S1-31; auxiliary instruments -- frame VBTs2-90, power supply unit BNN2-90, mixer unit BKA2-90, unit BSV2-90, unit VZA2-90, unit BTE2-90, unit BOA-98, output registers BZTs-99. (Replacement is permissible with instruments of other types with analogous parameters).

The nanosecond interval conversion unit BPV2-91 is intended for converting nanosecond time intervals to a digital code.

The unit operates by the start-stop method of measuring time intervals when the time interval being studied is converted by an analog converter to an interval which is K_{conv} times greater than the input interval, where K_{conv} is the conversion coefficient, and then is filled by scale pulses of the master generator with a definite table repetition frequency T.

The sequence of these pulses is an address code directed to the accumulator of the multichannel analyzer from the address register.

The time interval being measured is $T_i=mn+\delta_3$, where m is the number of the channel; n is the channel width; δ_3 -- is the measurement error.

The unit is protected by screens from four sides.

The unit set includes: 1) storage box; 2) conversion unit of nanosecond intervals BPV2-91; 3) manufacturer's rating certificate.

Basic Specifications

Parameters of Standard Logical Pulses of Negative Polarity

Input current, mA, for circuits:	
"log.1"	-12÷-36
"log.1"	-4÷+20
Buildup and decay time, ns, not over	3
Error, %, for all values	5
Time instability of channel width, %, not over	1
Differential nonlinearity of the unit K_d, %, not over	1
Integral unit nonlinearity K_i, %, not over	1
Maximum number of quantization levels	2^{10}
Conversion time (t_{con}), microseconds, $t_{con.max}$= $[T_i \pm (MT_g+t_d)]+10\%$ [T_i -- time interval being measured; M-1024 -- maximum channel jack; T_g -- period of the master generator; T_g = 20 ns; T_d -- internal delay; $(M \cdot T_g+t_d)_{max}$= 25 microseconds].	
Voltage, V, for signals:	
"log.1"	0-0.5
"log.0"	2.4-5
Current, mA, for signals:	
"log.1"	16
"log.0"	0.4
Buildup and decay time, ns, with a load capacitance of 100 pF, not over	50
Power supply of the unit from a direct voltage source, V	±6; ±24
Unit dimensions, mm, not over	80X329X366
Unit weight, kg, not over	2.5±0.3

Operation conditions of the unit correspond to Group II of GOST 9763-67.

The unit must be checked periodically by the metrological service of the enterprise using the unit.

Characteristics checked: channel width and differential nonlinearity. Periodic checks -- once a year.

Instruments necessary for checking: reference instruments -- time interval generator unit BGK2-90, data accumulation and processing unit UNO-4096-90; auxiliary set of reference spectrometric gamma sources OSGI, basic detection unit BDBS3-1eM, power supply unit BNN2-90, power supply unit BNV2-95, decade scaling device PP9-2M, unit BTA2-92, digital printing device UVTs2-95, frame VBTs2-94.

Replacement with instruments of other types with analogous parameters is permissible.

The Counter Unit BSchTs2-92. This unit is intended for counting the number of pulses arriving at its inputs; it works in a standard data channel.

The counter unit contains two 24-digit binary counters based on a circuit of serial counting register. Each counter in the unit has an overflow signal output on the front panel and an element indicating the presence of this signal.

The front panel has six connectors and two indicators. The elements of the circuit are located on a printed plate.

The unit set includes: 1) storage box; 2) unit of two counters BSchTs2-92; 3) manufacturer's rating certificate.

Basic Specifications

Number of counters in the unit	2
Number of binary digits in each counter	24
Input resistance, Ohms, of each counting input of the counters (VKh1, VKh2) and each control input STROB1, STROB2	50±5%
Input current (for matched input), mA, for circuits:	
"log.0"	from 2 to +20
"log.1"	from -12 to -36

The parameters of nonmatched overflow signals, as well as the parameters of logical communication signals with the data channel of the frame correspond to the values given in Table 11.1.

Table 11.1

Signal Parameters	Logical "0"	Logical "1"
Input voltage,	from 2.1 to 5	from 0 to +0.8
Input current, mA, not over	0.04	1.6
Output voltage, V	from 2.4 to 5	from 0 to +0.5
Output current, mA, not over	0.6	16

Resolving time for two pulses, ns, for each counter in the unit, not over 10

Pulse duration, ns, not over 5

Resolving time, ns, for the counting input and control input of each counter, for the edge of the control signal and decay of the counting pulse, as well as for the edge of the counting pulse and control signal decay, not over 10

Maximum counting frequency, MHz, of periodic signals for each counter, not less than 100

Duration time of continuous work of the unit, hours, not less than 8

Power supply of the unit is from a direct current source with a voltage, V, of ..... +6

Dimensions, mm, not over 20X239X366

Unit weight, kg, not over ..... 1±0.1

The operating conditions conform with the requirements of Group II of GOST 9763-67.

Instruments necessary for checking: refrence instruments -- unit BKTs2-94, pulse generator G5-44, frequency meter Ch3-24; auxiliary instruments -- frame VBTs2-90, power supply unit BNN2-90, unit BKA2-90, unit BSV2-90, oscillograph S7-8, unit BOA-98-01, delay unit BZA2-90.

Replacement with instruments of other types with analogous parameters is permissible.

11.3. Pulse Parameter Meters

The Pulse Parameter Meter I4-3. This instrument is intended for measuring the generalized amplitude and length of periodic and single video pulses

of positive and negative polarities with a length from 5 ns (periodic) and from 10 ns (single) to 3 microseconds and an amplitude from 10 mV to 10 V at a reciprocal of the pulse duty factor of over 1000.

The operation in the mode of measuring video pulses consists in the following: the measured input pulses of positive and negative polarities are delivered through the built-in attenuator to the transistorized pulse stretchers. At the outputs of the integral converters, there are pulses with a polarity opposite to the input pulses whose amplitude is a linear duration function and amplitudes of the input pulses. The ratio of the amplitudes of the converted pulses at the outputs of two converters do not depend on the length of the pulses, but serve only as a function of the amplitude and shape of pulses. The instrument indicates a value proportional to the logarithm of the ratio of the amplitudes of the stretched pulses which, in turn, is proportional to the amplitude of the signals being measured, therefore, the scale of the pointer-type length indicator is logarithmic. The duration of the pulses is measured by finding the ratio of the amplitudes of the stretched pulse obtained from the linear signal stretcher proportional to the generalized amplitude of the pulse being measured.

The pulse parameter meter I4-3 is designed as an independent instrument without a case.

The instrument set includes: 1) differentiator; 2) coaxial adapter of 50-75 Ohms; 3) resistor attenuator of 20 dB; 4) plates (2 items); 5) connecting cables (8 items); 6) screwdriver; 7) safety devices (2 items); 8) transistors (2 items); 9) electronic indicator; 10) switch; 11) technical description and operation manual with manufacturer's rating certificate.

Basic Specifications

Input resistance of the instrument, Ohms	50
Range of amplitude changes of single and periodic pulses, mV	10-30
Fundamental measurement error of single pulses in the subranges:	
30-100; 100-300 ns; 0.3-1; 1-3 microsec	10
10-3, ns	±(15% A + 2 mV)
(A -- pulse amplitude)	
Fundamental measurement error of periodic pulses in the subranges:	
30-100; 100-300 ns; 0.3-1; 1-3 microsec	±5
5-10 and 10-30 ns	±(15%/A+2 mV)
Error of the built-in attenuator, %, does not exceed	±6

Error of duration measurement referred to the finite value of the measurement limit within the duration range from 5 ns to 3 microsec in the periodic mode and from 10 ns to 3 microsec in the single mode does not exceed $\pm 15\%$ $\tau + 3$ ns (τ -- pulse duration).

CHAPTER 13

MEASURING AMPLIFIERS

13.1. Selective Amplifiers

The Selective Amplifier U2-8 (Figure 13.1) is intended for amplifying and separating sinusoidal-shape small voltages and for converting a root-mean-square voltage to a constant voltage under laboratory and workshop conditions.

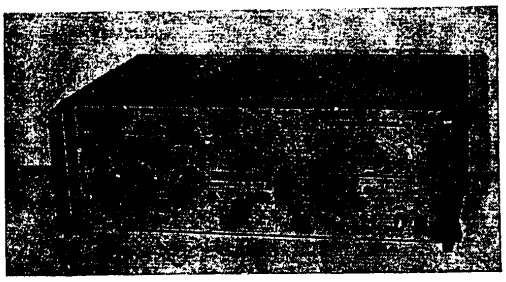

Figure 13.1

With respect to its climatic and mechanical requirements, the instrument belongs to Group II of GOST 9763-67.

The instrument operates on the principle of direct selection and amplification of the frequency of the signal being measured. The synchronous converter is based on a gating circuit with an internal reference generator covered by a phase frequency control system. The instrument produces amplification in the wide-band and selective modes and converts alternating voltage to direct-current voltage by two methods: linear and synchronous.

The instrument is fully transistorized and uses microcircuits. The circuit is based on the functional assembly method using printed-circuit cards. The printed-circuit cards are placed in cast aluminum blocks connected by bunched conductors with detachable connectors.

The instrument set includes: 1) selective amplifier U2-8; 2) measuring cables (4 items); 3) repair cables (2 items); 4) connecting cables; 5) clamps (2 items); 6) T-joint SR-50-94P; 7) end cap (by special order); 8) tubes SMN-10-55-2 (6 items); 9) safety devices VP-1-0.25A (6 items); 10) technical description and operation manual; 11) technical record; 12) storage box.

Basic Specifications

Frequency range of voltages amplified by the instrument, kHz, in the operation modes:	
in wide-band mode with linear conversion	0.02-200
in the selective and wide-band modes with synchronous conversion (covered by four subranges)	0.02-100
Normalizing value of output voltages, V, at a load of not less than 1 kOhm	1

The amplification factors of linear and synchronous conversions have a step-by-step control every 10 dB within the limits given later in the text.

The normalized error for the output in the entire frequency range does not exceed the values shown in Table 13.1.

Checking is done by the method of comparing the indications of reference voltmeters.

The voltage of the direct and alternating currents at the outputs is controlled by the voltmeters V2-25 and F584, respectively. The voltage is delivered to the input of the amplifier from the generator G3-102 through the reference attenuator ASO-3M; voltage at the input of the attenuator is controlled by the voltmeter F584.

The normalized output error in the selective mode and in synchronous conversion is determined as an algebraic sum of the error of a part of the calibration (1 kHz + 10%) and the nonuniformity of the frequency characteristic in relation to the calibration frequency for the amplification (conversion) factor of 40 dB.

The amplification (conversion) factor of the instrument is determined by the formula $k_{ampl} = (A+201 \text{ g } U_{output}/U_{attenuator})$, where A is the attenuation of the attenuator ASO-3M; U_{output} is the voltage at the instrument's output, V; $U_{attenuator}$ is the voltage at the input of the attenuator ASO-3M, V.

Table 13.1

(1) Коэффициент усиления (преобразования), дБ	(2) Погрешность, %					
	(3) Широкополосный режим			(4) Селективный режим		
	(5) усиления	(6) преобразования		(5) усиления	(6) преобразования	
		(7) линейного	(8) синхронного		(7) линейного	(8) синхронного
—20; —10	6	10	—	—	—	—
0; 10	6	10	15	15	15	—
20—90	6	10	15	15	15	25
100	25	25	15	15	15	25
110	—	—	25	15	15	25
120	—	—	—	15	15	15
130	—	—	—	—	—	25

Key: 1. Amplification factor (conversion), dB
2. Error, %
3. Wide-band mode
4. Selective mode
5. Amplification
6. Conversion
7. Linear
8. Synchronous

The error in the amplification (conversion) factor is determined at an output voltage of 0.9 V.

13.2. High-Frequency Amplifiers

The superhigh-frequency amplifier UKZ-17 is intended for amplifying and modulating signals in the decimetric and centimetric wave ranges, as well as for stabilizing the output power levels.

The instrument satisfies the requirements of GOST 9763-67.

The instrument operates on the principle of amplification and modulation of superhigh-frequency signals by means of an amplifier using a low-power traveling-wave tube (LBV).

The amplifier is designed as a separate portable instrument without a case: it can be built into a bay with the front panel 480 mm wide.

The instrument set includes: 1) storage boxes (2 items); 2) box; 3) high-frequency connecting cable; 4) low-frequency connecting cable; 5) directional coupler; 6) coaxial adapters (3 items); 7) thermoelectric heads; 8) releasing device; 9) safety devices (5 items); 10) brackers (2 items); 11) angle bars (2 items); 12) screws (4 items); 13 technical description and operation manual for the thermoelectric head; 14) rating certificate for the thermoelectric head; 15) technical description and operation manual for the amplifier; 16) rating certificate for the amplifier.

Basic Specifications

Output power, W:	
in the saturation mode	0.055
at a load with KSVN [voltage standanding wave ratio], not over	1.4
Amplification factor, dB, in the linear mode, not less than	25

The instrument ensures pulse modulation of the signal by a meander with the frequencies: 100±1 kHz (internal modulation) and from 0.4 to 100 kHz (external modulation) at a voltage of the modulating sinusoidal signal from 10 to 40 V. In this case, the buildup and decay time of the high-frequency output pulse is not more than (0.1 T+0.5) microseconds, where T is the pulse duration.

The Instrument Has Provisions for External Pulse Modulation:

Positive pulses with a length, microseconds, of	0-10
Pulse repetition frequency, kHz	1-10
Length of positive and negative pulses, microsec	10-100
Their repetition frequency, kHz	0.4-1
Depth of pulse modulation in the linear amplification mode, dB, not less than	6

When the Instrument Works in the Continuous Mode with a Thermoelectric Head and in the Linear Mode with a Directional Coupler:

Length of transitional period, seconds, not over	$5 \cdot 10^{-3}$
Stabilization factor, not less than	100
KSV [standing wave ratio] of the instrument's output, not over	1.5
Power supply of the instrument from an alternating current network with a voltage, V, of	220±22
Power consumption at the nominal voltage, V·A	150

13.3. Wide-Band Amplifiers

The Wide-Band Amplifier U3-29 is intended for detecting radio pulses with a length from 0.05 to 10 microseconds and their preamplification to a level ensuring the observation of the envelope of radio pulses on oscillographs, as well as for amplifying sinusoidal pulse signals in the frequency range of 50 Hz - 20 MHz.

The wide-band amplifier consists of an input stage with an attenuator, three stages of video amplifiers with emitter followers, a power supply unit, a calibrator, and four external detector heads.

The instrument set includes: 1) storage box with a kit of spare parts, tools and accessories, including auxiliary equipment; 2) detector heads (0.05-4, 3.86-10.02, 8.15-12.42 and 11.72-17.85 GHz (4 items); 3) waveguide-to-coaxial adapters (2 items); 4) coaxial adapters (3 items); 5) input cable; 6) connecting cables (4 items); 7) connecting wires (2 items); 8) laboratory clamps (2 items); 9) description, operation manual, and manufacturer's rating ceritificate.

Basic Specifications

Passband of the amplifier, MHz	0.05-20
Nonuniformity of the frequency characteristic within the limits of the passband, dB, not over	2
Amplification factor, not less than	200
Input voltage range of the instrument, mV	1.5-200
Frequency range of detector heads, MHz	50-17,850
Standing wave ratio of detector heads, not over	2.5
Power consumed by the instrument, V·A, not over	50
Dimensions, mm	492X135X355
Weight, kg	13.5

13.4. Multipurpose Amplifiers

Five-Channel Amplifier F1510. The direct and alternating voltage semiconductor five-channel amplifier with current efficiency F1510 is intended for amplifying low voltages by means of oscillographs, recorders, and other instruments.

This amplifier is intended for operation at ambient air temperatures from 5 to 40 degrees C and a relative humidity of up to 80% in the entire temperature range and must correspond to version V of Category 4, 2 (GOST 15150-69). The use of the amplifier makes it possible to expand the possibilities of using oscillographs, registers, and indicating instruments. The amplifier is designed as a portable unit, and, depending on its version can be placed in a standard bay, or on the working bench of the operator. Each channel of the amplifier is designed as a self-contained unit. Within the housing of the channel, there is a fiber-glass laminate plate with printed wiring. All channels are combined in a common casing.

The body of the amplifier has runners for placing it in a standard bay. The amplifier is secured in the bay with four screws.

The instrument set includes: 1) connecting cords (6 items); 2) power cord; 3) handle for removing the channel from the housing; 4) incandescent lamp; 5) protective devices (5 items); 6) packing box; 7) technical description and operation manual; 8) manufacturer's rating certificate.

Basic Specifications

Parameters of the amplifiers depending on the nominal value of the input voltage are given in Table 13.2.

Table 13.2

Номинальное значение входного напряжения, мВ (1)	Входное сопротивление, кОм (2)	Номинальное значение коэффициента передачи, мА/мВ (3)	Номинальное значение выходного тока, мА (4)	Сопротивление нагрузки, Ом (5)
10	(6) Более 50	3,0 7,5	30 75	300±20 50±3,5
20		1,5 3,75	30 75	300±20 50±3,5
50		0,6 1,5	30 75	300±20 50±3,5
100	2±0,05	0,3 0,75	30 75	300±20 50±3,5
200	4±0,1	0,15 0,375	30 75	300±20 50±3,5
500	10±0,25	0,06 0,15	30 75	300±20 50±3,5
1000	20±0,5	0,03 0,075	30 75	300±20 50±3,5

Key: 1. Nominal value of input voltage, mV
2. Input resistance kilohms
3. Nominal value of transmission factor mA/mV
4. Nominal value of output current, mA
5. Load resistance, Ohms
6. Over 50

Transfer factor measurement error, %	4
Normal frequency region, Hz	0-20,000
Nonlinearity of frequency characteristic, %, not over	±4
Resistance of the signal source, kOhm, in the measurement ranges with nominal voltages of 10, 20, and 50 mV, not over	1

Resistance of the signal source is not limited in measurement ranges with other input voltages.

Preheating time of the amplifier, minutes, does not exceed	30
Amplitude value of noise voltage of the amplifier (including stray pickup and interference) in the normal region of frequencies, %, from the nominal values of output currents, does not exceed	4
Drift of the zero level, kV/h, adjusted to the input of the amplifier at an ambient air temperature of 20±5 degrees C after two hours of preheating, does not exceed	150
F1510 amplifier is fed from an alternating current network:	
voltage, V	$220^{+10\%}_{-15\%}$
frequency, Hz	50±2%
Power consumed from the power network, V·A	200
Dimensions, mm:	
bay-model amplifier	521X158X515
portable-model amplifier	589X170X489
Weight, kg:	
bay-model amplifier	27.5
portable-model amplifier	26.0

13.5. Direct Current Voltage Amplifiers

The Electrometric Amplifier U5-8 (Figure 13.2) is intended for measuring small voltages and weak currents of positively and negatively charged particles from sources with a high internal resistance.

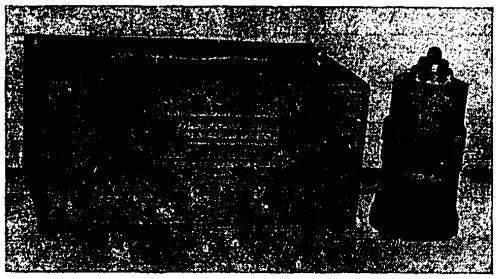

Figure 13.2

These devices are used in electrometry, mass spectrometry, and in various areas of physical and chemical measurements. The amplifiers are intended for operation at ambient air temperatures of 10-35 degrees C and a relative humidity of up to 80% at 20 degrees C.

The instrument operates on the principle of measuring weak currents by the voltage drop from the current being measured at a known resistance.

The measured current I from a source with a large internal resistance creates a voltage drop U on a known resistance R which is an element of a circuit of a hundred-percent parallel negative feedback of a direct-current amplifier with a large input resistance. The value of the measured current is determined by the formula $I = U_{output}/R$, where U_{output} is the output voltage of the amplifier; R is the resistance of the negative feedback circuit.

Voltage is measured with a circuit with a hundred percent sequence of negative feedback.

The amplifier set includes: 1) remote unit VB-1; 2) measuring unit; 3) connecting cable; 4) set of accessories and spare parts in a ZIP box; 5) storage box; 6) technical description and operation manual; 7) technical record.

Basic Specifications

Measured voltage, V	$\pm 10^{-3} \div \pm 100$
Nominal values of impedances of input resistors, Ohms	10^{12}, 10^{9}, 10^{6}
Measured currents, A	$\pm 3 \cdot 10^{-15} \pm 1 \cdot 10^{-4}$

Fundamental reduced error of voltage measurements, %, at voltage limits, does not exceed:

0.01 V	10
0.03 V	4
0.1 V	2.5
0.3-100 V	1.5

Error of current measurement is shown in Table 13.3.

Table 13.3

Падение напряжения на входном резисторе (1)	Погрешность измерения тока, %, при сопротивлении входных резисторов, Ом (2)		
	10^{15}	10^{9}	10^{6}
~~(3) (4)~~			
300 мВ; 1 В	5	2	2
100 мВ	6	3	3
30 мВ	10	5	5
10 мВ	15	10	10

Key: 1. Voltage drop on input resistor
2. Current measurement errors, %, at input resistor impedance, Ohm.

Maximum electric zero drift of the instrument at a constant ambient air temperature, does not exceed	2 mV in 20 min
Displacement current A, does not exceed	$\cdot 10^{-15}$
Output resistance of the amplifier, Ohms, not over.	5
Power supply of the instrument from an alternating current network:	
voltage, V	220 ± 22
frequency, Hz	50 ± 0.5
Power consumption of the amplifier from the network, V·A, does not exceed	40
Dimensions, mm:	
remote unit	100X145
measuring unit	360X184X223
Weight, kg	9.5

Direct-Current Measuring Amplifiers F756, F757, F758, F759 are intended for linear conversion of direct current voltage to a standardized direct-current output signal (F757, F759) or voltage (F756, F758).

These amplifiers can be used in complex automation systems in communication circuits of sensors of electrical and nonelectrical values with measuring and monitoring devices, in automatic control systems of technological processes for expanding the measurement limits of electrical measuring instruments.

The amplifiers are intended for operation at temperatures from 5 to 50 degrees C and a relative humidity of up to 80%.

Direct-current input voltage is converted to alternating voltage by modulators based on a bridge circuit using field-effect transistors. The alternating current amplifier consists of two amplification cells -- U1 and U2 using integrated microcircuits. The outputs stage of the amplification cell U2 uses a transformer circuit. A full-wave compensated transistor key with an RC-filter at the output is used as a demodulator. The prescribed technical parameters are obtained by introducing a noninverting sequence of voltage or current negative feedbadk.

The modulator and demodulator are controlled by a generator based on the Royer circuit. The pulse recurrence frequency is 2.5 kHz.

The instruments are designed in the form of a cassette suitable for installing in instrument bays, panels, and cabinets.

The instruments set includes: 1) jack plug; 2) cable plugs (2 items); 3) packing box; 4) manufacturer's rating certificate.

Input resistance, kiloohms, not less than	10
Input signal of the amplifiers changes within the following limits for the amplifiers:	
F756 and F758 on a load from 2 to 10 kiloohms .	$\pm$10 V
F757 and F759 at a load from 0 to 2.5 kiloohms.	$\pm$5 mA
Power supply from an alternating current network:	
voltage, V	220$\pm$10%
frequency, Hz	50
Power consumption from the network, V·A	7.5
Setting time of the output signal, seconds, not over	0.1
Dimensions, mm	40X180, 5X330
Weight, kg	2

Table 13.4

(1) Тип усилителя	(2) Диапазон измерения входной величины, мВ	(3) Коэффициент передачи	(4) Класс точности
Ф756 (5)	0±10	1000	1,0
	0±20	500	0,5
	0±50	200	0,2
	0±100	100	0,1
	0±500	50	0,1
	0±500	20	0,1
	0±1000	10	0,1
Ф757	0±10	0,5 мА/мВ	1,0
	0±20	0,25 мА/мВ	0,5
	0±50	0,1 мА/мВ	0,2
	0±100	0,05 мА/мВ	0,1
	0±200	0,025 мА/мВ	0,1
	0±500	0,01 мА/мВ	0,1
	0±1000	0,005 мА/мВ	0,1
Ф758	0±10	1000	1,5
	0±20	500	1,5
	0±50	200	1,0
	0±100	100	0,5
	0±200	50	0,5
	0±500	20	0,5
	0±1000	10	0,5
Ф759	0±10	0,5 мА/мВ	1,5
	0±20	0,25 мА/мВ	1,5
	0±50	0,1 мА/мВ	1,0
	0±100	0,05 мА/мВ	0,5
	0±200	0,025 мА/мВ	0,5
	0±500	0,01 мА/мВ	0,5
	0±1000	0,005 мА/мВ	0,5

Key: 1. Type of amplifier
2. Input value measuring range, mV
3. Transmission factor
4. Accuracy class
5. F756

13.6. Shaping Amplifiers

The Shaping Amplifier UF-1 (Figure 13.3) is intended for amplifying and converting electrical signals to negative-polarity rectangular-shape voltage pulses for delivery to electronic meters and frequency meters, as well as to rectangular-shape current pulses with a code characteristic for recording on an oscillograph.

The amplifier is a part of a set of a standardized bench-type conversion indicating electronic equipment for turbine flow sensors. A signal amplified to the necessary level is delivered to the input of the shaper, where it is converted to rectangular-shape pulses. Positive polarity rectangular-shape pulses are delivered from one of the outputs to input of the divisions decade D1, and negative-polarity pulses go from another output to one of the inputs of the current divider.

The dividion decade D1 is connected with the division decade D2. Each of decades ensures the division of the input pulse frequency by 10. Rectangular

Figure 13.3

pulses of negative polarity go from the code division decades D1 and D2 to the input of the logical assembly in which each tenth and ninetyninth pulse is separated. The separated rectangular pulses of positive polarities from the output of the logical assembly go to the second input of the current divider.

The current divider converts the rectangular voltage pulses arriving at both inputs to current pulses when each tenth and ninetyninth current pulses are not less than 1.5 times greater than the remaining pulses. The rectangular current pulses are delivered from the output of the current divider to a light-beam oscillograph.

The rectangular pulses of positive polarity from the output of the shaper and from the outputs of the divider decades D1 and D2 with a frequency of 1, 10, and 100 times, respectively, smaller than the input frequency are delivered through the assembly of emitter followers to electronic meters and frequency meters.

All circuits of the instrument are fed from an internal power supply source.

The instrument has a light indication of the passage of the signal to the output. In the "Control" mode, the light indication signals the operation capacity of the instrument and the condition of the current load circuit.

The UF-1 amplifier is a portable instrument and consists of a sectional frame, a rack, two planks, an amplifier, plate 1, plate 2, decades D1 and D2, and a rectifier. The sectional frame is the rigid front and back frames connected by cast rods. The front and back panels are secured in front and behind the rack. On the right side of the sectional frame, the rack is secured to the front and back frames, and two planks are secured on the left side.

From the top and below, the frame is covered by П -shaped cases with ventilation openings. The upper case has a carrying handle, and the lower case has the legs of the damper.

The instrument set includes: 1) shaping amplifier; 2) safety devices (2 items); 3) sockets (3 items); 4) cable plugs (3 items); 5) lamp SM-37; 6) neon lamp 1N-0.2-1; 7) technical description and operation manual; 8) manufacturer's rating certificate.

Basic Specifications

Frequency range of the sinusoidal-shape input signal, Hz	10-2000
Amplitude range of the input signal, mV	20-2000
Sensitivity threshold, mV, not over	20

Voltage pulses recurrence frequency at the outputs "1:1", "1:10", "1:100", less than the frequency of the input signal by 1, 10, 100 times respectively.

Voltage Pulse Parameters:

pulse duration, microseconds, not less than	50
edge length, microseconds, not over	20
pulse amplitude, V	from 6 to 12

Current pulse recurrence frequency at the "Output" is equal to the frequency of the input signal.

Each tenth and ninetyninth pulse have a code characteristic -- amplitude separation in relation to the remaining pulses. Current pulse parameters (at a load resistance of 20 Ohms):

pulse on-of-time ratio	2-3
amplitude adjustment limit of each ninth and ninetyninth pulse, mA, not less than	12-16
ratio of the amplitude of each tenth and ninetyninth pulse to the remaining pulses, not less than	1.5
Error in the ratio of the frequency of the input signal to the frequency of the output signals, not over	±0.05

Parameters checked: sensitivity threshold in the frequency range of 10-2000 Hz -- not over 20 mV; voltage pulse parameters -- at outputs "1:1"; "1:10"; "1:100" in the frequency range of 10-2000 Hz: current pulse parameters (at a load resistance of not over 20 Ohms) in the frequency range of 10-2000 Hz.

The error in the ratio of the frequency of the input signal to the frequency of the output pulses, %, not over ±0.05.

The main means of checking are: generators G3-49 and G3-56; oscillograph S1-65; K12-22; frequency meter Ch3-46; resistance box R-33; voltmeter V3-40. Checking conditions are normal.

The checking consists of external inspection, checking the operating ability, determination of metrological characteristics, and registration of the results of the checking.

13.7. Logarithmic Amplifiers

Logarithmic Amplifier U3-28. The U3-28 instrument is intended for expanding the dynamic range, increasing the sensitivity and accuracy in respect to amplitude measurements. When used together with instrument Kh1-38, it can be used also as an independent two-channel wide-band measuring amplifier with a linear and a logarithmic amplitude characteristics.

The instrument is a wide-band transistor amplifier with a nonlinear automatic gain control (ARU). The ARU can be turned off in order to create a linear mode with a regulated gain factor.

The instrument set includes: 1) tester; 2) attenuator 10 dB; 3) high-frequency connecting cables (5 items); 4) connecting cord; 5) storage box; 6) base; 7) electron tubes (2 items); 8) signal lamps (2 items); 9) safety devices (3 items); 10) manufacturer's rating certificate; 11) technical description and operation manual.

Basic Specifications

Nonuniformity of the amplitude-frequency characteristic, dB in the frequency ranges:	
0.5-50 MHz, not over	±1
20 kHz - 100 MHz, not over	±2
Dynamic ranges, dB, in the logarithmic scale	80; 60 and 40
Gain factor in the linear mode, dB	0-60
Nonlinearity of the amplitude characteristic, dB, in the linear mode	0.4
Nonidentity of amplitude-frequency characteristics of one channel in relation to another, dB	0.3
Voltage of the input signal of the amplifier, V:	
maximum	1
minimum	0.1

Maximum output high-frequency voltage, V, at a load of 75 Ohms	0.5
Input and output resistance of the matched channel, Ohms, at a voltage standing wave ratio of 1.2	75
Input impedance of a high-resistance tester, kilohms, connected in parallel with a capacitance of 10 pF in the frequency range of up to 30 MHz	30
Power consumption, V·A	60
Dimensions, mm	480X120X300
Weight, kg	13

CHAPTER 14

MEASURING GENERATORS

14.1. Noise Signal Generators

Noise Generators G2-41, G2-42, G2-43. The instruments are intended for use as noise signal sources in measuring noise factors of reception-amplifying devices and consist of a gas-discharge tube serving as a noise source and a transmitting line.

Noise generators are a section of a waveguide in the center of whose wide wall a gas-discharge tube is located. The inclined position of the tube in the waveguide ensures an even introduction of losses during the discharge on a sufficiently long line, due to which it is possible to achieve the required matching of the noise generator with the transmission line in a wide frequency range.

In order to reduce resonance phenomena, the noise generator G2-43 has a narrow slit cut out in the middle of the wide walls of the waveguide and the shielding tube of the generating section.

The instrument set includes: 1) set of spare parts; 2) set of bracing devices; 3) manufacturer's rating certificate.

Basic Specifications

The working frequency range and the connecting dimensions of the output waveguide are shown in Table 14.1

The value of the spectral density of the noise power is recorded in the rating certificate for the instrument.

Standing wave ratio of the output of the generator, not over:

with a cold tube	1.3
with a burning tube	1.25

Table 14.1

(1) Характеристики	(2) Тип генератора Г2-41	Г2-42	Г2-43
Диапазон частот, ГГц (3)	12,04—17,44	17,44—25,86	25,86—37,5
Сечение волновода, мм (4)	17X8	11X5,5	7,2X3,4
Габариты, кг (5)	396X63X35	396X55X29	286X65X24

Key: 1. Characteristics
2. Generator type
3. Frequency range, GHz
4. Waveguide section, mm
5. Dimensions, mm

The Coaxial Noise Generators G2-5B, G2-6B are intended for use as a source of a calibrated noise signal in measuring the noise factor and the amplification factor of reception-amplifying devices.

These generators belong to Group IV of GOST 9763-67 with respect to their stability to climatic and mechanical influences.

The noise source is the gas-discharge tube in the coaxial line. The necessary matching of the tube with the coaxial line is ensured by the selection of the diameter and the winding pitch of the spiral within the coaxial line.

The generator has two high-frequency connectors: a matched load is connected to one of them, and the other is intended for removing the noise signal.

The generator set includes: 1) modulator; 2) matched load with a constant phase; 3) plug connector; 4) cable; 5) releasing device; 6) assembling key; 7) coaxial adapters (2 items); 8) gas-discharge tubes; 9) storage box; 10) technical description, operation manual, and manufacturer's rating certificate.

Basic Specifications

Generated frequency ranges, GHz, for generators:	
G2-5B	0.5-2
G2-6B	0.8-4
Wave resistance, Ohms, for generators:	
G2-5B	75
G2-6B	50
Dimensions, mm	78X48X455
Weight, kg	1.6

14.2. Low-Frequency Signal Generators

Generator G3-54. This functional generator which is a source of sawtooth, rectangular, and sinusoidal electrical oscillations of the infrasonic and audio frequencies is intended for tuning and testing various electronic instruments under laboratory and plant conditions. The instrument satisfies the requirements of Group II of GOST 9763-67.

The generator operates on the principle of functional conversion of the initial form of voltage to prescribed forms. The sawtooth form is taken to be the initial form of voltage. The generator consists of the following functional assemblies: constant-temperature master generator of sawtooth oscillations; buffer stage; sawtooth voltage amplifier; shaper; trigger; output amplifier; temperature control device; smooth and step attenuators; power supply unit.

The output of the generator is unsymmetrical.

The sawtooth voltage produced in the master generator goes, through the buffer and linear amplifiers, to the shaper, where it is converted to a sinusoidal-shape voltage and is delivered to the output amplifier. Here, the signal is amplified and, through the smooth and step attenuators, is delivered to the output of the generator.

In order to obtain a rectangular-shape voltage at the output of the generator, a signal from the same master generator, through the buffer amplifier, is delivered to the trigger, from which the signal of the rectangular-shape voltage arrives at the output amplifier and further through the same assemblies arrives at the output of the generator.

In order to obtain a sawtooth-voltage at the output of the generator, a signal from the master generator, through the buffer amplifier of sawtooth voltage, is delivered to the output amplifier, and then, through the smooth and step attenuators, to the output of the generator.

The generator can work in two modes: continuous generation, or generation of one period with manual triggering.

The instrument set includes: 1) connecting cable; 2) safety fuses (20 items); 3) manufacturer's rating certificate.

Basic Specifications

Generator generates signals of three kinds: sawtooth, rectangular (meander), sinusoidal, as well as marking signals to a special output.

Frequency range, Hz 0.01-1000

Subranges: from 0.01 to 0.1 Hz; from 0.1 to 1 Hz; from 1 to 10 Hz; from 10 to 100 Hz; from 100 to 1000 Hz.

Permissible fundamental error $\pm(0.03\ F + 0.02\ F_{max})$ Hz, where F -- generated frequency; F_{max} -- maximum subrange frequency.

Nominal amplitude voltage, V, on a load of 600 Ohms	7.75
Range of smoothly regulated output voltage, V (for all signal shapes)	1-10

Provisions are made for changing the output voltage by 60 dB in steps every 20 dB.

Step attenuator error, dB, at frequencies from 20 to 1000 Hz, does not exceed	0.5

Back swing time of sawtooth voltage and length of the cut-off fronts, microseconds, for rectangular pulses, does not exceed 0.01 T + 50 (T -- oscillation period).

Nonlinearity of sawtooth voltage, %, in the frequency range from 0.01 to 0.1 Hz, does not exceed	5
Harmonic distortion factor of the sinusoidal output voltage, %, on frequencies of 20-1000 Hz at a nominal output voltage, does not exceed	6
Pulse amplitude, V, at the marking output, not less than	1
Power supply of the generator -- from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50±1
Power consumption, V·A	150
Dimensions, mm	485X405X270
Weight, kg	30

The following operations are performed during checking.

The presence of all forms of the output voltage is checked visually in a range of 100-1000 Hz by means of an oscillograph.

The frequency error is determined by measuring the frequency at the output of the instrument (in the mode of the generation of sinusoidal oscillations at an output voltage of 1-10 V) in a range of 100-1000 Hz and by measuring the period in the remaining frequency range by any method.

Amplitudes of all forms of the output voltage are measured at a frequency of 0.01 Hz with a direct current voltmeter, in a range of 20-1000 Hz -- by any method ensuring the amplitude measurements with an error of not more than 0.5%.

The duration of the fronts of sawtooth rectangular voltage is determined with the aid of an oscillograph with calibrated scanning.

The nonlinearity of the sawtooth voltage in the frequency range 0.01-0.1 Hz is checked by means of an EPP-09M2 recorder. The harmonic distortion factor of the sinusoidal output voltage is checked with a nonlinear distortion meter in a frequency range of 20-1000 Hz.

The amplitude of the marking pulses is determined with the aid of a voltage-calibrated oscillograph.

Low-Frequency Signal Generator G3-55. This instrument is intended for use in a set of monitoring equipment for quality indexes of frequency-modulated and amplitude-modulated transmitters, broadcasting channels, and television sound channels, and can be used only in a bay (Figure 14.1).

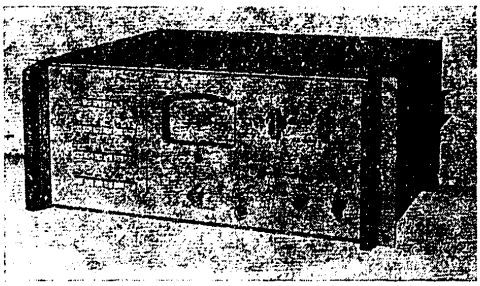

Figure 14.1

The instrument is designed to operate under the conditions of the fields of amplitude-modulated and frequency-modulated transmitter of up to 20 V/m.

The generator meets the requirements of GOST 9763-67. With respect to its stability to mechanical and climatic influences, the instrument belongs to Group II of GOST 9763-67 with expansion of the operating temperature range from 5 to 50 degrees C.

The generator consists of eight units: master generator; amplifier NChI [low-frequency I]; amplifier NChII; power supply unit; transformer; level meter; attenuator and output units.

The master generator with resistance-capacitance tuning based on the Wien circuit generates a sinusoidal signal which is amplified by the amplifier NChI ensuring the required output power at the unsymmetrical output. The balancing of the signal output is achieved by using an additional amplifier NChII with a transmission factor of 1.

The level of the output voltage is monitored by the level meter which serves simultaneously as an indicator of the instrument's operation capacity. The output voltage is regulated smoothly with the aid of a regulator installed in the input circuit of the amplifier NChI, and is regulated in steps with the aid of attenuators installed at the output of both amplifiers.

The power supply unit provides stabilized voltage for the master generator, both amplifiers, and the level meter.

The generator is designed as a standard bay type whose frame consists of two cast carrier brackets.

The instrument set includes: 1) set of spare parts and accessories consisting of: safety devices (4 items), power supply cord, connecting cable, headpiece with clamps, adapter, incandescent lamp, push-button switch; 2) description and operation manual, manufacturer's rating certificate; 3) description of nonstandard measuring instruments.

Basic Specifications

Generator produces a sinusoidal signal at 20 fixed frequencies: 30; 50; 60; 100; 120; 200; 400; 800; 1000; 2000; 4000; 5000; 6000; 7000; 8000; 8500; 10,000; 12,000; 15,000; 20,000 Hz.

Fundamental frequency error, %, not over	±1.5
Nominal output voltage, V, at the symmetric output at a matched load with output resistance,	
600 Ohms	4
50 Ohms	2
at the unsymmetric output with output resistance of 50 Ohms at a load resistance of 600 Ohms	4
Maximum output voltage, V, under normal conditions at load resistances:	
600 Ohms, not less than	5.2
50 Ohms, not less than	2.5
Output voltage asymmetry at the symmetric output,%, at output resistances:	

600 Ohms, does not exceed	5
50 Ohms, does not exceed	10

Frequency characteristic nonuniformity, %, in relation to the signal level on a frequency of 1000 Hz in temperature intervals from 5 to 25 degrees C for frequency ranges, does not exceed:

from 30 to 10,000 Hz	2.5(0.2 dB)
from 12,000 to 20,000 Hz	3.5(0.3 dB)

For temperature intervals from 25 to 50 degrees C, this nonuniformity, %, does not exceed 7

Normalized fundamental error of the level meter, %, does not exceed 2.5

Frequency characteristic nonuniformity of the level meter, %, in relation to the level in the frequency ranges, does not exceed:

from 30 to 1000 Hz	1.5
from 12,000 to 20,000 Hz	2

At the output with a load resistance of 600 Ohms, the sinusoidal signal is attenuated by the attenuator operating on a matched active load with a nominal resistance value of 600 Ohms by -60 dB (in steps at every 1 dB).

Harmonic distortions, %, at a load resistance of 600 Ohms and nominal output voltage at unsymmetric and symmetric outputs on frequencies,

30 Hz	0.15
from 50 to 120 and 12,000 to 20,000 Hz	0.1
from 200 to 10,000 Hz	0.05

Harmonic distortions, %, at a load resistance of 50 Ohms and nominal output voltage at the symmetric output on frequencies:

40; 50; 60 Hz	0.2
100; 120 Hz	0.15
from 200 to 20,000 Hz	0.1

The largest variable component of supply voltage and its four harmonics, %, against the nominal output voltage on both outputs, does not exceed 0.025

Power supply from an alternating current network:

voltage, V	220±10%
frequency, Hz	50/60±1%
harmonic content, %	up to 5

Power consumed by the instrument, V·A	60
Dimensions, mm	520X215X520
Weight, kg	30

Low-Frequency Signal Precision Generator G3-105. The instrument is a source of sinusoidal electrical oscillations with a high degree of accuracy and stability of frequency in the range from 0.01 Hz to 2 MHz.

The instrument is intended for operation at ambient air temperatures from 5 to 40 degrees C and a relative humidity of up to 95% at an ambient air temperature of 30 degrees C and an atmospheric pressure of (96-104) kPa.

The generator is designed by the method of direct synthesis of signals of prescribed frequencies with the aid of a system of identical decade converters. All of them work on the same frequencies. The circuit uses 10 reference frequencies: 18; 18.1; 18.2; 18.3; 18.4; 18.5; 18.6; 18.7; 18.8; 18.9 MHz formed in advance in the reference frequency unit.

Reference frequency signals are amplified by the output amplifiers and are delivered through the electronic signal switch to the decade converters.

Reference frequency is selected by pressing the buttons on the front panel of the generators.

The system of decade converters consists of seven identical decades each of which is a mixer with a band filter and a frequency divider with the division factor 10.

The generator has an interpolation heterodyne whose frequency changes within the range from 18 to 19 MHz. The heterodyne can be connected to any decade converter for a complete change of the output frequency in any position.

The generator is designed in the form of two portable instruments: generator proper and power supply unit.

The instrument set includes: 1) signal generator; 2) power supply unit; 3) combination set; 4) cables (10 items); 5) clamp; 6) 50 Ohm load; 7) divider 1:100; 8) T-joint; 9) sockets (3 items); 10) intermediate socket; 11) brace; 12) switching unit; 13) plug; 14) indication lamps (2 items); 15) signal lamps (3 items); 16) safety devices (8 items); 17) storage box; 18) technical description and operation manual; 19) technical record.

Basic Specifications

Main frequency range, Hz	10-1999999.99
Additional frequency range, Hz	0.01-10

Minimal step of discrete frequency adjustment, Hz..	0.01
Fundamental relative error of discrete frequency values, not over	$\pm 5 \cdot 10^{-7}$
Relative frequency instability at discrete points, does not exceed during arbitrarily selected:	
three-hour or one-hour intervals	$\pm 5 \cdot 10^{-3}$
15-minute interval	$\pm 2 \cdot 10^{-3}$
Maximum output voltage, V, at the main output with a connected external load of 50±0.25 Ohms, not less than	1
Output voltage is regulated by the built-in attenuator within the limits of, dB:	
in steps (every 10 dB)	60
continuously	12
Remote 1:100 divider connected to the jack ensures attenuation, dB	40
Fundamental error of the adjustment of the reference level of the output voltage from the final value of the measurement range of the built-in output level meter, does not exceed	±6
Error of the attenuator and the remote divider, dB, does not exceed	±0.5
Maximum output voltage, mV, at the auxiliary output with a connected external load of 10 kOhms, not less than	50
The instrument can work from an external reference generator:	
with frequency, MHz	5 and 10
with signal amplitude, mV	150-250
Power supply of the generator from an alternating current network:	
voltage, V	220±22
with frequency, Hz	50±0.5
with harmonic content, %	5
Instrument self-heating time, hours	2
Power consumed by the instrument from the network at a nominal voltage, V·A	150

Dimensions, mm:	
generators	480X240X470
power unit	480X120X470
Weight, kg:	
generators	30
power unit	18

Low-Frequency Signal Generator G3-101. This instrument is intended for regulating and testing radio equipment under laboratory and shop conditions, and meets the requirements of GOST 9763-67.

The G3-101 is designed as a bench-type portable instrument which includes two separate units. The first unit consists of: a power unit, an impulser, a control generator, an operation mode unit, an output unit, and attenuators. The second unit includes: frequency dividers; a high-frequency, a low-frequency, and a fixed generators; a frequency manipulator, a thermistor, and a voltage divider.

The instrument set includes: 1) cables (8 items); 2) 1:100 divider; 3) 75 Ohm load; 4) clamps (4 items); 5) transition plates; 6) adapters (2 items); 7) cable plugs; 8) T-joints (2 items); 9) safety devices (4 items); 10) lamps (2 items); 11) covers (2 items); 12) description, operation manual; 13) technical record.

Checking methods are described in the operation manual included in the set.

Basic Specifications

Frequency range of the instrument (with discrete points every 1 kHz), kHz	$1\text{-}2\cdot10^3$
Fundamental error of the adjustment of discrete frequency values, not over $\pm1\cdot10f$ (f -- output signal frequency).	
There is a possibility of frequency separation in the instrument at any of the discrete points within the limits of, Hz	±500
Voltage of spurious frequencies at the output, with the exception of the harmonic components of the signal, is weakened in relation to the level of the useful signal:	
in the frequency band of ±250, not less than	by 500 times
in the entire remaining frequency range	1000
Level of the largest harmonic component of the output signal, %	5

Overall dimensions of the packing of each unit, mm	695X390X560
Weight of the instrument, kg:	
without packing	22
with packing	40

The method of checking is described in the operation manual included in the set.

The Low-Frequency Signal Generator G3-36A is a portable source of sinusoidal and rectangular electrical oscillations of the sonic and ultrasonic frequencies. It is intended for regulating and testing low-frequency and ultrasonic stages of radio equipment under laboratory and industrial conditions.

The generator consists of the following main units: exciter; sinusoidal signal output amplifier; matching amplifier; square signal shaper; square signal output amplifier; voltage divider; output indicator; stabilizer.

The exciter of the generator is based on the Wien bridge circuit; the positive feedback circuit contains an L-type phasing circuit.

All electric equipment is assembled in a standard portable bench-type caseless housing.

The instrument set includes: 1) low-frequency signal generator G3-36A; 2) connecting cords (2 items); ?) alligator clips (2 items); 4) technical description and operation manual; 5) technical record.

Basic Specifications

Frequency range of 20 Hz - 200 kHz is covered by four subranges:	
X1	20-200
X10	200-2000
X100	2000-20,000
X1000	20,000-200,000
Fundamental error of frequency adjustment not over $\pm(3+150/f_H)\%$, where f_H is the value of frequency in hertz as established by the scale.	
Temperature coefficient of frequency, %, in the operating temperature interval per each 10 degrees C, does not exceed	1
Provisions are made in the generator to regulate output voltage smoothly. The nominal value of the output voltage, V, at a frequency of 1000 Hz and a load of 600 Ohms, not less than	5

At the output, there is a three-step divider ensuring the division of the output voltage by 10, 100, 1000 times.

Error of division coefficient, dB, not over	±0.8
at load resistance, kOhms, not less than	20
Error in the adjustment of the reference value of the output voltage in % of the upper measurement level in the entire frequency range, does not exceed	±6
Harmonic distortion factors at a nominal output voltage and load resistance of 600 Ohms in the frequency ranges:	
20-50 Hz	2
over 50 Hz - 20 kHz	1
20-200 kHz	2
Additional value of the harmonic distortion factor, %, per each 10 degrees C, does not exceed	1
Generator has a square signal mode with the following characteristic:	
Repetition frequency corresponds to the frequency of the sinusoidal signals; maximum amplitude of the output voltage, V, not less than	5
Fundamental reduced error of the level meter, %, for the square signal, not over	±20
Length of the edge and cutoff of the square signal, ns, at a load resistance of 600±6 Ohms in the entire repetition frequency range, does not exceed	300
Square signal on-off time ratio at a load resistance of 600±6 Ohms in the entire repetition frequency range	2+0.4
Power supply of the instrument from an alternating current network:	
voltage, V	220+22
frequency, Hz	50±0.5
harmonic content, %	5
Power consumed by the instrument, V·A	9
Instrument weight, kg, not over	5
Dimensions, mm, not over	235X240X170

The generator is checked in accordance with GOST 12691-67 "Low-Frequency Generators. Methods and Means of Checking".

14.3. High-Frequency Signal Generators

The High-Frequency Signal Generator G4-70 is intended for checking and tuning various radio receiving devices and their elements operating in the modes of amplitude modulation (AM), frequency modulation (ChM) and television signal modulation. The instrument can be used in laboratories and workshops producing the above-mentioned equipment, in repair shops, and in television studios.

The generator G4-70 ensures voltage modulation by high-frequency television signals of both polarities.

The wide band of modulating frequencies during frequency modulation and amplitude modulation ensures the possibility of the modulation of high-frequency voltage by a stereosignal.

The small value of parasitic frequency modulation makes it possible to check the set background of high-quality television sets and receivers of frequency-modulated broadcasting.

The generator performs the following types of operations: continuous generation; internal amplitude modulation by sinusoidal voltage; external amplitude modulation by sinusoidal voltage; internal frequency modulation by sinusoidal voltage; external frequency modulation by sinusoidal voltage; a combined frequency-amplitude modulation by sinusoidal voltage; internal amplitude modulation by a meander; external amplitude modulation by a video signal at frequencies above 20 MHz; external pulse modulation at frequencies above 20 MHz.

The G4-70 generator set includes: 1) high-frequency cable; 2) coaxial adapter; 3) repair cable; 4) high-frequency connecting cables (2 items); 5) connecting adapter; 6) power supply cable; 7) safety devices (20 items); 8) storage box; 9) technical description, operation manual, and manufacturer's rating certificate.

Basic Specifications

Frequency range, MHz, covered by eight subranges ..	4-300
Fundamental error of frequency adjustment, %	1
Short-term frequency instability in 15 minutes 1.5 hours after self-heating	$15 \cdot 10^5$
Parasitic frequency modulation in the mode of continuous generation, Hz, at:	

f $\leq$ 225 MHz	75
f $>$ 226 MHz	10^{-6}

Output Parameters in the Mode of Continuous Generation:

Output voltage, mV, at a load of 75 Ohms:	
calibrated	$5 \cdot 10^{-4} \div 50$
uncalibrated	up to 100
Error of reference voltage, %, at:	
f $\leq$ 250 MHz	10P
f $>$ 250 MHz	25
Adjustment error of the system of attenuators, %, at:	
f $\leq$ 250 MHz	1.2
f $>$ 250 MHz	1.5
Parasitic amplitude modulation, %	0.3

Parameters of Amplitude Modulation by Sinusoidal Signal:

Frequency of internal amplitude modulation, Hz	1000
Range during external amplitude modulation, Hz	50-6000
Limits of modulation depth regulation, %	10-95
Fundamental error of modulation depth adjustment on frequencies above 8 MHz at M=10 $\div$ 90% and M=10 $\div$ 50%	$\pm$0.05 M + 5
Parasitic frequency modulation during amplitude modulation at M=30%	$2 \cdot 10^{-5}$ f+300 Hz

Parameters of Frequency Modulation by Sinusoidal Signal:

Frequency of internal frequency modulation, Hz	1000
Frequency range, Hz, during external frequency modulation	30-60,000
Regulation limits of frequency deviation, kHz, at:	
f = 4 $\div$ 6 MHz	up to 50
f = 6 $\div$ 20 MHz	up to 75
in the remaining range	up to 100
Nonlinear distortion coefficient during frequency modulation, %, not over	3

Fundamental measurement error, %	10
During frequency modulation, the parasitic amplitude modulation, %, at deviation of 75 kHz, not over ...	6
Modulation Parameters by a Pulse Signal and a Video Signal:	
Frequency range, Hz, during external modulation by video signal	$50 \div 6.5 \cdot 10^{-6}$
Frequency characteristic nonuniformity, dB	1
Variation limits of depth modulation, %	10-90
Variation of the maximum "black" level, % during changes in modulation depth	8
Distortion of horizontal sections, %, of a square symmetric pulse with a frequency of 50 Hz	3
Power supply -- from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50-60
Power consumption, V·A	115
Dimensions, mm	540X300X350
Weight, kg	30

The Generator of Standard Signals G4-73 is an instrument with a quartz frequency control within the range which puts out an output signal of a calibrated level with various types of modulation and is intended for controlling and monitoring receiving and transmitting communication systems with various types of modulation, including single-band modulation, within the frequency range of 0.1-70 MHz.

The generator can be used for checking frequency and amplitude distortions of narrow-band channels of UPCh [intermediate-frequency amplifiers].

The instrument meets the requirements of GOST 9763-67, GOST 9788-69 and maintains its technical characteristics at the ambient temperature from 5 to 40 degrees C, low pressure, and a relative humidity of 95% at a temperature of 30 degrees C.

The generator is a source of a highly stable radio signal which can have various types of modulation, as well as a single frequency, a two-frequency, and a three-frequency structure.

The generator is arranged in three cases (decade converter, modulator unit, and power supply unit) placed one on top of the other and connected by cables. The instrument is designed with the use of replaceable units. Each mode can be obtained with a set of a definite combination of units inserted in the appropriate compartment of the instrument.

The instrument set includes: 1) replaceable units; 2) ZIP [kit of spare parts, tools and accessories]; 3) operational documentation.

Basic Specifications

Discrete frequency retuning, kHz	10
Frequency range, MHz	185-255
Relative error of frequency adjustment in the unmodulated carrier mode at fixed points of the range of 01-70, MHz, not over	$\pm 1 \cdot 10^{-7}$
Short-term frequency instability in the unmodulated carrier mode in 10 minutes of the instrument's operation under normal conditions at fixed points of the range of 0.1-70 MHz, not over	$\pm 1 \cdot 10^{-7}$
Output voltage at a resistance of 50 Ohms in the frequency range of 0.1-70 MHz changes in steps every 1 V with smooth coverage within the step, V	10^{-7}-0.1
Reference value of output signal voltage, V	0.1
Error of reference level, %, not over	10

The high-frequency signal generator G4-93 (Figure 14.2) is intended for checking and tuning radio receiving, radio transmitting, and other radio engineering equipment within the ranges of long, medium, and shortwaves under laboratory and workshop conditions.

With respect to its stability to climatic and mechanical influences, the generator belongs to Group II of GOST 9763-67, and with respect to its technical characteristics -- to Class I of GOST 10622-70.

The generator has ten functional assemblies: master self-oscillator; modulator; high-frequency amplifier; amplifier of automatic gain control ARU, attenuator; indication amplifier; quartz calibrator; beat indicator; RC generator; power supply unit.

Operation modes -- continuous generation, internal and external modulation by sinusoidal signal.

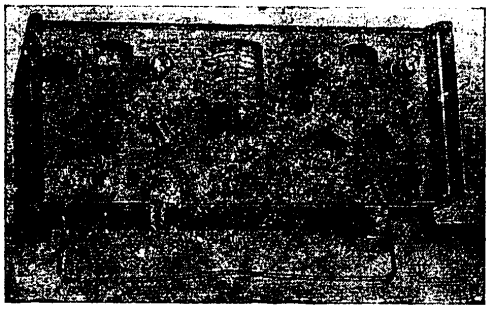

Figure 14.2

The generator set includes: 1) connecting cord; 2) high-frequency connecting cables (4 items); 3) 50 Ohm load resistor; 4) 50 to 75 Ohm adapter; 5) 1:10 divider; 6) safety fuses (10 items); 7) technical description, instructions for periodic checking, manufacturer's rating certificate.

Basic Specifications

Frequency range, MHz	0.01-0.050
Frequency scale error, %	0.5
Modulation depth adjustment limits, %, at an input signal of not over 1 V, not less than	0-100
Error in the establishment of the reference level of 1 V at a load of 50±0.5 Ohms for all frequency ranges, does not exceed, dB	±0.5
Fundamental error in the establishment of the modulation depth coefficient at a modulation depth of up to 90% in % of the absolute value of the modulation coefficient, does not exceed	±5
Error in the weakening of the attenuator for the attenuations:	
from 0 to 80 dB	±0.6
over 80 to 140 dB	±1.0

Frequency instability in any 15 minutes of the instrument's operation under normal conditions after one hour of self-heating, does not exceed $\pm(40 \cdot 10^{-6} f_{est} + 10)$ Hz (f_{est} -- established frequency value).

Instrument's power supply from an alternating current network:	
voltage, V	200±(8÷10)%
frequency, Hz	50±1%
harmonic content, %	up to 5
Dimensions, mm	480X200X355
Weight, kg	18

The High-Frequency Signal Generator G4-102 (Figure 14.3) is intended for tuning, regulating, and monitoring radio receiving equipment of the radio broadcasting range. These generators are used to measure frequency and amplitude characteristics of various devices, real sensitivity and fidelity curves of receivers.

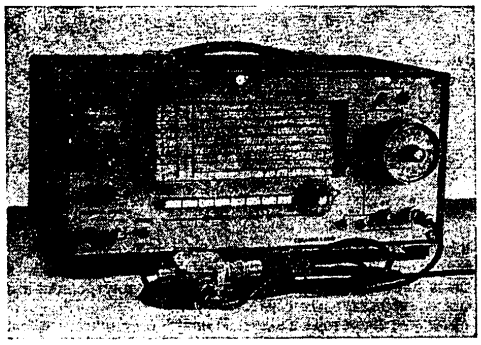

Figure 14.3

The instruments are intended for operation under laboratory and workshop conditions and belong to Group II of GOST 9763-67.

These signal generators consist of three main functional systems: a system for setting and reading signal frequencies; a system of setting and reading modulation depths; a system for forming and reading the output signal level

Stabilization of the output signal level is ensured at a constant reference voltage.

The generator set includes: 1) high-frequency cables (2 items); 2) low-frequency cable; 3) remote attenuator; 4) safety fuses (10 items); 5) technical description, operation manual, and manufacturer's rating certificate.

Operation modes -- continuous generation and amplitude modulation.

Basic Specifications

Frequency range, MHz	0.1-50
Adjustment limits of the output signal level in the main channel, V	10^{-7} - 0.5
Frequency setting error, %, not over	1
Frequency instability in 15 minutes after 30 minutes of self-heating, not over $\pm(2.5 \cdot 10^{-4} f_{est} + 50)$ Hz, where f_{est} -- established frequency value.	
Harmonic distortion factor of the output signal (at the main output), %, not over	5
Error in setting the reference voltage level, dB, not over	1
Error in the establishment of the modulation depth, %, not over	10
Error in the establishment of the weakening of the attenuator, dB, not over	1.5

14.4. Pulse Generators

The Generator of Code Pulse Packets G5-37 (Figure 14.4) is intended for tuning and testing radio electronic equipment.

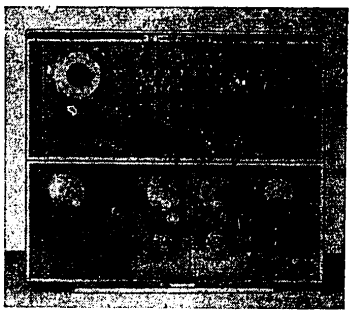

Figure 14.4

The instrument works at temperatures from 5 to 40 degrees C, maximum relative humidity of 95% at a temperature of 35 degrees C and satisfies the requirements of GOST 9763-67, GOST 11113-72.

The generator produces a packet or groups of packets of pulses with changing parameters (amplitude, length, time spacing). The repetition period of code packets is determined either by a timing oscillator or by an external generator.

Pulses of the external timing generator are sent to the unit forming the triggering pulse of the generator unit, the synchropulse, and the preparation pulses. The generator unit produces a series of pulses which enters the next unit which forms the output code signal and auxiliary control signals of other units.

The code signal goes to the unit forming the length of the output pulses, after which it goes to the output unit which forms the prescribed amplitudes, the edges, the falloff, and other parts of pulses.

The generator set includes: 1) a set of spare parts and accessories in a storage box; 2) manufacturer's rating certificate, technical description, and operation manual; 3) technical record.

The generator of code pulse packets operates in the following modes: one 40-unit code; two consecutive 20-unit codes; three consecutive 10-unit codes; four consecutive 10-unit codes; four parallel 10-unit codes; delivery of a packet of pulses coded by their length with a maximum number of pulses of not over 20 in the packet.

Provision is made for the possibility of deviation of selected individual pulses in the packet while maintaining the parameters of the remaining pulses.

Basic Specifications

Repetition period of code packets of pulses with internal triggering (regulated), microseconds	$20\text{-}10^6$
Time interval between code packets, microseconds ..	$1\text{-}10^6$
Time shift, microseconds, between units in the code packet	$1\text{-}10^4$
Pulse duration in the code packet, microseconds ...	0.4-5000
Maximum pulse amplitude, V, in the code packet at a load of 75 Ohms	10
Pulse polarity in the code packet -- positive or negative.	

Pulse edge length, ns, in the packet at an external load of 75 Ohms, not over	50
Pulse fall-off length, ns, at a load of 75 Ohms, not over	75
The attenuator at the output of the generator ensures signal attenuation, dB (in steps every 10 dB)	by 50
Error in the establishment of the amplitude of output pulses at the input of the attenuator, %, does not exceed	10
External triggering by a pulsed and sinusoidal signal with an amplitude, V, of	2-25
Power supply of the generator from an alternating current network:	
voltage, V	$220\pm10\%$
frequency	$50\pm1\%$
harmonic content, %	5
voltage, V	$200\pm5\%$
frequency, Hz	$400^{+7}_{-3}\%$
Power consumed by the generator, V·A	220
Dimensions, mm:	
generator	450X380X380
converter	410X375X210
Weight, kg:	
generator	23
converter	17

Test Pulse Generator Sets G5-39, G5-40, G5-41. The generator G5-39 is used in combination with the generator G5-41 for checking the vertical beam deflection channel of oscillographs with a frequency band of 0-100 MHz by the transient characteristics; the generator G5-40 (Figure 14.5) is used in combination with the generator G5-41 (Figure 14.6) for checking the channel of oscillographs with a frequency band of 0-40 MHz.

The generator set can be used also for checking video amplifiers by the transient characteristics in the same frequency ranges.

Generators G5-39 and G5-40 are designed as single-unit instruments, and G5-41 -- as a two-unit instrument.

Generators G5-39 and G5-40 work in the internal triggering mode. Output pulses are formed by the test pulse shaping unit which consists of two independent pulse shaping channels.

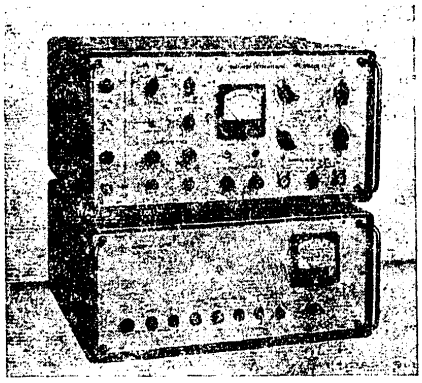

Figure 14.5

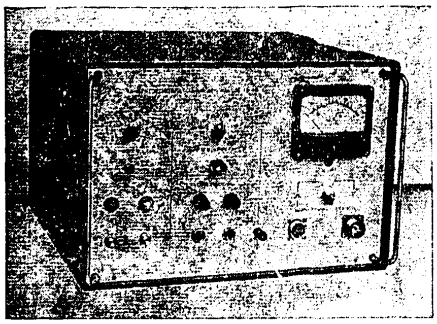

Figure 14.6

The instruments put out synchropulses intended for triggering the scanning units of oscillographs being tested. The time shift between the test pulses and synchronizing pulses creates the delay circuit of the test pulse. Continuous monitoring of the output pulse amplitude is achieved with the aid of the amplitude measuring unit connected to tne appropriate output stages. The external attenuator which is included in the set is used for regulating the test pulse amplitude. The power unit converts the network voltage to direct voltage and alternating voltage for all circuits of the instrument.

The generator G5-41 consists of two identical channels each of which has circuits corresponding to G5-39 and G5-40.

The G5-39 generator set includes: 1) storage box for the set of spare parts and auxiliary items; 2) compensation heads (2 items); 3) 50-Ohm passage load; 4) 50-75 Ohm matching transition; 5) 1:10 divider with a low-resistance output; 6) attenuator; 7) electron tubes (7 items); 8) incandescent lamps (2 items); 9) neon lamps (2 items); 10) safety devices (16 items); 11) angle brackets (2 items); 12) cables (5 items); 13) technical description and operation manual; 14) manufacturer's rating certificate.

The G5-40 generator set includes: 1) storage box for the set of spare parts and auxiliary items; 2) compensation heads (2 items); 3) 75-Ohm coaxial passage load; 4) 75-50 Ohm matching transition; 5) 1:10 divider with a low-resistance output; 6) attenuator; 7) cables (5 items); 8) electron tubes (7 items); 9) incandescent lamps (2 items); 10) neon lamps (2 items); 11) safety devices (16 items); 12) angle brackets (for mounting in the bay) (2 items); 13) technical description; 14) manufacturer's rating certificate.

The G5-41 generator set includes: 1) storage box with working and auxiliary equipment; 2) cables (9 items); 3) 100-75 Ohm transition; 4) 1:10 dividers (2 items); 5) 5 kOhm and 100 Ohm loads (2 items); 6) angle brackets (2 items); 7) electron tubes (4 items); 8) incandescent lamps (2 items); 9) neon lamps (2 items); 10) safety devices (10 items); 11) compensation head; 12) technical operation description; 13) manufacturer's rating certificate.

Basic Specification

Generator G5-39

At an external matched load of 50 Ohms, the instrument puts out test pulses of positive and negative polarity.	
Edge length of the test pulse, ns, does not exceed	1.2
Fall-off length, ns	10
Test pulse length at a 0.5 amplitude level, ns, not less than	300
Overshoot at the peak, %, from the pulse amplitude, does not exceed	2
Incline of the flat part of the peak, %, from the pulse amplitude, not over	3
Amplitude of test pulses, V, at an external matching load of 50 Ohms, not less than	50

Error, %, with which the amplitude is monitored, not over	±10
Repetition frequency of test pulses, kHz	1;3;5;10
Frequency adjustment error, %, not over	±10
Provision is made for delivering a single pulse. Parameters of synchropulses are of both polarities:	
pulse length, microseconds	0.3±0.1
edge length, not over	30
Amplitude, V, at a load of 500 Ohms, not less than.	20
Smooth amplitude adjustment, in % of the maximum value	10-100
Synchropulse lead in relation to the test pulse is regulated continuously and in steps within the limits of, ns	0-300
Short-term lead instability, ns, during 0.1 sec does not exceed	0.3
Power supply from an alternating current network:	
voltage, V	220±10%
frequency, Hz	50±1%
harmonic content, %	5
Power consumption, V·A	450
Dimensions, mm	480X318X435
Weight, kg	35

Generator G5-40

Test pulses are obtained from the external matched load of 75 hms.	
Edge length, ns, does not exceed	3
Fall-off length, ns	20
Duration at a 0.5 amplitude level, microsecond, not less than	1
Overshoot at the peak, %, from the pulse amplitude, does not exceed	2

Nonuniformity of the flat part of the peak to the point of 90% of its duration, %, from the pulse amplitude, does not exceed	1.5
When a capacitance of up to 40 pF is connected to the parallel matched load, the overshoot and the nonuniformity of the flat part of the peak do not exceed the above values, with the exception of deviation caused by repeated reflection from the generator input.	
Incline of the flat part of the peak, %, of the pulse amplitude, does not exceed	3
Amplitude of test pulses at an external matched load resistance of 75 Ohms, not less than, V	100
Amplitude adjustment error, %, not over	±10
Attenuation of the test pulse is achieved with the aid of an external attenuator and matching transitions included in the set. Provision is made for delivering a a single pulse.	
Frequency adjustment error, %, not over	±10
Test pulse repetition frequency, kHz	0.1; 0.3; 3
Parameters of Synchropulses:	
Duration, microseconds	0.3±0.1
Edge duration, not over	30
Amplitude, V, at a load of 500 Ohms, not less than.	20
Continuous amplitude adjustment, % of the maximum value	10-100
Synchropulse lead in relation to the test pulse is regulated continuously and steps within the limits of, ns	0-500
Short-term lead instability during 0.1 sec, does not exceed, ns	0.5
Power supply -- from an alternating current network:	
voltage, V	120±10%
frequency, Hz	50±1%

Power consumption, V·A	450
Dimensions, mm	480X318X435
Weight, kg	35

Generator G5-41

The generator has two independent outputs for signals of test pulses of positive and negative polarity. Pulses are obtained from an external load of 75 Ohms and parallel capacitance of 40 pF.

Parameters of Test Pulses of Both Polarities:

Edge duration, ns, not over	20
Fall-off duration, ns, not over	200
Pulse duration, microseconds, not less than	10
Overshoot at the peak and nonuniformity of the flat part of the peak to the point of 90% of its length, % (of pulse amplitude)	1
Incline of the flat part of the peak, % of the pulse amplitude, not over	1
Maximum pulse amplitude, V, at an external load of 100 Ohms, not less than	100
Amplitude is regulated continuously and in step with the aid of an internal attenuator within the limits of, dB	0-40
Provision is made for additional attenuation of the amplitude, dB, with the aid of two external dividers (by 20 dB with each)	40
Repetition frequency, Hz	100; 300; 1000
Adjustment error, %, not over	10

Parameters of Meander-Type Positive Test Pulses

Meander-type pulses are obtained from a load of 15 Ohms and capacitance of not over 50 pF. The generator generates test pulses with a repetition frequency of 5 Hz (duration of 100 ms±10%) and 500 Hz (duration of 1.5 ms±10%) with an error of not over +10%.

Edge duration, ns, not over	200
Fall-off duration, microseconds, not over	10
Overshoot at the peak, %, from the pulse amplitude at its duration of not over 200 ns, does not exceed	5
Peak nonuniformity, % of the pulse amplitude, not over	1
Incline of the flat part of the peak, % of the pulse amplitude, not over	1
Maximum drop amplitude, V, not less than	100
Parameters of Synchropulses of Both Polarities:	
Duration, microseconds	1 ± 0.3
Edge duration, ns, not over	100
Amplitude, V, at a load of 1 kOhm with continuous adjustment within the limits from 10 to 100% of the maximum value, not less than	20
Synchropulse lead in relation to pulses I and II is controlled in steps, microseconds	0-1
Short-term (in 0.1 sec) lead instability, ns, does not exceed	2
Test pulse outputs of the generator do not permit connection to circuits with direct voltage in relation to the body.	
Synchronization pulse outputs can be connected to circuits with direct voltage in relation to the body, V, not over	100
Output resistance of the jacks "Synchropulses", Ohms, with extreme right position of the handles "Amplitude", not over	120
Output resistance, Ohms (for the jack "main pulse output"):	
for pulse I	$100\pm10\%$
for pulse II, not over	900
Power supply from an alternating current network:	
voltage, V	$220\pm10\%$
frequency, Hz	$50\pm1\%$
harmonic content, %	5

Power consumption, V·A, not over	500
Dimensions, mm:	
unit generator	480X238X435
power supply unit	480X198X435
box with ZIP [kit of spare parts, tools and accessories]	335X225X95
Weight, kg:	
unit generator	17
power supply unit	30
box with ZIP	5

The Single Channel Nanosecond Pulse Generator G5-44 is intended for tuning and checking high-speed computers and radio engineering devices under laboratory and workshop conditions: it meets the requirements of GOST 9763-67.

The instrument is a single-channel nanosecond pulse generator.

The generator set includes: 1) box with spare parts; 2) set of connecting cables; 3) technical description and operation manual; 4) manufacturer's rating certificate.

Basic Specifications

Duration of output pulses, ns, (adjusted smoothly on the basis of the calibration chart)	1-50
Error, not over $\pm(0.05\tau \div 0.5$ ns), where τ-- established length.	
Repetition frequency of output pulses, MHz	0.1-100
Error, %, not over	10
Maximum amplitude of the fundamental pulses, V, at an external matched load of 75 Ohms with a repetition frequency of not over 80 MHz and a pulse length of 2 ns	7.5
Output pulse amplitude is adjusted smoothly within the limits from 70 to 100% of the maximum amplitude with an adjustment error, %, of not more than	$\pm$25
Length of output pulse edge, ns, not over	0.8
Cutoff length, ns, not over	1

The generator has an output of synchropulses with a frequency equal to the frequency of the main pulses.

The Two-Channel Nanosecond Pulse Generator G5-45 is intended for tuning and checking high-speed computers and radio engineering devices.

The generator consists of three structurally and functionally independent devices: two generators G5-44 and a time shift device.

The instrument set includes: 1) generators G5-44 (2 items); 2) time shift device; 3) connecting cables (6 items); 4) technical description; 5) manufacturer's rating certificate.

Basic Specifications

The instrument has two independent outputs of main pulses whose parameters are determined by the parameters of the generator G5-44.

Time shift between main pulses of the first and second channels is controlled with steps of 5 ns within the limits of, ns	0-150
Instantaneous instability between pulses of the first and second channels, ns	1
Dimensions, mm:	
generator G5-44	480X320X175
time shift device	480X120X175

The generator G5-47 is intended for studying, tuning, and checking radio engineering devices. The instrument operates at temperatures from 5 to 40 degrees C, relative air humidity of up to 95% at 30 degrees C, and atmospheric pressure of 96-104 kPa.

The generator G5-47 meets the requirements of GOST 9763-67 and GOST 13269-67. The generator has the following functional assemblies: master oscillator; external triggering device; continuous delay device; synchropulse shaping device; step delay device; pulse length regulation device; preshaping device of channel 1; shaping line of channel 1; preshaping device of channel 2; inverting amplifier; output shaper; pulse shortening circuits of channel 1 and channel 2; blocking circuits; amplitude meter of main pulses; inverting coaxial transformer; attenuator; power supply circuit of the instrument.

The generator set includes: 1) cables (2 items); 2) high-frequency connecting cables (6 items); 3) connecting cord; 4) matching adapter from 75 to 50 Ohms; 5) passage loads of 50 and 75 Ohms; 6) adapters (6 items); 7) compensation heads (2 items); 8) transition plate; 9) conducting wires (5 items); 10) electron tubes (5 items); 11) signal lamps (2 items); 12) safety devices (14 items); 13) attenuator; 14) technical description and operation manual; 15) manufacturer's rating certificate.

Basic Specifications

The generator produces main pulses of positive and negative polarities at an external matched load of 75 Ohms. Provision is made for operation on a matched channel of 50 Ohms with the use of a matching adapter included in the set.

Parameters of main pulses:

Duration, ns, (continuously regulated)	3-100
Pulse adjustment error, ns, not over	$\pm(0.1\tau + 1)$
Duration of the edge and falloff of the main pulse, ns, measured between the 0.1 and 0.9 levels of the amplitude, not over	1.8 and 3
Overshoot at the peak of the pulse, its nonuniformity and the inclination of the flat part, % of the amplitude, not over	5
Maximum amplitude of the main pulse, V, at an external matched load of 75 Ohms, not less than	50
Repetition frequency of main pulses, Hz, in the mode of internal triggering	$20 \div 200 \cdot 10^3$
Frequency adjustment error, not over	$\pm(0.1\ f + 4$ Hz)
In the external triggering mode, the generator is triggered with a mechanical (manual) starter by pulses of both polarities:	
with an amplitude, V, of	0.5-20
with a length, microseconds, of	0.1-10
with a repetition frequency, kHz, of	up to 200
by a sinusoidal signal:	
with an amplitude, V, of	3-20
with a frequency, Hz, of	$500 \div 200 \cdot 10^3$
with an amplitude, V, of	10-20
with a frequency, Hz, of	50-500

Parameters of synchropulses of both polarities (pulses are obtained from a load with a resistance of 500 Ohms and a parallel capacitance of not over 50 pF):

Duration, microseconds, not less than	0.1
Amplitude, V, not less than	20

(regulated continuously from 100 to 10% of the maximum value)	
Edge duration, ns, not over	30
Delay of the main pulse T_d in relation to the synchropulse is regulated:	
continuously in the subrange, ns	0-100
in steps within the limits, microseconds	0-1
Delay adjustment error, does not exceed	$\pm(1T_d+10$ ns)
Power supply -- from an alternating current network:	
voltage, V	$220\pm10\%$
frequency, Hz	$50\pm1\%$
Power consumption, V·A	220
Dimensions, mm:	
generator	490X215X475
attenuator	255X172X191
Weight, kg:	
generator	21
attenuator	6

Generator G5-48. This generator of nanosecond pulses with a high repetition frequency (Figure 14.7) is intended for studying, tuning, and checking radio engineering devices operating under laboratory and workshop conditions. Moreover, the generator can be used in studying high-speed electronic computers.

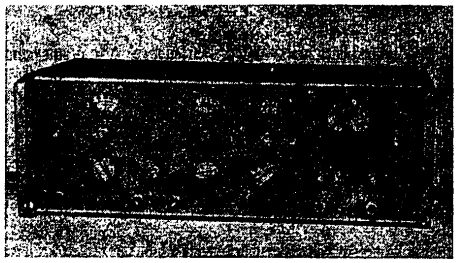

Figure 14.7

The generator includes the following units: unit of internal and single triggering (master oscillator); external triggering unit; preshaping unit; synchronization unit; delay unit of the main pulse in relation to the synchropulse; pulse length formation unit; shaping amplifiers of positive and negative pulses; output pulse amplitude adjustment unit; power supply unit.

The internal triggering circuit produces triggering pulses in the frequency range from 1 kHz to 20 MHz. The external triggering circuit produces pulses for triggering the preshaping and synchronization circuits.

The synchronization circuit produces pulses with a frequency equal to the repetition frequency of the meander-type main pulses. Having used scaling units, these pulses can be used for obtaining synchropulses tying them to the main sequence, as well as for triggering generators in unitizing into multichannel systems.

The generator set includes: 1) attenuators (5 items); 2) 50 Ohm loads (2 items); 3) coaxial adapters (6 items); 4) coaxial adapter from 50 to 75 Ohms; 5) sets of connecting cables (6 items); 6) connecting cord; 7) safety devices (14 items); 8) signal lamps (2 items); 9) alligator clips (3 items); 10) storage box for ZIP; 11) technical description and operation manual; 12) manufacturer's rating certificate.

Basic Specifications

The generator generates pulses of positive and negative polarities at an external matched load of 50 Ohms. The overshoot, nonuniformity of the peak, and nonuniformity in the interval between pulses is not over 10% of the pulse amplitude at an external matched load of 50 Ohms during continuous amplitude adjustment within the limits of $(0.7 \div 1.0)\ U_{max}$.

Duration of main pulses (regulated continuously, in steps) microseconds	$5 \cdot 10^{-3} \div 250$
Error in the adjustment of main pulses, not over...	$\pm$(10% + 2 ns)
Additional duration error, ns, caused by temperature changes per each 10 degrees C, does not exceed	$\pm$(3.5% +.1)
Edge and falloff lengths of main pulses, ns, between the 0.1 and 0.9 amplitude levels at an external matched load of 50 Ohms are, respectively, not over	1.5 and 6
Maximum amplitude of main pulses, V, at an external matched load of 50 Ohms, not less than	10
Main pulse amplitude, % from the maximum amplitude is regulated continuously within the limits of	100-30

Step-by-step attenuation of the pulse amplitude with the aid of the attenuator, dB	3; 6; 10; 20; 40
Fundamental error of amplitude adjustment within the adjustment levels (0.7 ÷ 1.0) U_{max}, does not exceed	10% + 0.25 V
Pulse repetition frequency, kHz, with internal triggering	$1\text{-}20\cdot10^3$
Pulse adjustment error, %, not over	10

In the external triggering mode, the generator is triggered by pulses of both polarities:

pulse length, microseconds	0.01-0.5
amplitude, V	1-5
repetition frequency, MHz	20

by a sinusoidal signal:

frequency, kHz	$1\div20\cdot10^3$
amplitude, V	1-5

mechanically (with a manual single-action starter).

The external triggering input is an open input, input resistance -- 75 Ohms, delivery of direct voltage is not permitted. The delay of pulses in relation to the synchropulse with the main repetition frequency is regulated continuously and in steps from 5 ns to 250 microseconds.

Power supply -- from an alternating current network:

voltage, V	220±10%
frequency, Hz	50±0.5
voltage, V	220±5%
frequency, Hz	400+7% -3%

Power consumption, V·A	120
Dimensions, mm	480X160X355
Weight, kg	15

The Pulse Generator G5-49 (Figure 14.8) is intended for shaping series of pulses with regulated repetition periods of these series, the number of pulses in a series, as well as the parameters of pulses in the series (length, duty time amplitude) and can be used for adjusting and testing radio electronic equipment.

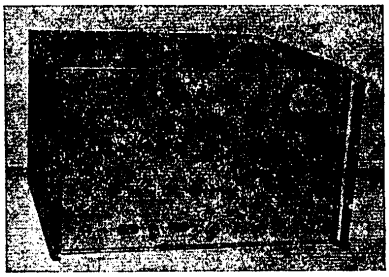

Figure 14.8

These instruments work at ambient air temperatures from -30 to 50 degrees C, a relative humidity of not over 98% at 40 degrees C, and atmospheric pressure of 101 kPa.

The generator operates on the principle of selecting any prescribed pulse from a finite sequence of pulses. In the internal triggering mode, the repetition period of the series is determined by the timing oscillator which contains an LC-generator and a frequency divider. Timing pulses arrive at the triggering pulse shaper which puts out a preparation pulse and a triggering pulse for the series generator.

The pulse series generator which includes a shock-excited LC-generator and a frequency divider forms a series of pulses with a regulated duty time. The number of pulses in a series is determined by a selective device which stops the operation of the series generator at a prescribed moment. The series of pulses arrives at the output pulse length shaper and then at the output stage which determines the amplitude and the edge and falloff lengths of the output pulses of the generator.

The generator has two modes of operation, the mode of delaying the beginning of the series in relation to the synchropulse, for which an auxiliary delay generator and a selecting device are turned on; a mode of selecting a synchropulse coinciding with any pulse of the series. The latter mode is ensured by selecting a series of output pulses and a synchropulse from the same series from the output of the shock-excited generator. Provision is made for the external electrical periodic triggering of the generator and single-action mechanical starting.

The instrument set includes: 1) set of accessories and spare parts in a box; 2) storage box; 3) technical description and operation manual; 4) manufacturer's rating certificate; 5) technical record.

Basic Specifications

Pulse length, microseconds	0.05-500
Length adjustment error $\pm(0.1\tau_n + 0.02$ microseconds), where τ_n -- established pulse length.	
Pulse amplitude, V, at the output of the generator (external load of 50 Ohms), not less than...	10
Repetition period of the series of output pulses, microseconds, with internal triggering	$1\text{-}10^8$
It is possible to set 352 fixed values.	
Error in setting the repetition period of the series of output pulses, does not exceed 0.1 T (T -- set period).	
Edge and falloff length of output pulses, microseconds, at an external load of 50 Ohms, does not exceed	0.05
Pulse edge and falloff overshoot, as well as the incline of the flat part, %, not over	5
Attenuation of the last pulse in a series in relation to the first pulse is, %	5
Number of pulses in a series	$1\text{-}10^4$
Duty time of the series, microseconds	$1\text{-}10^4$
It is possible to set 176 fixed values.	
Error in establishing the duty period, does not exceed $\pm 0.1\ T_{duty}$ (T_{duty} -- established duty period of the series).	
Frequency of the pulse voltage of external triggering, MHz	up to 1
Frequency of sinusoidal voltage, Hz	$20 \div 1 \cdot 10^6$
Delay of the series of output pulses, microseconds, in relation to the synchropulse (changes discretely every one microsecond).....	$0\text{-}10^4$
Delay adjustment error, does not exceed $\pm(0.05\ T_d + 0.1\ T_{delay} + 0.05$ microsecond) where T_d -- established delay of the series.	

Power supply of the generator from alternating current networks:	
voltage, V	$220\pm10\%$
frequency, Hz	$50\pm1\%$
voltage, V	$220+5\%$
frequency, Hz	$400^{+7\%}_{-3\%}$
Power consumption, V·A	150
Dimensions, mm	480X280X475
Weight, kg	32

The Modulation Pulse Generator G5-50 (Figure 14.9) is intended for studying, tuning, and checking radio engineering devices at the time of their development, manufacturing, and operation.

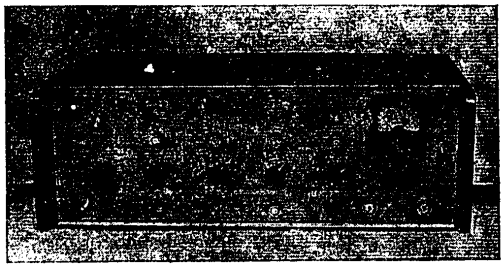

Figure 14.9

These instruments work at ambient temperatures from -30 to 50 degrees C and a relative humidity of up to 98%. The generator generates: square video pulses of switchable polarity with regulated length amplitude, and repetition frequency; sawtooth signals -- with regulated frequency and amplitude; synchropulses of positive polarity -- with regulated amplitude.

Provision is made for regulated time shifts of output pulses in relation to synchopulses. Provisions are also made for external triggering by pulsed and sinusoidal signals, as well as for single-action manual triggering (with a button).

The instrument is designed as a standard bench (portable) unit in which functional assemblies and devices are arranged on dismountable printed circuit plates.

The generator set includes: 1)connecting cables (6 items); 2) connecting network cord; 3) 50-Ohm and 500-Ohm loads (2 items); 4) adapters (2 items); 5) compensation heads (2 items); 6) extension plates (2 items); 7) signal lamp; 8) electron tube; 9) safety devices (8 items); 10) laboratory clamps (12 items); 11) technical description and operation manual; 12) technical record.

Basic Specifications

Parameters of Output Pulses:	
Duration, microseconds (regulated continuously, in steps)	0.05-500
Adjustment error $\pm(0.1\tau + 20$ ns), where τ -- adjusted pulse length.	
Repetition frequency with internal triggering, kHz (regulated continuously, in steps)	0.01-30
Relative error of frequency adjustment, %	10
Parameters of the Synchropulse:	
Duration, microsecond	0.5
Amplitude, V (regulated continuously at an external load of 1 kOhm)	1-10
Power supply -- from an alternating current network:	
voltage, V	115 and 220±5%
frequency, Hz	400
Power consumption, V·A	150
Dimensions, mm	490X176X355
Weight, kg	15

The Pulse Generator G5-54 is intended for studying, adjustment, and tuning radio engineering devices in various branches of the national economy and in scientific studies.

The instrument works at ambient air temperatures from 10 to 35 degrees C and relative humidity of up to 80% at 20 degrees C, and an atmospheric pressure of 96-104 kPa.

The master oscillator puts out timing pulses (it is possible to regulate the repetition frequency continuously in steps) which arrive at the shaping

circuit of synchronization pulses and the delay circuit of main pulses. The delay circuit puts out pulses with regulated delay, as well as ensures the zero delay mode of the main synchronization pulse. Pulses from the delay circuit arrive at the pulse length formation circuit, and then at the circuit of output shaping and regulation of the pulse amplitude.

The pulse generator is designed as a small bench-type instrument in a standardized housing.

The generator set includes: 1) storage box for ZIP containing four cables, a 500-Ohm load, and a connecting cord; 2) technical description and record.

Basic Specifications

Duration of main output pulses, microseconds	0.1-1000
Maximum pulse amplitude, V, not less than	50
Edge and cutoff length, ns, respectively, ...	50 and 100
Repetition frequency, kHz	0.01-100
Main pulse delay range, microseconds (regulated continuously in steps)	0-1000
Instrument's accuracy class	1.0
Dimensions, mm	366X183X245

The Signal Time Shift Sources I1-5 (Figure 14.10) are six-channel generators of shifted pulses which are intended for triggering measuring instruments in a prescribed sequence. These instruments can be used in radio measuring techniques, physics, etc under laboratory conditions and meet the requirements of GOST 9763-67.

This instrument is a set consisting of three identical delay units and an amplification unit.

Each delay unit has one reference pulse channel and two delay pulse channels with independent adjustment of the delay time for each channel. In the amplification unit, three appropriate signals are formed from each reference and delayed pulse.

Each unit has an independent power supply. Each delay unit can be used independently as a source of time-shifted pulses.

There are three types of triggering: external, single-action, and internal.

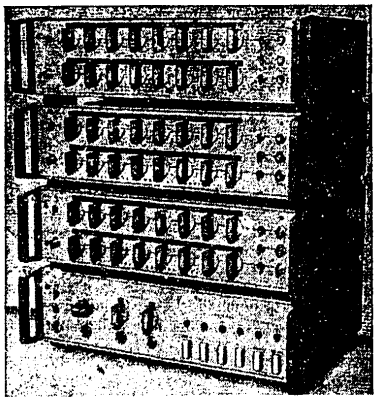

Figure 14.10

The external triggering signal formed in the amplification unit arrives simultaneously for triggering all three delay units. Single-action triggering can be achieved either with a button or from an external signal. Internal triggering at a frequency of 25 Hz synchronized with the power supply network is accomplished from the master oscillator located in the amplification unit.

The delaying is based on the principle of division of frequency of 10 MHz on meters with a variable division factor.

The instrument set includes: 1) delay unit with a working set of plates (3 items); 2) amplification unit with a working set of plates; 3) storage box with a set of auxiliary items and spare parts; 4) technical description and operation manual; 5) manufacturer's rating certificate.

Basic Specifications

Adjustment range of the time shift of delayed pulses in relation to reference pulses from 10^{-8} to 0.99999999 sec.

Error in time shift adjustment does not exceed $\pm(0.001\ T_d + 20\ ns)$, where T_d -- delay time.

Delay of the reference pulse, microseconds, in relation to the input triggering pulse does not exceed 5

Parameters of Reference and Delayed Pulses:	
Polarity, microseconds, not less than	1
Edge length, ns, not over	200
Amplitude, V, not less than	50
Parameters of External Triggering Pulse:	
Polarity	positive
Repetition frequency, Hz, not over	50
Length, microsecond, not less than	1
Edge length, ns, not over	200
Amplitude, V	50-100
Triggering input resistance, Ohms	75±10%
Power consumed from the power supply network, V·A.	130
Dimensions, mm:	
delay unit	480X120X375
amplification unit	480X120X475
entire instrument	480X480X475
Weight, kg:	
delay unit	10
amplification unit	14
entire instrument	44

The Voltage Drop Generator and Microwave Synchronizer YaChS-20A are used for synchronizing stroboscopic oscillographs at a high (up to 6 GHz) repetition frequency of signals being studied; for checking transient characteristics of stroboscopic oscillographs and other broadband devices with the aid of the voltage drop created by them.

The instrument is intended for operation under laboratory and workshop conditions at an ambient air temperature of +(5-40) degrees C, relative humidity of up to 95% at 30 degrees C, network voltage of 220 V±10% at an atmospheric pressure of 96-104 kPa. The instrument can be used as a generator of the main pulse when a stroboscopic oscillograph works in the system of a reflectometer.

The YaChS-20A instrument consists of a power supply source, a synchronizer, and a voltage drop generator in the delay line housed in one casing (Figure 14.11).

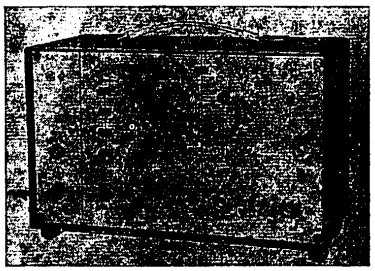

Figure 14.11

The YaChS-20A instrument can work in two modes: as a microwave synchronizer and a voltage drop generator.

In the microwave synchronizer mode, the instrument is a relaxation generator using a tunnel diode 1I308K. The circuit performs the division of the frequency of the studied signal, i.e., forms pulses with a low repetition frequency of 15±30 MHz synchronous with the input signals, which is necessary for triggering the scanning units of stroboscopic oscillographs. The synchronization effect is based on the phenomenon of the entrainment of the frequency of a multivibrator by the frequency of an external EDS [electromotive force]. Without tuning, synchronization is accomplished not on all frequencies, but only in the narrow zones -- "synchronization zones". For accomplishing synchronization of stroboscopic devices on all frequencies, the front panel of the instrument has handles of variable resistors "Repetition Frequency, Smooth, Coarse". These handles are used to change the oscillation frequency of the tunnel diode 1I308K, as a result of which the synchronizer is tuned. The division coefficient is adjusted with the aid of the RC-circuit.

When the instrument works in the voltage drop generator mode and a triggering pulse is delivered to its input, a positive or negative pulse with a short rise time (0.15 ns) is formed with the aid of high-speed germanium tunnel diodes.

The presence of pulses with a short rise time makes it possible to check the rise time and the transition time of the transient characteristics of a stroboscopic oscillograph and to determine indirectly the passband of the vertical deflection channel of the oscillograph by the formula $f_{ch}=0.35/t_{rise}$, and the rise time t_{rise} can be determined by the formula $t_{rise}=\sqrt{T_1^2 - T_2^2}$

where T_1 -- the measured rise time on the oscillograph screen; T_2 -- rise time of the pulse from the voltage drop generator.

The instrument set includes: 1) voltage drop generator and microwave synchronizer YaChS-20A; 2) combination set: coaxial adapters E2-114/3, E2-115/3, E2-115/4, T-joint No 1, 50-Ohm load, connecting cord No 10, connecting cables (2 items), ZIP, safety device VP1-1; 0.5 A, jack, semiconductor diode 1I308k, connecting cable No 9; 3) technical description and operation manual; 4) technical record.

Basic Specifications

Instrument in the Microwave Synchronizer Mode: "Output 5 ns": 1 V -- pulses of positive polarity with a rise time of not over 5 ns and an amplitude of not less than 1 V and not over 3 V at a load of 50 Ohms; "Output 0.5 ns": 100 mV -- pulses of positive polarity with a rise time of not over 0.5 ns and amplitude of not less than 100 mV and not over 200 mV at a load of 50 Ohms. Instability of the adjustment of the synchropulses to the sinusoidal signal, ns, at a frequency of the sinusoidal signal of 4000 MHz and an amplitude of 250 mV must not exceed 30. When synchronizing by sinusoidal signals with the parameters f = 30 MHz $\div$ 6 GHz; U = 50 mV $\div$ 2 V, it is permissible to increase the instability to a value of not over 0.1 ns + 0.02 T_s, where T_s is the period of the sinusoidal signal.

Frequency range of signals being synchronized, MHz	$30 \div 6 \cdot 10^3$
Dynamic range of amplitudes of signals, V, delivered to the input of the synchronizer	0.05-2
Input resistance of the synchronizer, Ohms, for direct current	47±5%

Instrument in the Voltage Drop Generator Mode. Output pulses of the voltage drop generator at the "Output" jacks can be delayed (in relation to the pulses arriving at the jack "Input" 50 Ohms, from 5 ns ± 50% to 75 ns ± 20% discretely with spacint of 5 ns ±20%.

Parameters of triggering pulses of positive polarity:	
amplitude, V, not over	1
rise time, ns, not over	30
amplitude, V, at a load of 50 Ohms	1-7
Output resistance of the voltage drop generator, Ohms	50±10%

Amplitude of output pulse drop, mV, at a load of 50 Ohms, not less than	350
Rise time (t_f) of output pulses, ns, between levels 0.1-0.9 on jacks "Output", not over	0.15
KSV [standing wave ratio] in the frequency range of 0-5 GHz, does not exceed	1.5
Instability of the output pulses of both positive and negative polarity in relation to the triggering pulses when the rise time of the triggering pulses is 2 ns, or less than 1 V, is not over 20. Average trouble-free operation of the instrument, hours, is not less than 5000.	

The instrument must be checked periodically not less than once in six months. Checking must be done at an ambient air temperature of +20 degrees C $\pm$5 degrees C, an atmospheric pressure of 96-104 kPa, and a relative humidity of 65$\pm$15%.

There must be no sharp voltage shocks in the power supply network. There must be no sources of strong magnetic and electric fields near the work place.

The following parameters are checked when the instrument works in the voltage drop generator mode: rise time of the output pulse between the levels of 0.1-0.9; amplitude of the output pulse drop; delay of output pulses in relation to triggering pulses; overshoot at the peak of the output pulse; instability of the flat part of the output pulse during the first 10 ns; fall-off of the peak of the output pulse during the first 100 ns; instability of the output pulse in relation to the triggering pulse when the rise time of the triggering pulse is 2 ns or less.

The following parameters are checked when the instrument works in the microwave synchronizer mode: range of synchronizing frequency; limits of input amplitudes; input resistance on direct current; rise time and amplitude of pulses from the output (0.5 ns; 100 mV); repetition frequency range of output pulses; instability value of the adjustment of synchropulses to the signals being studied; value of the parasitic signal at the input jack.

14.5. Special-Shape Signal Generators

The Special-Shape Signal Generator G6-15 (Figure 14.12) is intended for studying and testing systems and instruments used in radio electronics, automation, computer and measuring techniques, geophysics, machine-building, biophysics, and medicine.

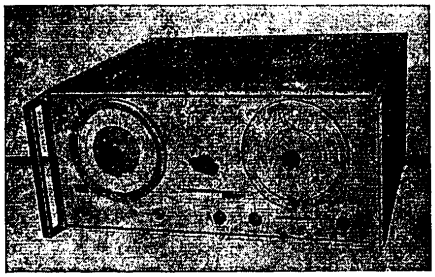

Figure 14.12

The generator operates in one of two modes. In the first mode, an automatic oscillation system works in the generator. It consists of three operational amplifiers closed in a ring, a relay control element, and an amplitude stabilization system. In this mode, sinusoidal signals shifted by 180 and 270 degrees in relation to the reference signal appear at the two outputs of the generator.

In the second mode, voltages of the rectangular, triangular, and sawtooth shapes are generated simultaneously. The output part of the generator in both modes is the same.

Structurally, the generator consists of three units: control unit, generator unit, and power supply unit.

The generator set includes: 1) safety devices (3 items); 2) cables (3 items); 3) attachments with clamps (3 items); 4) plate; 5) incandescent lamp; 6) loads of 1000 Ohms (4 items); 7) low-frequency filter; 8) attachment of compensation measuring circuit; 9) manufacturer's rating certificate.

Basic Specifications

Range of sinusoidal signals, Hz	0.001-1000
Fundamental error of frequency adjustment, %, does not exceed	± 2
Range of output voltages, V	0.01-10

Fundamental error of output voltage adjustment, %, not over	±3
Nonuniformity of the amplitude of the output sinusoidal signal in the frequency range, %, not over	±2.5
Harmonic distortion factor, %, does not exceed	1.5
Parameters of Synchropulses:	
Amplitude, V, at an external load of 1 kOhm ±1%, not less than	5
Capacitance, pF, not over	150
Polarity	positive
Duration, microseconds, not over	10
Nonlinearity coefficient of the triangular and sawtooth voltages, %, in the frequency range 0.001-0.1 Hz, does not exceed	2
Edge and cutoff length (each separately), as well as the duration of the reverse run of sawtooth voltage, microseconds, does not exceed	5
Power consumed from the network at a nominal voltage, V·A	75
Instrument dimensions, mm	490X215X475

The Special-Shape Signal Generator G6-22 (Figure 14.13) is intended for tuning and checking scaling, computing, and other high-speed electronic devices.

With respect to its stability to climatic and mechanical influences, the instrument meets the requirements of Group II of GOST 9763-67.

The generator operates on the principle of forming pulse edges of sinusoidal voltage with the aid of a line using parametric diodes with subsequent shaping of a pulse by the tube circuit of the limiting amplifier.

The instrument consists of a generator of sinusoidal oscillations, a pulse shaping unit, a synchronization unit, a voltmeter, an attenuator, a power supply unit, and an inverting transformer.

The generator of sinusoidal oscillations has a two-cycle circuit. It has five frequency subranges which are switched with a knob. Continuous frequency adjustment of the generator is done with the aid of a capacitor. Power is drawn from the generator from the pickup coils of the power amplifier.

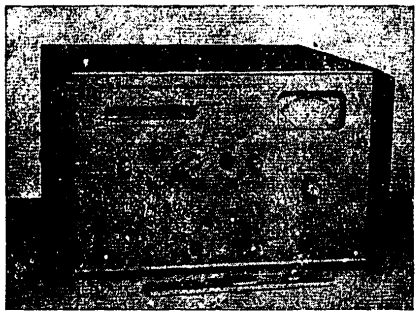

Figure 14.13

Sinusoidal oscillations from the output of the generator are delivered to the input of the shaping circuit consisting of shaping lines using parametric diodes and a limiting amplifier.

Formation of a line is an artificial transmission line in which semiconductor silicone diodes are used as capacitors. The capacitance of their p-n-junction is the function of the reverse voltage delivered to the diode. The line consists of 20 cells.

The wave impedance of the line is about 75 Ohms. Positive bias from 0 to 35 V is delivered to the lines which increases as the frequency of the sinusoidal oscillation generator increases.

Sawtooth pulses with an edge of 2.5-3 ns and amplitude of 10-30 V are removed from the output of the line and delivered to the output limiting amplifier. Its load is a choke on which bell-sbaped output pulses with a length of less than 5 ns and an amplitude of 15-30 V are isolated. The voltmeter measures the amplitude of the output pulses isolated on the anode load of the output stage.

The step attenuator has Π -shaped cells.

Attenuation is adjusted in steps of 6 dB in the range from 5 to 20 dB. A pulse of positive polarity from the output of the generator is obtained by the inverting transformer. Structurally, it is a high-frequency coaxial adapter with a built-in transformer with a toroidal ferrite core.

The generator is a bench-type portable instrument in a case.

The generator set includes: 1) connecting cords; 2) high-frequency connecting cable; 3) inverting transformer; 4) attenuators (2 items); 5) safety devices (2 items); 6) signal lamps (2 items); 7) manufacturer's rating certificate.

Basic Specifications

Repetition frequency of output pulses, MHz	10-110
Frequency adjustment error, %	± 2
Bell-shaped pulse length, ns (0.5 level), not over.	5
Edge length of output pulses, ns, not over	3
Minimum on-off time ratio of output pulses, not over	2
Amplitude of output pulses, V, at a load resistance of 75 Ohms, not less than (at frequencies of 100 MHz, it is permissible to lower the amplitude to 12 V)	15
Amplitude of output signals is adjusted within the limits, dB:	
in steps every 5 dB	20
continuously	5

Error in amplitude adjustment at the input of the attenuator, not more than $\pm(0.1\ U_{adj}+0.5\ V)$, where U_{adj} -- adjusted amplitude.

Length of synchronizing pulses, ns	50-200
Repetition frequency, kHz	5-50
Amplitude, V, not less than	10
At a load of 1000 Ohms and edge length, ns, not over	80
Self-heating time, minutes	15
Power consumption, V·A, does not exceed	300
Dimensions, mm	496X475X295
Weight, kg	32

The Measuring Generator GI-25 is intended for providing the necessary voltage of sinusoidal signals when taking measurements in multiplexing systems of coaxial cables in the frequency range 0.05-25 MHz.

The generator can be used in the measuring console of 0.05-25 MHz (IP-10/25) and the panoramic console of 0.05-25 MHz (PP-25) for operation in conjunction with a 36-62 MHz sweep generator (GKCh36-62) and can be used in tuning and operational measurements of wire communication equipment, as well as in various radio engineering measurements.

The measuring generator meets the requirements of GOST 9763-67, and, with respect to operational conditions, belongs to Group II of GOST 9763-67 with the operating temperature range expanded to 40 degrees C.

The generator is based on the principle of the beat-frequency oscillator (in the analysis circuit); the output voltage of the generator is the product of the conversion of sinusoidal signals with different frequencies. The instrument includes two high-frequency generators of variable and fixed (conditionally) frequencies, a pedestal frequency generator, a frequency converter, filters, and amplifiers.

The variable frequency generator has an automatic system of pulse-phase frequency tuning and makes it possible to adjust the output frequency from 0 to 25 MHz discretely every 200 kHz.

The fixed frequency generator has an automatic system of phase frequency tuning with an interpolation oscillator and ensures smooth frequency coverage within the limits of 200 kHz.

The stability and uniformity of the amplitude-frequency characteristic are ensured by the automatic gain control system (ARU). Smooth adjustment of the output level is achieved by changing the reference voltage in the ARU. Step-by-step adjustment of the output level is accomplished by switching the attenuation links at the output.

The 0.05-25 MHz measuring generator (GI-25) consists of two devices: a master oscillator and a 0.05-25 MHz output unit (UV-25).

Electrical connection of the GZ and UV-25 instruments is accomplished with coaxial cords with plug and socket units.

Both instruments are sectional units in the "Nadel" frame.

The instrument set includes: 1) master oscillator (GZ); 2) 0.05-25 MHz output unit (UV-25); 3) operational documentation, including manufacturer's rating certificate; 4) spare parts, tools, and accessories; 5) set of spare parts, instruments and accessories (set of stretchers RKh4.072.081).

Basic Specifications

Operating frequency range of the generator, kHz....	$50 \div 25 \cdot 10^3$
Fundamental error of frequency adjustment after calibration, Hz	$\pm(2 \cdot 10^{-5} f + 600$ Hz)

Frequency instability due to network voltage fluctuation by ±10%	$\pm(2\cdot10^{-7}f+50$ Hz)
Additional error of frequency adjustment due to temperature changes, after calibration	$\pm(1\cdot10^{-5}f+300$ Hz) per each 10° C
Fundamental error of output level adjustment, dB, by the pointer-type instrument:	
On the frequency of 1 MHz at the mark "0dB"	±0.2
by instrument's scale on the frequency of 1 MHz at the marks:	
"1 dB"	±0.2
"-4 dB"	±0.3
"-9 dB"	±0.5
when frequency changes in relation to the level set on the frequency of 1 MHz at the mark "0dB"	±0.3
Maximum voltage level efficiency, dB on a load of 75 Ohms, not less than	1
Smooth adjustment of the output level, dB, not less than	11
Step-by-step adjustment of the output level is ensured within the limits of 60 dB in steps, dB, every	10
Fundamental error, dB, from step-by-step adjustment of the output level on the frequency of 1 MHz for output levels:	
-10, -20, -30, -40	±0.2
-50, -60	±0.25
Changes in the output level, dB, depending on the frequency being set (at an output voltage level of 0 dB at a load of 75 Ohms) in relation to the frequency of 1 MHz in the frequency ranges:	
from 0.005 to 10 MHz	±0.3
from 10 to 25 MHz	±0.4
Nonlinear distortion coefficient of the generator, %, of the second and third harmonics at the output level of 0 dB at a load of 75 Ohms in the frequency ranges:	
from 0.05 to 10 MHz	3
from 10 to 25 MHz	5

Attenuation of the mismatching of the generator's output, dB, unbalanced in relation to the earth with a characteristic impedance of 75 Ohms at the output level from -10 to -60 dB in the frequency ranges:	
from 0.05 to 10 MHz	32
from 10 to 25 MHz	26
At the output level from 0 to -10 dB in the frequency range:	
from 0.05 to 10 MHz	26
from 10 to 25 MHz	23
Power consumption, V·A, at a voltage of 242 V, does not exceed	140
Dimensions of the instrument, mm	540X310X480
Weight of the instrument, kg, not over	48

The instrument is checked under the following conditions: ambient air temperature 20±5 degrees C; relative air humidity 65±15%; voltage of the power supply network 220 V±2% with a frequency of 50 Hz ± 2%.

The instrument is checked after self-heating in the course of one hour in three stages: external examination; determination of metrological parameters; preparation of checking report.

The following metrological parameters are determined in checking: fundamental error of frequency adjustment; fundamental error of output level adjustment at a frequency of 1 MHz; frequency nonuniformity of the output level; nonlinear distortion coefficient in the frequency range from 0.05 to 10 MHz. Checking is done once a year, as well as after repairs of the instrument.

Determination of the fundamental error of frequency adjustment is done by measuring frequency with the aid of a frequency meter (for example, Ch3-38).

Determination of the fundamental error of the output level adjustment and frequency nonuniformity is done by comparing with a standard voltage source ($K_f < 0.05\%$). A level meter (for example, of the IU-25-type) ensuring the measurement of the root-mean-square value of voltage of an arbitrary form is used as a comparison indicator. The voltage of the standard source is measured with the aid of a standard voltmeter (for example, of the V3-24-type).

Determination of the fundamental error of step-by-step adjustment of the output level is done by the substitution method with the use of standard stretchers, a standard voltmeter (for example, of the V3-24-type) and a selective level meter (for example, of the IUI-25-type).

The nonlinear distortion coefficient is determined by measuring the harmonic components with the aid of a selective voltmeter (for example, of the V6-1-type).

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END