INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY

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[redacted] 50X1-HUM

COUNTRY	USSR	REPORT	[redacted]
SUBJECT	English Translation of Technical Description of Display Equipment of the Soviet P-30-M (BIG BAR) Radar	DATE DISTR.	5 June 1964
		NO. PAGES	1
		REFERENCES	[redacted]
DATE OF INFO.	[redacted]		
PLACE & DATE ACQ.	[redacted]		

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An English translation of a Soviet manual entitled Mobile Acquisition and Guidance Radar P-30-M, Technical Description YeA1.231.008 TO-II-B, Part II, Display Equipment (Podvizhnaya radiolokatsionnaya stantsiya obnaruzheniya i navedeniya P-30-M: tekhnicheskoye opisaniye, chast vtoraya, indikatornaya apparatura, YeA1.231.008 TO-II-B) [redacted]

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MOBILE ACQUISITION AND GUIDANCE RADAR

PP–30M

TECHNICAL DESCRIPTION

PART II

DISPLAY UNIT

YeA1.231.008 TO–II–B

(English Translation)

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MOBILE ACQUISITION AND GUIDANCE RADAR P-30-M

TECHNICAL DESCRIPTION YeA1.231.008 TO-II-B

PART II. DISPLAY EQUIPMENT

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CONTENTS

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Table of Conventional Designations

RL-30-1	Radio Relay Line	(p 5)
NRZ-1	Ground Radar Interrogator	
KPN	Command Guidance Post of the RL-30-1 System	
ZN-F1	Master Voltage and Filter Cabinet	
BZ	Trigger Unit	
SSP	Synchronous Tracking Transmission System	
FD-02	Main Selsyn Unit	
IV	Rotation Simulator Unit	
VD-1	Secondary Selsyn Unit	
US	Servoamplifier Unit	
GCh	Higher-Frequency Generator Unit	
OA-5-1	5-Degree and 30-Degree Marker Unit	
OA-1-1	1-Degree Marker Unit	
KO-3	Test Unit	
IU-1	Integrating Unit	
VU	Input Unit	
GR	Sweep Generator Unit	
U-OCh	Amplifier Subassembly	
IKO-1	Plan Position Indicator	
TI-1	IKO-1 and IKO-V1 Scope Unit	
ZR-3	Sweep Delay Unit for IKO-1 and IAD-1	
IKO-V1	Plan Position Indicator for Command Guidance Post	
RD	Range Sweep Unit	(p 6)

VS-3	IKO-1 and IAD-1 Video Signal Unit
DUS-1	Station Remote Control Cabinet
SS-1	Signal Mixer
BNF	Blanking and Tuning Unit of Noise-Protection Apparatus
IIV-1	Height Measurement Indicator
TI-2	IIV-1 Scope Unit
PN-12	Projection Adapter of Unit TI-2
RU-1	Elevation Sweep Input Unit
RU-2	Elevation Sweep Output Unit
VS-4	Video Signal Unit for IIV-1
IAD-1	Azimuth-Range Indicator
TI-3	IAD-1 Scope Unit
RA	Azimuth Sweep Unit
BP-300	+300 Volt Power Supply Unit
BP-200	+200 Volt Power Supply Unit
BP-150	-150 Volt Power Supply Unit
BP-7	+7.1 KV Power Supply Unit
UPT-1	Power Supply Control Unit
ShchOV	Lighting and Ventilation Panel

[Note: two pages of original-language text missing.]

The instruments of the synchronous tracking transmission system (SSP) are designed for the remote transmission of the rotation of the antenna. Voltages generated by this system are used to turn the deflection coils in the plan position indicators, to supply the elevation and azimuth sweeps in the height-measurement and azimuth-range indicators, and for shaping electrical markers for the angle of rotation of the antenna. Elements of the SSP system are component parts of the display equipment cabinets and various auxiliary units. The main selsyn unit of the system is located in vehicle No 1. (p 9)

Electrical range-marker pips, corresponding to given ranges and angles of rotation of the antenna, are created on the indicator screens by range marker instruments located in the master voltage cabinet.

Each display cabinet receives power from standard power supply units supplying stabilized voltages of +200 v, -150 v, and +7.1 kv and an unstabilized voltage of +300 v. The tube filament circuits are supplied by self-contained filament transformers located in each of the units.

The monitoring PPI and its auxilliary equipment are used to carry out continuous remote monitoring of the operation of all station receivers and to select the optimum operating mode for the station.

The remote control panel located at the monitoring indicator provides for remote control and observation of equipment in the transceiver cabin.

2. Make-up of the Display Equipment (p 10)

Vehicle No 2 (Figure 1) contains:

1. Master voltage and filter cabinet ZN-F1.
2. Plan position indicator cabinet IKO-1.
3. Station remote control cabinet DUS-1.
4. Height measurement indicator cabinet IIV-1.
5. Azimuth-range indicator cabinet IAD-1.
6. Radio relay line cabinet P-11-1.
7. Equipment of the interrogator system B-10, B-12, B-14, B-16.
8. Communications equipment for the station.

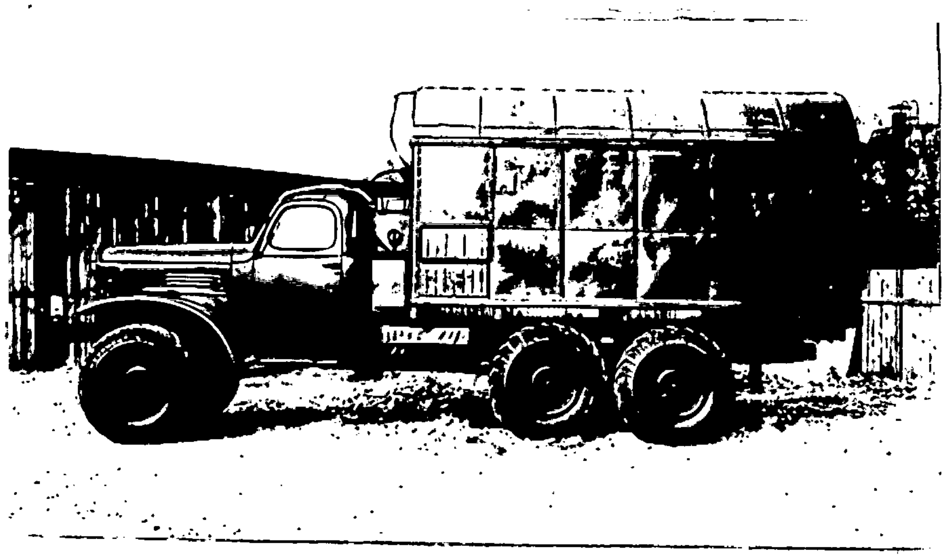

Fig. 1. Vehicle No 2.

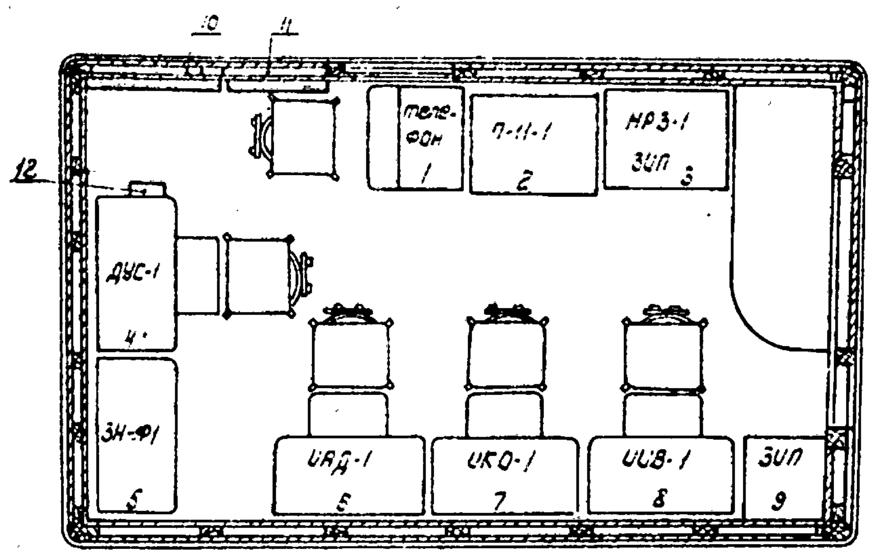

Fig. 2. Arrangement of Equipment in Vehicle No 2.

1 - telephone operator's table; 2 - radio relay line; 3 - IFF system equipment and spare parts; 4 - DUS-1 remote control cabinet; 5 - master voltage cabinet ZN-F1; 6 - IAD-1 azimuth-range indicator cabinet; 7 - IKO-1 PPI cabinet; 8 - IIV-1 height measurement indicator cabinet; 9 - spare parts cabinet; 10 - input distributing board; 11 - output distributing board; 12 - B-12 control panel.

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9. Auxilliary equipment for lighting and ventilation of the vehicle.

A diagram showing the location of the equipment in the vehicle is given in Figure 2.

The equipment located at the command guidance post and operating in the radio relay system includes:

1. Receiver cabinet for radio relay line RL-30-1.

2. Four cabinets for the IKO-V1 plan position indicator.

3. Communications equipment.

4. Auxilliary equipment.

The ZN-F1 cabinet includes units which generate trigger pulses, (p 13) range-and azimuth-marker pulses, and secondary voltages of the SSP system, and which produce voltages of the main selsyn unit; it also includes units which decrease non-synchronous pulse noises on the screens of the indicators (filter units).

The IKO-1 and IKO-V1 cabinets include units used to observe the position of targets within the zone of visibility of the station and to determine their slant range and azimuth.

The DUS-1 cabinet contains the monitoring PPI, mixers of the reflected signal channel, and the station remote control panel. The scope of the monitoring indicator may be used to monitor the output circuits of all receivers in the station in addition to observing targets and determining their coordinates.

The IIV-1 cabinet is used to measure the altitude of detected targets. For this purpose, a special scale is projected on the scope by means of an optical device.

The IAD-1 cabinet is used for the accurate measurement of the slant range and azimuth of detected targets.

The radio relay equipment serves for the transmission of displays from the scope of the PPI to the command post, which may be located up to 15 km from the station.

The interrogation system, located in the indicator vehicle, includes transceiver unit B-10, indicator B-16, distributor and circuit-protection unit B14, and control panel B-12.

The communications equipment of the station includes a 10-line switchboard with phone, phones located in the indicator cabinets, and a VHF radio R-109 for communication with the command guidance post.

Heating and ventilation of the vehicle is provided by an OV-65 heater apparatus, an electric heater, and a ventilation system which maintains normal temperatures in the cabinets and the vehicle.

Construction of the display equipment is based on the principle of using small functional units linked together in cabinets serving different purposes.

A significant number of units are of general purpose and are used in different cabinets. Structurally, the majority of the units are made on standard cast chassis to which are attached the components and assemblies making up the unit.

The tubes of each unit are placed in a special tube compartment closed by a door on the front panel.

Each cabinet contains, in addition to the standard units, a group of non-standard units. The cabinets are arranged so that the non-standard units are located in central compartments in the cabinet and the standard (p 15) units are in side compartments. All cabinets are of a single type.

The standard units are placed one under the other so that their tube compartments form two vertical ducts (tube channels) on either side of the cabinet. The tube channels of all cabinets are connected to a common heating-ventilating system of the vehicle, thus maintaining normal temperature conditions within each cabinet.

On the chassis of each unit is a plate with a picture of the schematic diagram of the unit, and on the doors of the tube compartments are plates with brief data on the unit.

The units are connected in each cabinet by means of knife-type connectors, and the cabinet connections in the vehicle are by plug connectors located on the cable mounting plates of each cabinet.

Figure 3 shows the IIV-1, IKO-1 and IAD-1 cabinets, and Figure 4 shows the ZN-F1 and DUS-1 cabinets.

3. Interaction of the Display Equipment.

A diagram showing the interaction of the display equipment is given in Figure 5.

Signals from the outputs of the centimeter-wave receivers and voltages of the test, control, and circuit-protection circuits of the transceiver apparatus pass from the transceiver cabin, through distributing board RShch-3, to vehicle No 2.

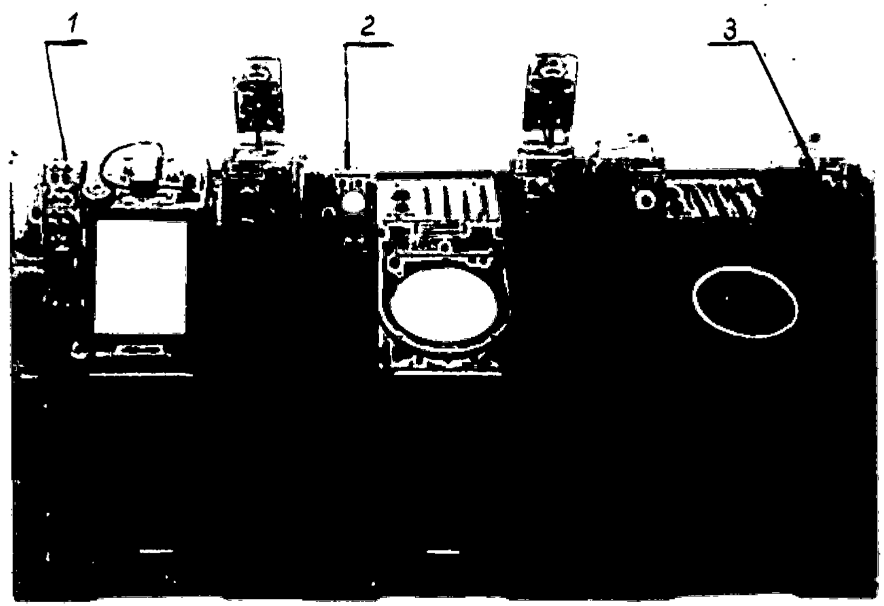

Fig. 3. IIV-1, IKO-1, and IAD-1 Displays.

1 - IIV-1; 2 - IKO-1; 3 - IAD-1.

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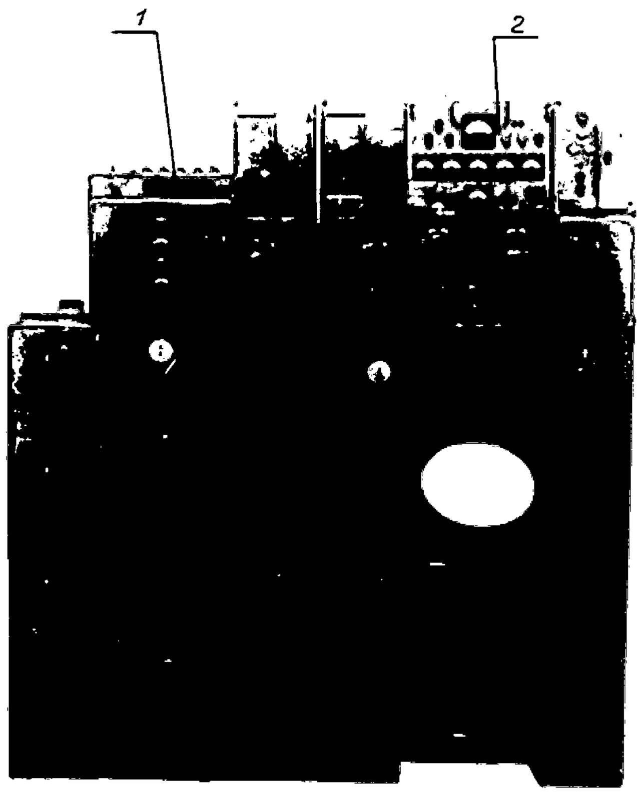

Fig. 4. ZN-F1 and DUS-1 Cabinets.

1 - ZN-F1; 2 - DUS-1.

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Signals are fed from the outputs of the centimeter-wave receivers to the DUS-1 cabinet, where they may be viewed on the scope of unit ZR-3 and the monitoring display, and then to two video channels EI and EII (corresponding to the receivers of the vertical and slant channels). (p 19)

The signals in channels EI and EII may be sent to the displays directly (first operating mode) or through units for protection against non-synchronous pulse noises (filter units), located in cabinet ZN-F1 (second operating mode).

The switching circuits of the first and second operating modes are located in unit VU of cabinet ZN-F1 and in units SS-1 of cabinet DUS-1.

The first mode is the direct transmission of signals of channels EI and EII to the station displays.

The signals are sent to unit VU in cabinet ZN-F1 (EIkf and EIIkf). When the switch is in the position "DUS," the signals are sent directly to the displays by way of IAD-1, IKO-1, IIV-1, cabinet P-11-1, and distributing board RShch-4.

At the same time, these signals pass through units designed to protect against non-synchronous pulse noises, and, after this filtering, return to cabinet DUS-1 (EI-F1 and EII-F1) where they are observed on the scope of the monitoring display; then they are sent through circuits EI-F2 and EII-F2 to unit VU in cabinet ZN-F1 to a load equivalent.

Switching of these signals occurs in units SS-1 when the signals are sent to the monitoring display; that is, when the switch on unit SS-1 is in the position "VYKh-F," filtered signals from EI and EII appear on the scope, and when the switch is in the position "VYKh SS," unfiltered signals appear.

The second mode is the transmission of signals of EI and EII to the station displays after they have been filtered. (p 20)

In this mode, the switch in unit VU of cabinet ZN-F1 is placed in the position "IND." In this case, the EI and EII signals are fed to units for protection against non-synchronous pulse noises, are filtered in these units, and are sent to the displays by way of the same circuits as in the first operating mode. The monitoring display of cabinet DUS-1 retains the capability of monitoring the EI and EII signals both before and after they have been filtered.

The NRZ-1 interrogator signal is sent from the output of transmitter B-11 through a T-junction to the antenna. The identification signals received by the antenna are fed through the same T-junction to receiver B-15 and from the output of the receiver to cabinets DUS-1 and P-11-1 and then to distributor board RShch-4, where the identification signal circuit is equivalent loaded.

The voltages from the synchronous tracking transmission circuits are sent from main selsyn unit FD-02 of the transceiver cabin to cabinet ZN-F1, where the operating mode of the SSP system is switched (operate-simulate) and secondary voltages at frequencies of 1,500 and 43 cps are generated.

The SSP voltages (1,500 and 50 cps) are fed from cabinet ZN-F1 to distributing board RShch-3 and from it to the displays. The 50-cps voltage is sent to the monitoring display of cabinet DUS-1, to IKO-1, and to output board RShch-4. The 1,500-cps voltages are fed from RShch-3 to the IAD-1 (p 21) and IIV-1 displays. The 43 cps voltages are sent to cabinet P-11-1.

Voltages of the control, testing, and circuit-protection system of the transceiver apparatus are applied directly to remote control panel PDU-1 located in cabinet DUS-1.

Rocking of the antenna may be controlled from the PDU-1 panel or from units UN-I (in cabinet IKO-1) and UN-II (in cabinet IIV-1). The voltages of these circuits are fed to PDU-1 through RShch-3.

The 220 v, 50 cps supply voltage from the electrical power unit in vehicle No 2 is fed to distributing board RShch-3 and then to each of the displays in the vehicle and the heating, ventilation, and lighting panels.

The telephone circuits lead to terminals on RShch-3. The telephone circuit of the display in cabinet DUS-1 is connected to the switchboard.

Other circuits which are fed to the station displays, in addition to the external circuits, are the trigger pulse and scale marker circuits, which originate in cabinet ZN-F1.

Two trigger pulses come from cabinet ZN-F1. One pulse (ZAP-I) is applied to distributing board RShch-3 and then to the transceiver cabin for synchronous triggering of the transmitter. (p 22)

The second pulse (ZAP-II) is fed in sequence to cabinets DUS-1, IAD-1, IKO-1, IIV-1, NRZ-1, cabinet P-11-1, and to distributing board RShch-4.

The range and azimuth markers are fed in sequence from cabinet ZN-F1 to cabinets DUS-1, IAD-1, IKO-1, IIV-1, cabinet P-11-1, and to RShch-4.

The PPI displays operating in the RL-30-1 radio relay line are connected to receiver cabinet V-11-1 through distributing board RShchV-KPN.

The following voltages are applied to each of the cabinets of IKO-V1: SSP at a frequency of 50 cps, power supply of 220 v, 50 cps, mixed signals through channels EI and EII, and trigger pulses.

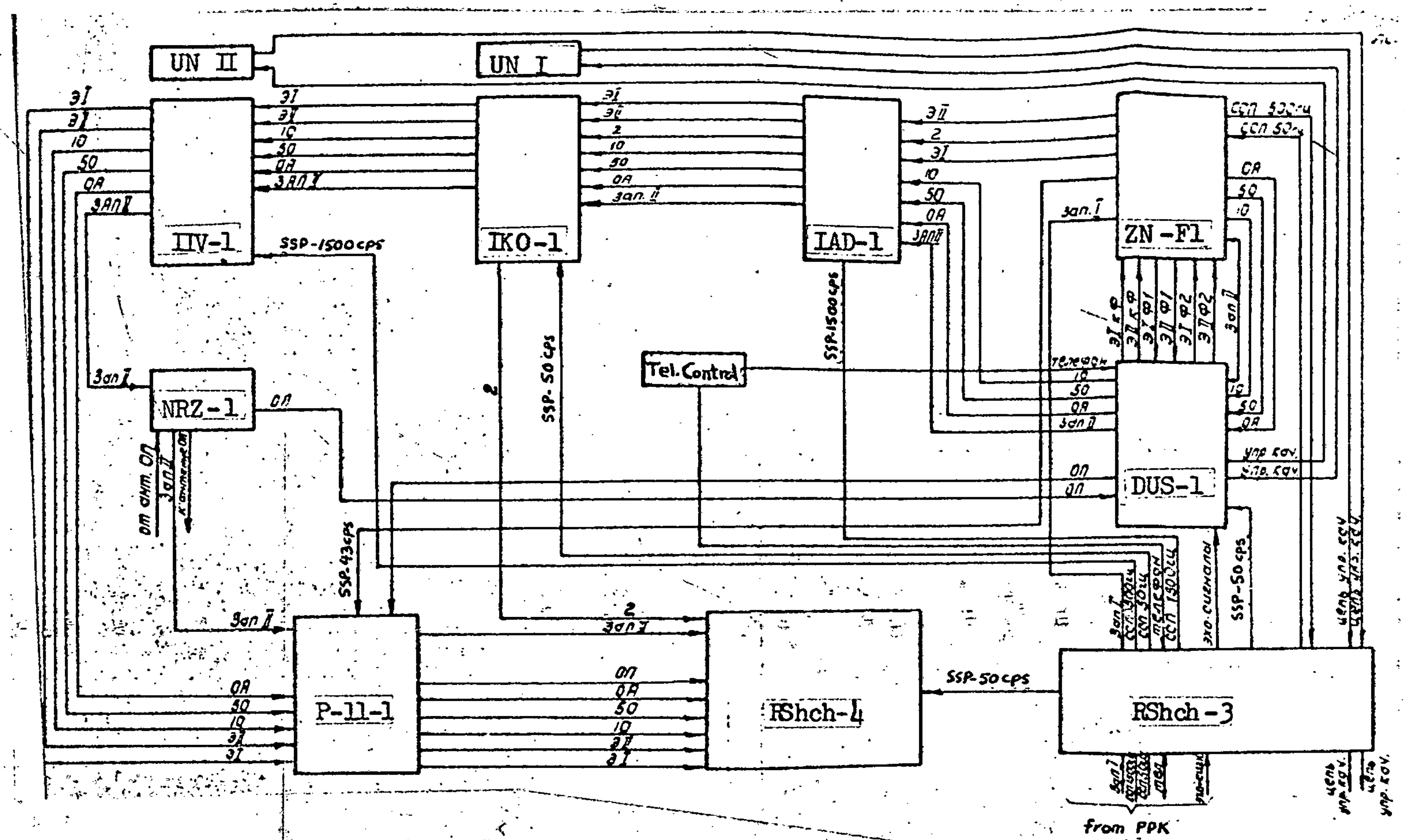

Fig. 5. Diagram of Interaction Between Display Equipment.

(See following page for KPN system)

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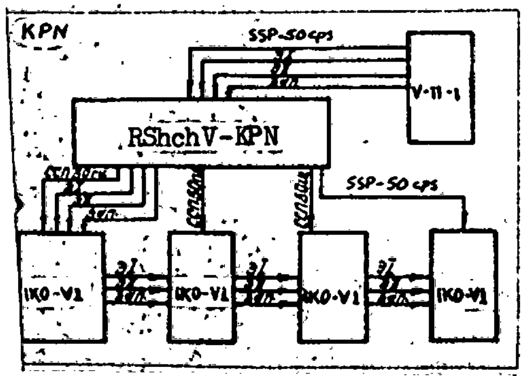

Fig. 5. (contd.) Interaction of Equipment in KPN System.

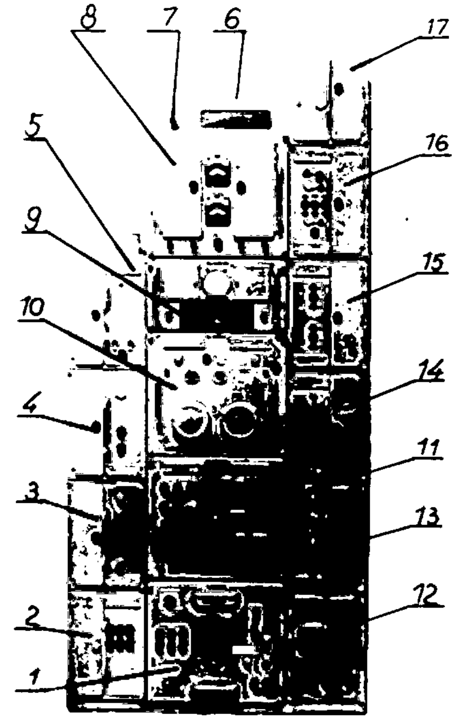

Fig. 6. Cabinet ZN-F1.

1 - unit UPT-1; 2 - unit BP-300; 3 - unit BP-200; 4 - unit GCh; 5 - unit OA-5-1; 6 - strip with plugs; 7 - switch for units IU-1, VU, and GR; 8 - unit IU-1; 9 - unit KO-3; 10 - unit VD-1; 11 - unit IV; 12 - unit BP-150; 13 - unit US; 14 - unit OA-1-1; 15 - unit BZ; 16 - unit VU; 17 - unit GR.

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CHAPTER TWO (p 23)

MASTER VOLTAGE AND FILTER CABINET ZN-F1

1. General Information

Cabinet ZN-F1 (Figure 6) generates trigger pulses for the transmitter and display equipment, range and azimuth scale markers, and supply voltages for elevation and azimuth scanning of the height measurement indicator and azimuth-range indicator. In addition, the cabinet also provides for protection of the video channels against non-synchronous pulse noises. Cabinet ZN-F1 also includes devices for simulating rotation of the antenna and the secondary transducer unit of the SSP system.

Technical data. Cabinet ZN-F1 produces the following:

1. A positive trigger pulse (with an amplitude of not less than 25 v).

2. Range scale markers of 2, 10, 50, and 100 km (with controlled marker amplitude).

3. Azimuth scale markers of 1°, 5°, and 30° (with controlled marker amplitude).

4. Antenna rotation angle voltages of the synchronous tracking transmission system for supplying the deflection coil rotation system of IKO-1, the elevation and azimuth sweeps of IIV-1 and IAD-1, and the shaping circuits for the azimuth scale markers.

Cabinet ZN-F1 also provides for protection of the video channel against interference created by adjacent radars having a pulse train rate up to 3,000 cps (when the separation of equal or multiple rates between the disturbing radars and the protected radar is not less than 0.5%). (p 25)

The ratio of the number of markers from one and the same target observed at IKO-1 before and after the noise-protection unit must be at least 95%.

Make-up of cabinet ZN-F1. Cabinet ZN-F1 includes the following units:

BZ - trigger and range markers;

OA-1-1 - one-degree azimuth markers;

OA-5-1 - five-degree and thirty-degree azimuth markers;

KO-3 - monitoring test oscilloscope;

VD-1 - secondary selsyn unit;

US - servoamplifier;

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IV - rotation simulator;

GCh - 1,500 cps frequency generator;

VU - input device;

IU-1 - integrator;

GR - sweep generator;

BP-300 - +300 v power supply;

BP-200 - +200 v power supply;

BP-150 - −150 v power supply;

UPT-1 - power supply control.

Units IU-1, KO-3, VD-1, IV, and UPT-1 are centralized. In the left compartments (from top to bottom) are units CA-5-1, GCh, BP-200, and BP-300, and in the right compartments -- GR, VU, BZ, OA-1-1, US, and BP-150.

Wiring diagram and principles of operation of equipment in the cabinet.

A wiring diagram of equipment in cabinet ZN-Fl is given in Figure 7.

Unit BZ generates trigger pulses which are sent to the transceiver (p 26) cabin, to all displays, to unit B-16 of the NRZ-1 system, and to the transmitter cabinet of the RL-30-1 system. This same unit forms the range scale markers. Units OA-1-1 and OA-5-1 generate the azimuth scale markers.

Units IV, VD-1, GCh, and US belong to the SSP system. Unit IV is the antenna rotation simulator of the radar. The unit generates primary voltages for supplying all elements of the SSP system. In addition, unit IV provides switching of the primary circuits of SSP running from main selsyn unit FD-02 and from unit IV. Unit VD-1 generates elevation and azimuth sweep voltages for IIV-1 and IAD-1, pulse-shaping voltages for the 30-degree azimuth markers, and SSP voltages at a frequency of 43 cps used in radio relay line RL-30-1. Unit US is used to rotate the motor in unit VD-1 in synchronization with the rotation of the selsyns of unit FD-02 or unit IV. Unit GCh generates voltages at a frequency of 1,500 cps for supplying the selsyns in units IV, VD-1, and FD-02.

The noise-protection apparatus (units VU, IU-1, and GR) are designed to decrease non-synchronous pulse noises on the indicator screens which are created by the operation of neighboring radars, as well as to decrease noise caused by the receivers themselves.

Return signals are mixed in units SS-1 (cabinet DUS-1) and are sent by two channels to the input device (unit VU) of the noise-protection apparatus.

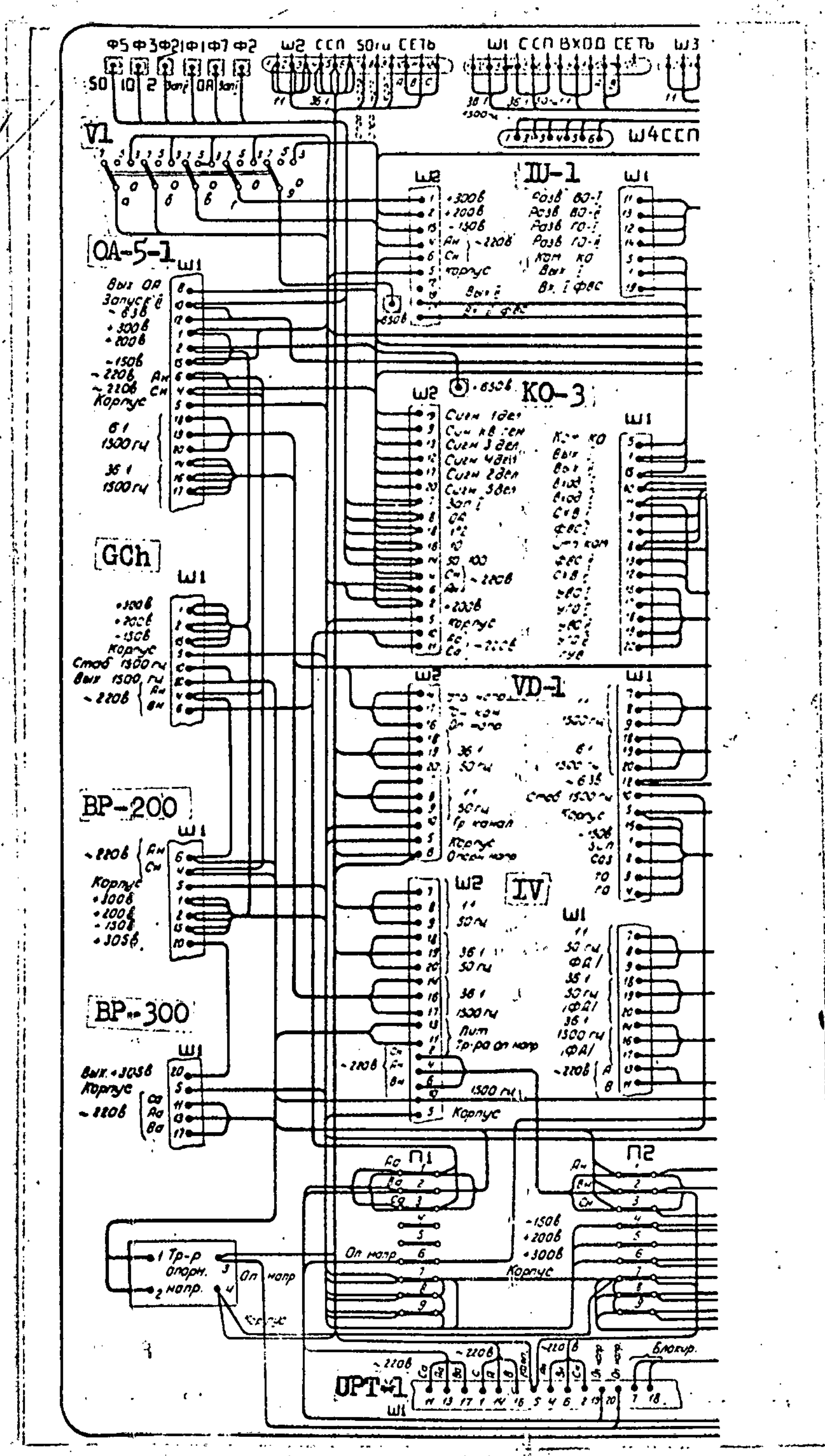

Fig. 7. Wiring Diagram for Cabinet ZN-F1.

Unit VU shapes all input signals into pulses of identical amplitude and duration. These signals pass to unit IU-1 where the useful signal is separated out and amplified. (p 28)

The filtered signals are applied to the displays or to load equivalents; that is, it is possible to connect the displays in front of the noise-protection apparatus or behind it.

Unit GR generates voltages for spiral scanning in tubes LN-7 of unit IU-1.

The noise-protection apparatus is capable of independently switching on and off the supply voltages.

Unit KO-3 is used to monitor different points in the circuits of units BZ, OA-1-1, OA-5-1, VU, GR, and IU-1. A stabilized voltage of +650 v is generated in this unit to supply tubes LN-7 in unit IU-1.

2. Trigger Unit BZ.

Function. The trigger unit (Figure 8) generates trigger pulses required for synchronous operation of the transceiver and display equipment and shapes 2, 10, 50, and 100-km range markers.

Technical data on the unit. Amplitude of the trigger pulses is at least 25 v, pulse duration of ZAP I is on the order of 1 microsecond and of ZAP II -- not less than 1.5 microseconds, and the repetition rate is 375 cps. The amplitude of the 10, 50, and 100-km range marker pulses is individually controlled within limits of 6 to 12 v, the 2-km range marker pulse amplitude -- within 9 to 12 v, while pulse duration is on the order of 1 microsecond.

Functional diagram of the unit. Figure 9 gives a functional diagram of unit BZ. The unit includes:

-- quartz oscillator; (p 31)

-- six frequency divider stages;

-- a trigger pulse repeater stage;

-- four delay lines;

-- four output stages for shaping the 2, 10, 50, and 100-km range scale markers.

The principle of operation of this circuit is based on division of the stable frequency of the quartz oscillator, which generates a relatively high frequency of 74,917 cps (75 kc is used for purposes of simplifying

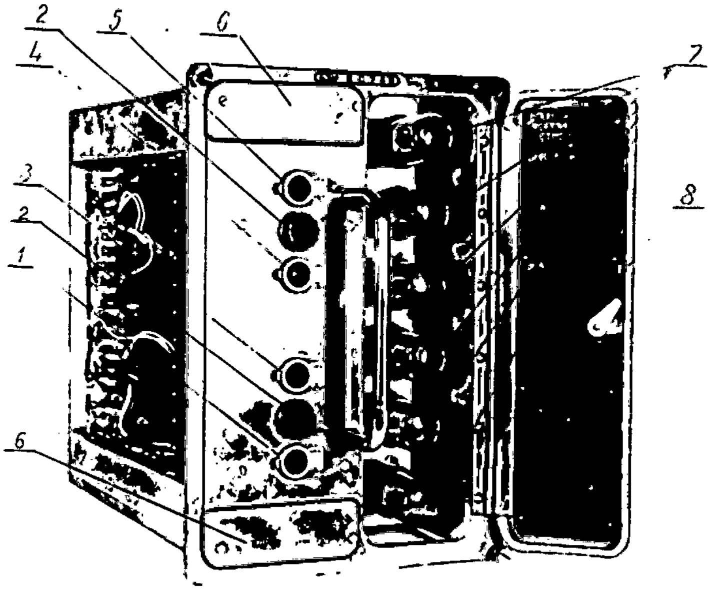

Fig. 8. Unit BZ.

1 - amplitude control for 2-km markers; 2 - illuminating bulb holder; 3 - amplitude control for 10-km markers; 4 - amplitude control for 50-km markers; 5 - amplitude control for 100-km markers; 6 - plug covers; 7 - tubes in tube channel; 8 - label inside door.

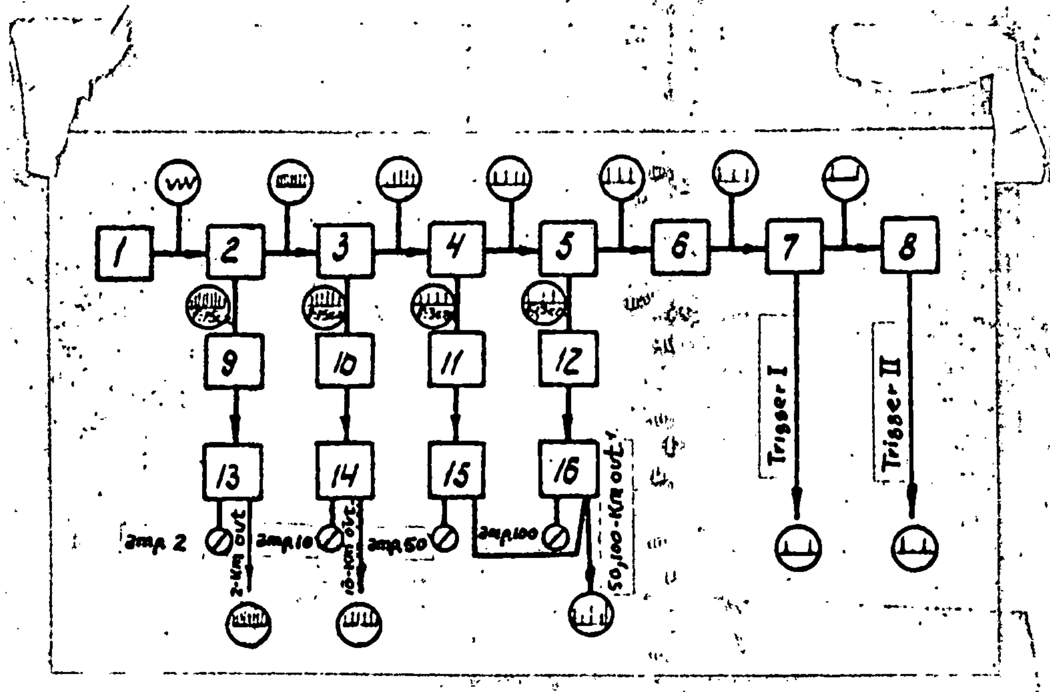

Fig. 9. Functional Diagram of Unit BZ.

1 - quartz oscillator; 2 - first divider stage; 3 - second divider stage; 4 - third divider stage; 5 - fourth divider stage; 6 - fifth divider stage; 7 - sixth divider stage; 8 - trigger pulse repeater stage; 9 - delay line U1; 10 - delay line U2; 11 - delay line U3; 12 - delay line U4; 13 - 2-km marker output stage; 14 - 10-km marker output stage; 15 - 50-km marker output stage; 16 - 100-km marker output stage.

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calculations); this frequency is divided in six stages in the following ratio:

first stage -- division of 1:1; $\frac{75}{1} = 75$ kc;

second stage -- division of 1:5; $\frac{75}{5} = 15$ kc;

third stage -- division of 1:5; $\frac{15}{5} = 3$ kc;

fourth stage -- division of 1:2; $\frac{3}{2} = 1.5$ kc;

fifth stage -- division of 1:2; $\frac{1,500}{2} = 750$ cps;

sixth stage -- division of 1:2; $\frac{750}{2} = 375$ cps.

Pulses of the sixth divider stage (ZAP I), with a frequency of 375 cps, are used to trigger the transmitter. These pulses are repeated by the trigger pulse repeater stage and are sent from here to trigger the display equipment (ZAP II).

Pulses of the first, second, third, and fourth divider stages are used to shape the range marker pulses:

First stage -- to shape the 2-km markers;

second stage -- to shape the 10-km markers;

third stage -- to shape the 50-km markers; (p 32)

fourth stage -- to shape the 100-km markers.

The trigger pulses are shaped in the output stages, which are blocking oscillators synchronized by pulses of the corresponding divider stage.

The blocking oscillators for the 2-km and 10-km markers have separate outputs, while the 50 and 100-km blocking oscillators have a common output.

All the frequency divider stages are blocking oscillators. There is a delay of the output pulse by 0.3 to 0.4 microsecond in each stage. In addition, the main pulse emitted by the transmitter is delayed relative to the output pulse of unit BZ. This delay is caused by the considerable length of the connecting cable and the time required to form the main pulse in the transmitter. The total delay time between a pulse of the first frequency divider stage in unit BZ and the main transmitter pulse must be compensated for by an identical displacement of the range scale markers. For this purpose a delay line is introduced into the synchronization circuit of the 2-km marker-shaping output stage. The pulse of the first divider stage, after being delayed by the line, is sent to the 2-km marker-shaping output stage. The output pulse of the 2-km marker blocking oscillator is delayed further by 0.3 to 0.4 microsecond.

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Thus, due to the presence of the delay line, the moment of radiation of the main transmitter pulse coincides with one of the 2-km range marker pulses.

The 10, 50, and 100-km markers are formed in the same manner as the 2-km pulses. Pulses of the second, third, and fourth stages are fed to their own output stages. Between the individual divider stages is a delay (p 33) of the output pulses by 0.3 to 0.4 microsecond which is compensated for by the introduction of delay lines.

The delay times in the 10, 50, and 100-km shaping circuits are different between each of the shaping stages and the output stages.

The unit has four controls: "AMPL 2," "AMPL 10," "AMPL 50" and "AMPL 100," which are used for individual adjustment of the amplitude of the range marker pulses at the output of unit BZ.

Description of the schematic diagram of the unit. A schematic diagram of unit BZ is given in Figure 10. The first stage of the circuit is the quartz oscillator which provides sinusoidal voltage at 74,917 cps. The oscillator uses the left half of tube V1, and the quartz is connected between the plate and grid of the tube. The first frequency divider stage is synchronized by sinusoidal oscillations of the quartz oscillator.

Description of the frequency dividers. The first frequency divider stage is a self-excited blocking oscillator which uses the right half of tube V1. The synchronizing oscillations from the plate of the left half of tube V1 are applied to the grid of the right half of the tube through blocking capacitor C13 and the grid winding of blocking transformer Tr1. The large amplitude of the synchronizing oscillations provides precise synchronization. The blocking oscillator of the first divider stage repeats the quartz frequency, that is, it operates at 74,917 cps.

During the passage of the blocking oscillator pulse, capacitor C14 is charged by the grid currents of the tube to a negative voltage which blanks the tube. The capacitor discharges during the interval between pulses through grid resistor R14. With this, the voltage at the grid almost reaches the triggering voltage of the tube, and, consequently, the voltage (p 35) of the quartz oscillator at the grid causes the blocking oscillator to trigger.

The external synchronization voltage causes an increase in the potential at the grid of the right half of tube V1 and forces the blocking oscillator to fire. Thus, the frequency of generated pulses is synchronized by the external voltage of the quartz oscillator.

The second divider stage, like the first, is a self-excited blocking oscillator and is based on the left half of tube V2. Pulses of the first divider stage, taken from the cathode of V1b, are used to synchronize this stage. These pulses are applied to the grid of V2a through decoupling resistor R15 and one of the windings of blocking transformer Tr2 (taps 1-4).

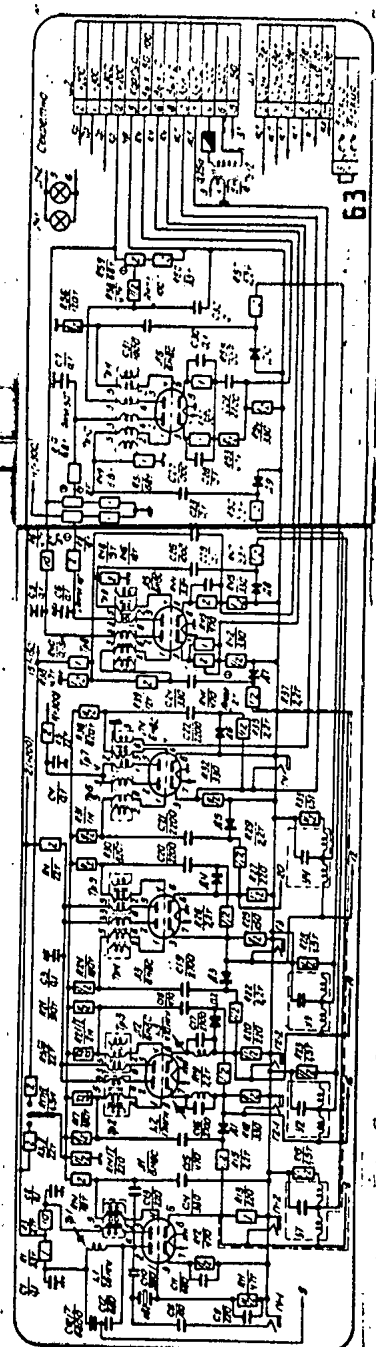

Fig. 10. Schematic Diagram of Unit BZ.

Resistor R15 reduces the influence of the second frequency divider stage on the first.

In the second stage there is a frequency division of 5; that is, the stage operates at a frequency of 15 kc. An oscillatory circuit consisting of L2 and C16 is connected to the cathode of blocking oscillator V2a to increase the stability of frequency division. The natural frequency of the circuit is 1.5 times greater than the frequency of the blocking oscillator of the second frequency divider stage and is equal to 22.5 kc. At the moment a pulse is generated by the blocking oscillator of the second frequency divider stage, sinusoidal oscillations are excited in this (p 36) circuit and, as a result, in the cathode of V2a. The voltage between the cathode and grid of V2a is the sum of the voltages in the cathode circuit and in the grid capacitor (Figure 11). Consequently, the grid potential of tube V2a relative to the cathode at the moment of arrival of the first four pulses of the first frequency divider stage will be considerably less than the triggering level of tube V2a.

By the time the fifth pulse arrives, the potential of the grid relative to the cathode increases to the triggering level of the tube and the blocking oscillator is excited. The function of the cathode circuit is to reduce the possibility of synchronization of the blocking oscillator by the first four pulses of the first frequency divider stage.

The third frequency divider stage is identical to the second, and is based on tube V2b. The synchronizing pulse is taken from the cathode of tube V2a to the grid of tube V2b through decoupling resistor R19 and one of the windings of blocking transformer Tr3 (taps 1-4). This stage generates pulses at a frequency of 3 kc.

The fourth frequency divider stage is, like the first stage, a self-excited blocking oscillator and is synchronized by pulses from the third stage. It uses the left half of tube V3 (V3a). Synchronizing pulses are applied from the cathode of tube V2b through decoupling resistor R22 and one of the windings of blocking transformer Tr4 (taps 1-4) to the grid of tube V3a. The fourth stage divides the frequency of the third by 2; that is, it operates at a frequency of 1.5 kc.

The fifth frequency divider stage is identical to the fourth stage. It uses tube V3b. Synchronizing pulses from the fourth stage are applied through resistor R26 and one of the windings of blocking transformer Tr5 (taps 1-4). The fifth stage divides the frequency of the fourth by 2; (p 37) that is, it operates at a frequency of 750 cps.

The sixth frequency divider stage is fundamentally like the fifth with the exception that a voltage of +300 v is applied to the plate of this stage in order to increase the amplitude of the output pulse. The sixth stage uses tube V4a. The synchronizing pulses of the fifth stage are applied through resistor R29 and one of the windings of blocking transformer Tr6 (taps 1-4). The sixth stage divides the frequency of the fifth by 2; that is, it operates at a frequency of 375 cps.

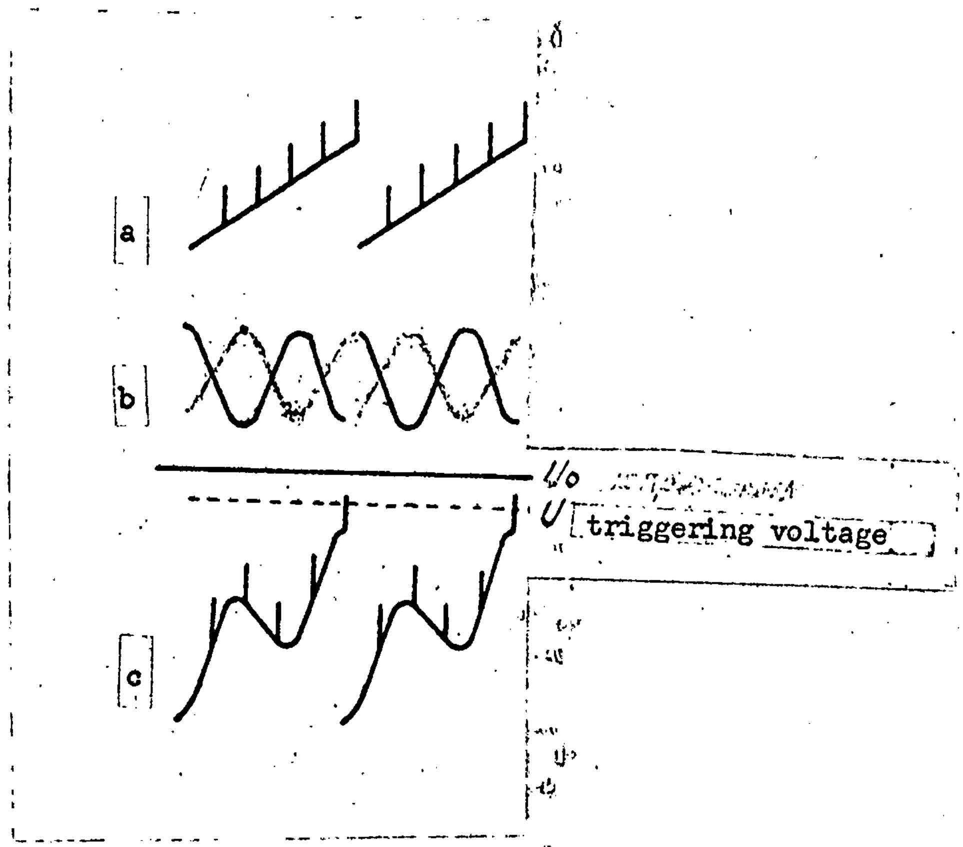

Fig. 11. Voltage Forms in Blocking Oscillator With Cathode Circuit.

a - form of voltage at grid capacitor of blocking oscillator with frequency division at 1:5; b - form of voltage in cathode circuit of blocking oscillator; c - resultant voltage in grid-cathode sector of blocking oscillator with cathode circuit.

The output pulse of this stage is used as the trigger pulse of the transceiver.

In addition, this pulse is sent to the grid of the trigger pulse repeater stage through circuit R35, C22 and the grid winding of blocking transformer Tr7. The repeater stage is based on tube V4b and is a blocking oscillator which operates basically the same as the blocking oscillator of the sixth frequency divider stage. It repeats the frequency of the sixth stage. Its output pulse, taken from the third winding of blocking transformer Tr7, is not less than 1.5 microseconds in duration and is used to trigger the display equipment.

Range marker shaping stages. The pulses of the first, second, third, and fourth frequency divider stages are applied to the output stages of the 2, 10, 50, and 100-km range marker-shaping circuits.

The 2-km marker-shaping output stage is a blocking oscillator based on tube V5a with negative bias taken from divider R38 and R40. When the blocking oscillator receives synchronizing pulses from the first frequency divider stage, it oscillates at the frequency of these incoming pulses. The synchronizing pulses are taken from the cathode of V1b through delay line U1, circuit R37, C24, and the grid winding of blocking transformer Tr8. The amplitude of the 2-km markers is controlled by means of variable resistor R41 connected in series with the output load. The 2-km marker output pulses are taken from cathode resistor R42. (p 39)

The 10-km marker-shaping output stage is a blocking oscillator based on tube V5b which is blanked by an automatic bias created by circuit R44, C25 in the cathode circuit of the blocking oscillator. Synchronizing pulses of the second frequency divider stage are applied to the grid of V5b from the cathode of V2a through delay line U2, circuit R47, C26, and the grid winding of blocking transformer Tr9. The blocking oscillator repeats the synchronizing pulses. The amplitude of the 10-km markers is controlled by changing the plate voltage with resistor R8. Due to the automatic bias, the value of the bias changes when the plate voltage is changed. In this way the operating mode of tube V5b and the conditions of synchronization are maintained. The 10-km marker output pulses are taken from cathode resistor R45.

The 50-km and 100-km marker-shaping output stages are also blocking oscillators and use tubes V6a and V6b, which are blanked by an automatic bias formed by circuit R52, C28, for V6a and R55, C30 for V6b. The synchronizing pulses of the third frequency divider stage are applied to the grid of V6b (for the 100-km markers) from the cathode of V3a through delay line U4, circuit R57, C31, and the grid winding of blocking transformer Tr11. The blocking oscillator is excited at the frequency of the synchronizing pulses. The amplitude of the 50-and 100-km markers is controlled by changing the plate voltages of the blocking oscillators with variable resistors R9 and R59.

The 50-km and 100-km blocking oscillators have a common cathode load R54 from which the mixed 50-and 100-km markers are taken. Independent regulation of the 50-km and 100-km markers is achieved by suppressing the 50-km markers for those ranges which are multiples of 100 km. For this purpose, the delays provided by lines U3 and U4 are selected so that the 100-km marker blocking oscillator is excited somewhat earlier than the 50-km marker oscillator.

In addition, the common cathode circuit of V6 contains capacitor C29 which, during the interval of the 100-km marker pulse, charges and increases the potential of the cathode of V6a. The tube is thus blanked, and synchronizing pulses arriving at its grid will not cause excitation of the 50-km marker blocking oscillator. Capacitor C29 discharges through resistor R53.

<u>Monitoring the unit.</u> Unit BZ is monitored by means of six test jacks:

G1-1 -- for monitoring oscillations of the quartz at the plate of V1a;

G1-2 -- for monitoring pulses of the first divider at the cathode of V1b;

G2-1 -- for monitoring pulses of the second divider at the cathode of V2a;

G2-2 -- for monitoring pulses of the third divider at the cathode of V2b;

G3 -- for monitoring pulses of the third divider at the cathode of V3a; (p 41)

G4 -- for monitoring pulses of the sixth divider (ZAP II) at the cathode of V4a.

The trigger pulse ZAP II is monitored directly on the screen of the indicator.

Test voltages of +1 v and -1 v are used to check the degree of operating stability of the trigger pulse-shaping circuit.

These test voltages are applied to the grid circuits of the blocking oscillators.

The test voltages are taken from a divider consisting of resistor R3/I and resistors R3/II and R3/III. Resistors R3/II and R3/III are connected alternately to resistor R14/I by means of switch V1. Unit KO-3 is used to monitor the division frequency.

The unit is operating stably if the division frequency does not change when the test voltages are applied.

Design of the unit. Unit BZ is made in the form of a self-contained instrument on a standard chassis. The tube channel contains six type 6N8S tubes, six test jacks, and switch V1. On the front panel are the potentiometers used to adjust the amplitude of the 2, 10, 50, and 100-km range markers. The unit is connected to other units in the cabinet by means of two plug connectors. The delay lines are located within the unit next to the front panel. The weight of the unit is 10 kg.

3. The Synchronous Tracking Transmission System SSP. (p 42)

Function and technical data. The SSP system serves for the remote transmission of the angle of rotation of the antenna system to the display equipment of the station and consists of an electrical and a power part.

The synchronous power system is used to rotate the deflecting coils of the plan position indicators in synchronization and in phase with the rotation of the antenna, as well as for rotation of the secondary transmitting selsyns of the electrical synchronous transmission system.

The power system is a two-channel system and operates at a frequency of 50 cps. Transmission error does not exceed 6 minutes, and the time required for synchronization is not more than 15 seconds.

A brief description of the principles of operation of the synchronous power and electrical transmission is given below for the purpose of explaining the operation of the SSP system.

Principle of operation of synchronous power transmission. The principle of operation of the simpler system of a single-channel servodrive may be seen in Figure 12.

The rotating shaft of the antenna system is linked through a reduction gear with a ratio of 1:1 to the shaft of the transmitting selsyn rotor. The single-phase winding of the transmitting selsyn stator is supplied from a 50-cps network.

The voltage from the rotor winding of the transmitting selsyn is sent by a three-phase line to the three-phase winding of the receiving selsyn stator.

If the rotor of the transmitting selsyn turns and the rotor of the receiving selsyn is stationary, the voltage in the winding of the latter will change sinusoidally with a period equal to the period of rotation of the transmitting selsyn; that is, to the period of rotation of the antenna.

If the rotor of the receiving selsyn turns synchronously with the rotation of the rotor of the transmitting selsyn, the voltage in its rotor winding will have a constant amplitude whose magnitude will be determined by the angle between the direction of the rotating magnetic field created (p 44) in the receiving selsyn, and the shaft of the rotor winding. When this angle is equal to $\pm 90^{\circ}$, the output voltage at the receiving selsyn will equal zero.

If the rotor of the receiving selsyn turns through a certain angle relative to the zero position, a voltage will appear in the rotor winding whose amplitude and phase will depend on the size and sign, respectively, of this angle. This voltage is called the misalignment voltage.

The misalignment voltage in the servo drive circuit is applied to the input of the servoamplifier where it is amplified and used to control the servomotor, which turns the output shaft of the servodrive and, with it, the rotor of the receiving selsyn.

Exact alignment of the position of the transmitting and receiving selsyn rotors, even with a constant load and a constant number of turns of the selsyn, is impossible, since the misalignment voltage in this case will equal zero and the servomotor will cease to be supplied with voltage.

The synchronization accuracy of a single-channel system is usually not greater than 1°.

In order to increase synchronization accuracy, a two-channel remote servodrive system is used.

A block diagram of such a system is shown in Figure 13. The shaft which rotates the antenna system is linked with the rotor of the coarse-tracking transmitting selsyn through a reduction gear having a ratio of 1:1 and with the rotor of the fine-tracking transmitting selsyn through a reduction gear having a ratio of 36:1.

The single-phase windings of both transmitting selsyns are supplied from a 50-cps network, and the three-phase windings are connected to the corresponding three-phase windings of the receiving selsyns. The rotors of the receiving selsyns are linked to each other and to a servomotor through a reduction gear. The gear ratio between the rotors of the receiving selsyns is 1:36. The voltages from the single-phase windings of both receiving selsyns are applied to the two inputs of the servoamplifier. The output voltage of the servoamplifier is fed to the control winding of the servomotor.

In the coarse-tracking channel of the servoamplifier circuit is a neon lamp which serves as a relay. It disconnects the coarse-tracking channel when the angle of misalignment between the transmitting selsyn and coarse-tracking receiving selsyn is less than $2^{\circ}30'$ (average value), and tracking is then carried out with the fine-tracking channel. Consequently, a two-channel system of this type has a synchronization accuracy which is 36 times greater than a single-channel system. (p 46)

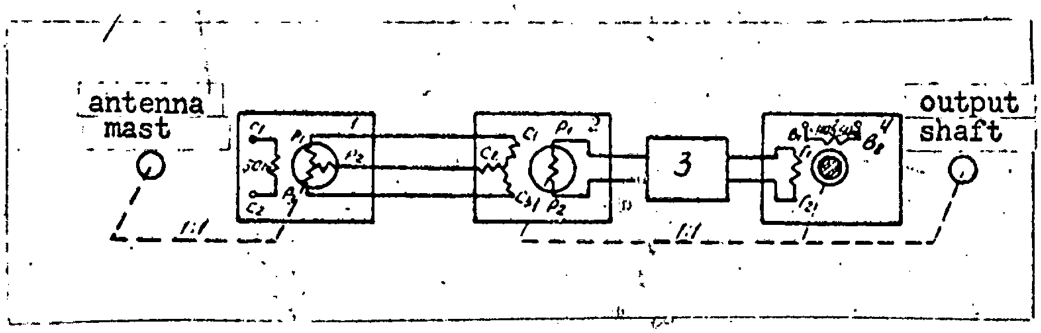

Fig. 12. Block Diagram of Single-Channel Remote Servodrive.

1 - transmitting selsyn; 2 - receiving selsyn; 3 - servoamplifier; 4 - servomotor.

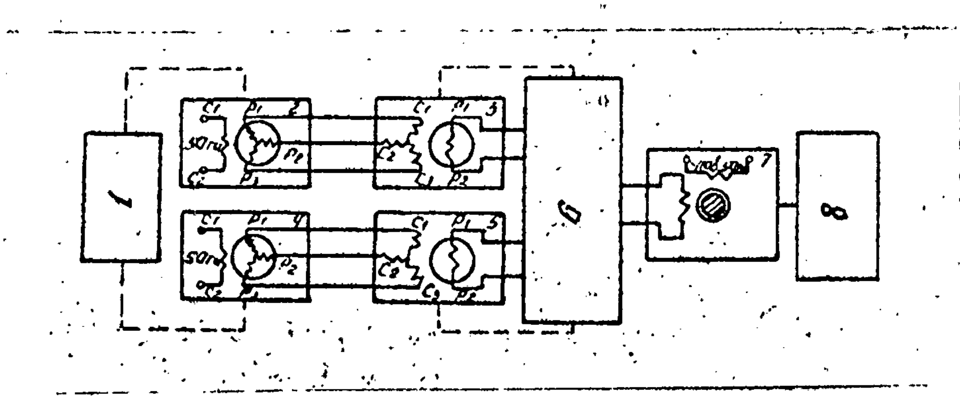

Fig. 13. Block Diagram of Two-Channel Remote Servodrive.

1 - antenna; 2 - coarse-tracking transmitting selsyn; 3 - coarse-tracking receiving selsyn; 4 - fine-tracking transmitting selsyn; 5 - fine-tracking receiving selsyn; 6 - servoamplifier; 7 - servomotor; 8 - deflecting systems of displays.

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The single-channel system has two zero positions for the receiving selsyn rotor which are mutually displaced by 180°. But alignment of the single-channel system in a false-zero position is impossible, since this position is unstable.

In a two-channel system, the voltage of the coarse-tracking channel passes through zero twice for each rotation of the antenna, and the voltage of the fine-tracking channel passes through zero 36 x 2 = 72 times. As a result, when the coarse channel is in a false zero position, the fine channel is in the position of the true zero; that is, the system can be aligned in the false-zero position. To eliminate this, an additional voltage at a frequency of 50 cps is introduced into the coarse-tracking channel in series with the misalignment voltage. As a result of this, the zero positions of the coarse channel are displaced so that the system is stable at only one of the zero positions of the coarse channel; that is, alignment of the system at a false zero is impossible. A description of the system of eliminating (striking) the false angle is given in the description of the servoamplifier unit (US).

<u>Principle of operation of the system of synchronous electrical angle transmission.</u> Figure 14 shows a block diagram of the electrical system for the synchronous transmission of the angle of rotation. The rotor of the selsyn generator is linked to the driving shaft (antenna shaft). The stationary single-phase winding of the stator is supplied by a 1,500-cps voltage provided by a special generator. The voltage is fed from the (p 48) three-phase winding of the selsyn generator over a three-phase line to the three-phase winding of the selsyn transformer.

The rotor of the selsyn generator is turned at a given speed, and the stator of the selsyn transformer is fixed in a pre-selected position.

The voltage in the single-phase winding of the selsyn-transformer changes sinusoidally; its phase is determined by the position of the selsyn generator rotor.

<u>Description of the circuit of the SSP system.</u> The circuit of the SSP system is given in Figure 15. The following units are included in the SSP system:

FD-02 -- main selsyn unit;

IV -- rotation simulator unit;

VD-1 -- secondary selsyn unit;

US -- servoamplifier unit;

GCh -- 1,500-cps voltage generator;

-- receivers of the synchronous power transmission system in units TI-1 of cabinets IKO-1 and DUS-1;

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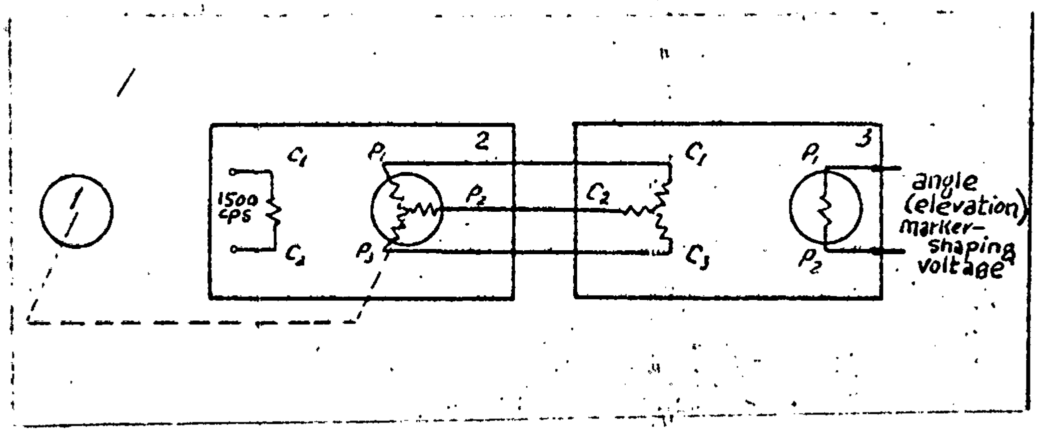

Fig. 14. Block Diagram of a Synchronous Electrical Angle-Transmission System.

1 - antenna mast; 2 - selsyn generator; 3 - selsyn transformer.

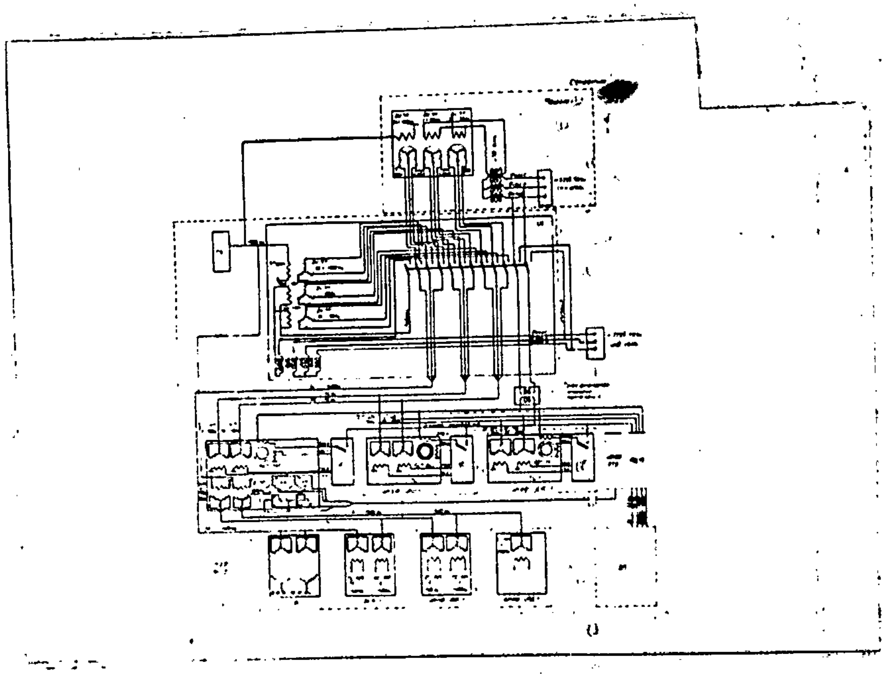

Fig. 15. Over-All Diagram of the SSP System.

-- azimuth sweep selsyn transformers in units RU-1 and RA of cabinets IIV-1 and IAD-1;

-- selsyn transformers of the azimuth marker-shaping circuits in units OA-1-1 and OA-5-1 of cabinet ZN-F1;

-- reference voltage transformer in cabinet ZN-F1 and transmitting selsyns supply transformer in cabinet ShU-1.

The main selsyn unit FD-02 is located in the transceiver cabin. It includes type DI-511 selsyn transmitters for coarse and fine tracking and selsyn generator DI-511 for the five-degree markers. The shaft of unit FD-02 is mechanically coupled to the shaft which rotates the cabin. When the antenna rotates, the selsyns, which rotate at a corresponding speed, generate a three-phase master voltage for the synchronous power transmission system and a three-phase master voltage for shaping the five-degree markers of the synchronous electrical transmission system. These three-phase voltages are applied to the rotation simulator (IV) located in cabinet ZN-F1. Unit IV affords the possibility of operating the display equipment in two modes:

1) In the OPERATE mode (with the cabin rotating). In this case, the SSP master voltage generated by unit FD-02 passes through unit IV to the display equipment.

2) In the SIMULATE mode, whereby the SSP voltages passing to the display equipment are generated in unit IV itself.

A switch located in unit IV is used to change from one mode to the other. The tracking voltages pass from unit IV to the receivers of the synchronous power transmission system located in cabinets ZN-F1, DUS-1, and IKO-1, as well as to cabinet P-11-1 and to distributor board RShch-4.

These devices (receivers) consist of a servomotor, linked through a reduction gear to type SS-405 receiving selsyns for coarse and fine tracking, and a servoamplifier (unit US). A two-phase synchronous motor ADP-262 is used as the servomotor in units TI-1 and an ADP-362 is used in unit VD-1. The misalignment voltage between the transmitting selsyns and the receiving selsyns, taken from the single-phase windings of the latter, is amplified by the servoamplifier. The amplified voltage is fed to the control winding of the servomotor.

A voltage of 110 v, 50 cps, called the reference voltage, is applied to the excitation winding of the servomotor. This voltage comes through unit US from the transformer located in cabinet ZN-F1. The servomotor turns the rotor of the receiving selsyns through a reduction gear, generating the angle of misalignment. At the same time, the servomotor turns the output element of the receiver in synchronization and in phase with the rotation of the antenna (or the coarse-tracking transmitter in unit IV in the SIMULATE mode). The output element for the SSP receiver located in cabinets IKO-1 and DUS-1 is the deflecting system of unit TI-1; (p 51) the output elements for the receiver located in cabinet ZN-F1 are the selsyn generators for the azimuth sweep and 30-degree markers, and the SK-MG coarse and fine transmitting selsyns for the RL-30-1 system located in unit VD-1.

The 220-v, 50-cps voltage which supplies the primary winding of the reference voltage transformer passes through unit IV.

When operating from unit FD-02, the voltage to the primary winding of the reference voltage transformer comes from two phases of the three-phase network; in the "simulate" mode it comes from two phases of the three-phase network supplying the display equipment. As a result of this, there is no need for phase adjustment of the SSP system when switching from one mode of operation to the other.

The system of synchronous electrical transmission of the angle of rotation of the antenna includes:

-- the 5-degree marker selsyn generator (in unit FD-02 or unit IV);

-- the azimuth sweep and 30-degree marker selsyn generators (in unit VD-1);

-- selsyn transformers SS-405 (in units OA-5-1, RU-1, and RA):

-- selsyn transformers ED-101 (in unit OA-1-1);

-- coarse and fine sine-cosine selsyns SK-MG for the RL-30-1 system.

An alternating voltage is present in the single-phase winding of each SS-405 selsyn transformer whose amplitude changes with a period which is equal to or a multiple of the period of rotation of the antenna, and whose phase envelope is determined by the position of the selsyn transformer rotor. (p 52)

A voltage from the 5-degree marker selsyn generator (in unit FD-02 or IV) and the 30-degree marker selsyn generator (in unit VD-1) is applied to unit OA-5-1. The 5-degree and 30-degree marker-shaping voltage is taken from the two selsyn transformers located in the unit. A voltage from the azimuth sweep selsyn generator (in unit VD-1) is applied to units RU-1 and RA. The azimuth sweep-shaping voltage for the height measurement and azimuth-range indicators is taken from the selsyn transformers of these units. A voltage from the 5-degree marker selsyn generator (in unit FD-02 or IV) is applied to the differential selsyns of unit OA-1-1 to provide the voltage which shapes the 1-degree markers.

The three-phase azimuth sweep and 30-degree marker voltages are also fed to distributing board RShch-4.

The SK-MG sine-cosine selsyns for coarse and fine readings are elements of the RL-30-1 equipment. The synchronization voltages taken from them for rotation of the azimuth sweep are applied to the transmitter of the RL-30-1 system.

4. Main Selsyn Unit FD-02[1].

Function. The FD-02 main selsyn unit (Figure 16) is designed to provide the master voltages for synchronous power transmission of the angle of rotation of the antenna and the master voltages for the 5-degree scale marker-shaping circuit. (p 52)

Technical data. The following voltages are generated in the main selsyn unit:

-- voltage of the coarse-tracking channel at a frequency of 50 cps;

-- voltage of the fine-tracking channel at a frequency of 50 cps;

-- voltage of the 5-degree marker-shaping circuit at a frequency of 1,500 cps.

Schematic diagram. A schematic diagram of unit FD-02 is given in Figure 17. The main elements of the unit are the type DI-511 selsyns, which have a three-phase rotor and a single-phase stator. The stator windings of the coarse- and fine-tracking transmitting selsyns are supplied by 70 volts, 50 cps from the three-phase transformer located in cabinet ShU-1. The rotor of the coarse-tracking transmitting selsyn turns at the speed of rotation of the antenna, and the rotor of the fine-tracking transmitting selsyn turns at a speed 36 times greater than the rotation speed of the antenna.

The stator winding of the 5-degree marker selsyn generator is supplied by 100 volts at 1,500 cps from unit GCh.

The rotor of this selsyn generator turns at a speed 36 times greater than the speed of rotation of the antenna.

The master (primary) voltages are taken from the rotor windings of the transmitting selsyns and are applied to the slip ring. The dials in the unit are illuminated by a 6.3 v, 0.28 a miniature bulb to which a filament voltage of 6.3 v is applied from one of the windings of the three-phase transformer.

1. Although the main selsyn unit is located in vehicle No 1, it is nevertheless useful to include its description in that of all instruments which belong to the SSP system.

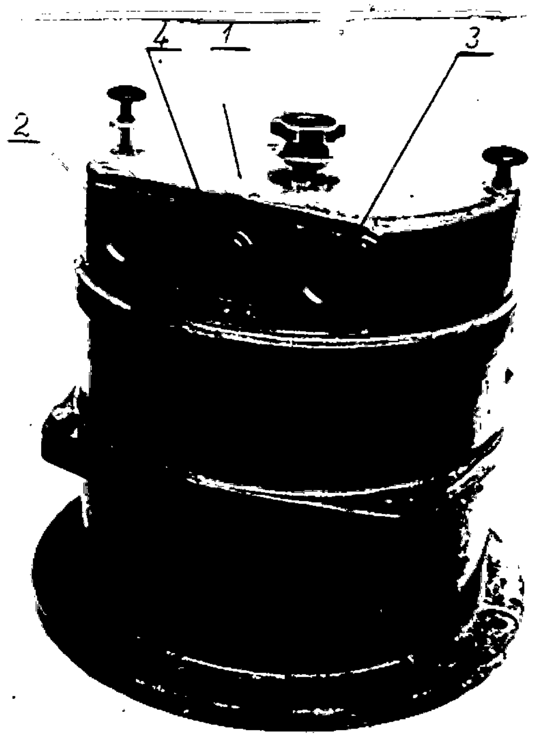

Fig. 16. Unit FD-02.

1 - cover of unit; 2 - window for fine-reading dial; 3 - window for coarse-reading dial; 4 - bulb holder for illuminating light.

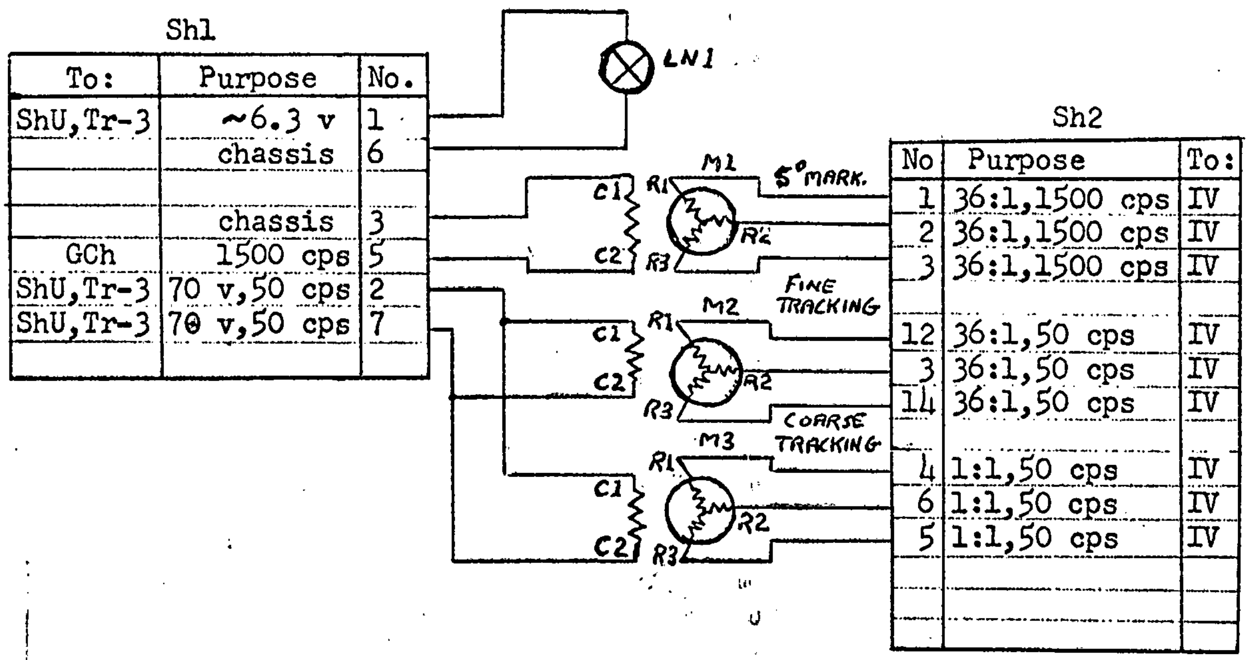

Fig. 17. Schematic Diagram of Unit FD-02.

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Design of the unit. The main selsyn unit is built in the form of three detachable parts -- the reduction gearing, the selsyn unit, and the cover.

A kinematic diagram of the unit is given in Figure 18. (p 57)

The reduction gearing, consisting of a set of spur gears, is mounted in the lower part of the unit. The input shaft of the reduction gearing, which is linked through a full-floating coupling to the axle of the slip ring, transmits the rotation of the antenna to the selsyns located in the central part of the unit.

The housing of the main selsyn unit is attached to the slip ring housing.

The input shaft of the reduction gearing is connected to the free-floating coupling by means of a coupling clamp.

This clamp is disconnected when setting the selsyn rotors in the zero position with the antenna directed toward the north. This permits the input shaft of the reduction gearing to be disconnected from the slip ring, and it is then possible to turn the selsyn rotors and set them in the required positions.

The reduction gearing is mounted in a cylindrical silumin housing. The housing is joined to that of the selsyn unit, in which the selsyn stators and plug connectors are located.

The selsyn rotors are equipped with half clutches and are connected to the output shafts of the reduction gearing. The coarse and fine selsyn rotors are equipped with the appropriate dials. The value of each division on the coarse selsyn dial is 5^{o}, and for the fine selsyn dial -- 10'.

The housing of the selsyn unit is closed by a cover.

5. Rotation Simulator Unit IV.

Function. Rotation simulator IV (Figures 19 and 20) serves for adjustment of the display equipment when the antenna is not being used ("simulate" mode). The display equipment is switched from the "operate" mode to the "simulate" mode by means of a switch located within unit IV itself.

Technical data. The same voltages taken from the main selsyn unit (section 5) are also taken from unit IV. (p 60)

The selsyns are rotated by means of a type DT-75 motor which is part of the rotation simulator.

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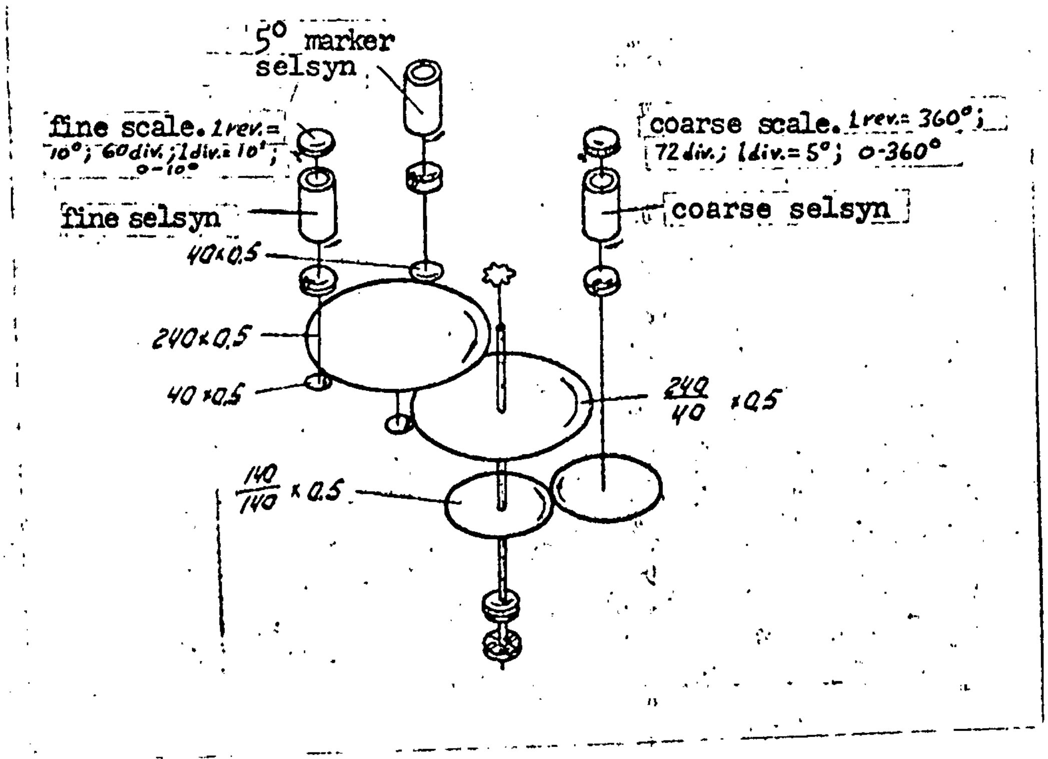

Fig. 18. Kinematic Diagram of Unit FD-02.

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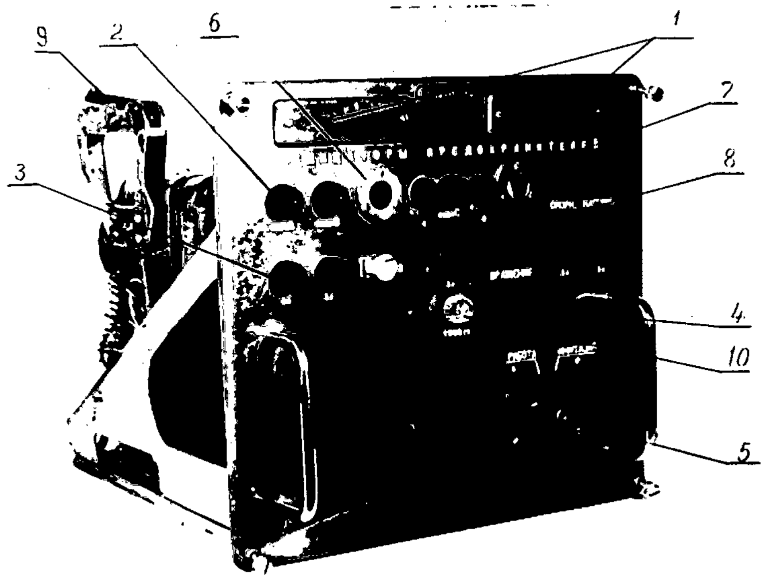

Fig. 19. Unit IV (View From Front).

1 - plug cover; 2 - fuse condition light; 3 - fuses; 4 - motor switch; 5 - operating mode switch; 6 - window for fine-reading dial; 7 - window for coarse-reading dial; 8 - opening for turning reduction gear; 9 - catch for unit; 10 - 1,500-cps frequency indicating light.

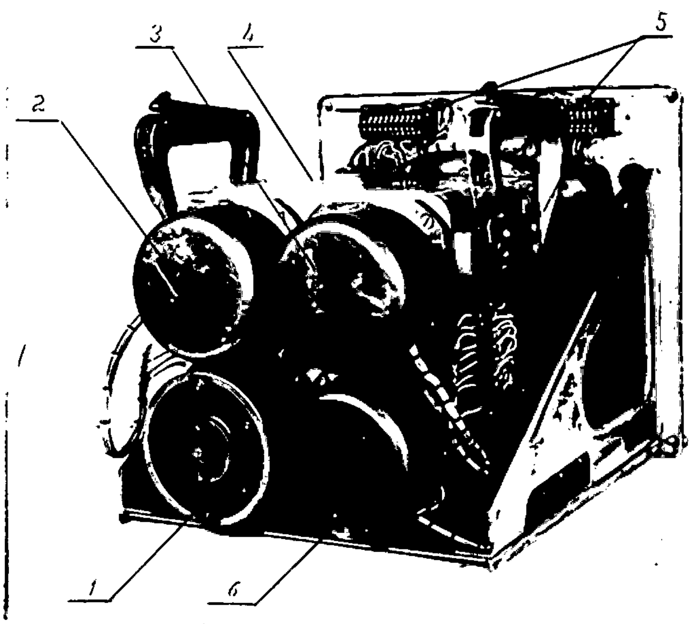

Fig. 20. Unit IV (Rear View).

1 - DT-75 motor; 2 - coarse selsyn; 3 - fine selsyn; 4 - circuit diagram label; 5 - plugs; 6 - 5-degree marker selsyn.

A voltage of 220 v, 50 cps, which is used to supply the reference voltage transformer, also passes through unit IV. Two phases of the three-phase circuit supplying the transceiver are used for this purpose when operating in the "OPERATE" mode; when operating in the "SIMULATE" mode, two phases of the three-phase circuit supplying the display equipment are used.

Description of the schematic diagram of the unit. Figure 21 gives a schematic diagram of unit IV. Unit IV has three type DI-511 selsyns to reproduce the voltages of the synchronous-servo system which are normally provided by the main selsyn unit. These are the coarse-tracking transmitting selsyn M3, the fine-tracking transmitting selsyn M1, and the 5-degree marker selsyn generator M2.

The rotors of the transmitting selsyns are connected through the reduction gearing to motor DT-75 (M4). When switch V1 is turned on, a three-phase voltage is applied to the windings of the motor through fuses Pr1, Pr2, and Pr3, the condition of which is monitored by neon bulbs NL2, NL3, and NL4.

The motor turns the selsyn rotors through the reduction gearing at the following speeds: rotor of the coarse-tracking transmitting selsyn -- 6 rpm; rotor of the fine-tracking transmitting selsyn -- 216 rpm; rotor of the 5-degree marker selsyn generator -- 216 rpm.

The single-phase winding of the 5-degree marker selsyn generator is supplied by 100 v at 1,500 cps; this voltage is monitored by neon bulb NL1. The single-phase windings of the coarse- and fine-tracking transmitting selsyns are supplied by 70 v at 50 cps taken from the secondary (p 62) winding (5-6) of three-phase transformer Tr1. A voltage of 6.3 v, used to light the miniature bulbs which illuminate the dials of the unit, is taken from the secondary winding (7-8) of this same transformer.

The three-phase voltages are fed from the selsyns to the operating mode switch V2. Analogous three-phase voltages are also fed to this switch from the main selsyn unit. When the switch is in the "OPERATE" position, the three-phase voltages of the synchronous system generated by the main selsyn unit are sent to the output of the unit and from there to the display equipment; when the switch is in the "SIMULATE" position, the three-phase voltages of the synchronous system are generated by unit IV.

In order to produce a rotating magnetic field in servomotors ADP-262 and ADP-362, it is necessary that the voltage in the control winding (G1-G2) of the servomotor be shifted 90° in phase with respect to the voltage in the excitation winding (V1-V2).

The control voltage which is applied to winding G1-G2 of the servomotor from unit US always coincides in phase with the transmitting selsyn supply voltage. Consequently, in order to obtain a phase shift of 90° between the voltages in the control winding and excitation winding of the motor, the excitation winding voltage (so-called reference voltage) must always be shifted 90° relative to the transmitting selsyn supply voltage.

This is accomplished as follows:

a) In the "SIMULATE" mode. The primary windings of three-phase transformer Tr1 are connected to phases A, B, and C. The voltage in phase C of the transformer is shifted 90° relative to the line voltage AB.

The secondary winding (5-6) which supplies the single-phase windings of the transmitting selsyns is wound on the same core as the winding with phase C. (p 63)

Line voltage AB passes through fuses Pr4 and Pr5 to the output of the unit and then to the reference voltage transformer located in cabinet ZN-F1. A voltage of 110 v, 50 cps, which is the reference voltage and supplies the excitation windings of all the servomotors, is also taken from this transformer.

Thus, when operating in the "SIMULATE" mode, the transmitting selsyns of the synchronous power transmitting system and the excitation windings of the servomotors are fed voltages which are shifted in phase by 90°.

b) In the "OPERATE" mode. When the switch is in the "OPERATE" mode, a line voltage from two phases of the three-phase transceiver network is applied to the reference voltage transformer. Since the transmitting selsyns of the main selsyn unit are also supplied from this network through the three-phase transformer, there will also be in this case a 90° phase shift between the voltages applied to the transmitting selsyns and to the excitation windings of the servomotors.

Design features of the unit. Unit IV is made in the form of a self-contained instrument on an angle-iron chassis. The cast silumin housing containing the reduction gearing, selsyns, and motor is attached to the horizontal panel of the chassis. The selsyns are linked to the reduction gearing by means of couplings.

A kinematic diagram of the reduction gearing is given in Figure 22.

The ratio of the reduction gearing is selected so that the rotor of the coarse-tracking transmitting selsyn makes 6 rpm while the rotors of the 5-degree marker and the fine-tracking selsyns make 216 rpm.

The unit is equipped with coarse- and fine-tracking dials which are read through windows on the front panel of the chassis. Also on the front panel are neon signal lights, fuses, the operating mode switch, and the switch for turning on the motor. (p 65)

The unit has two plug connectors. The weight of the unit is 45 kg.

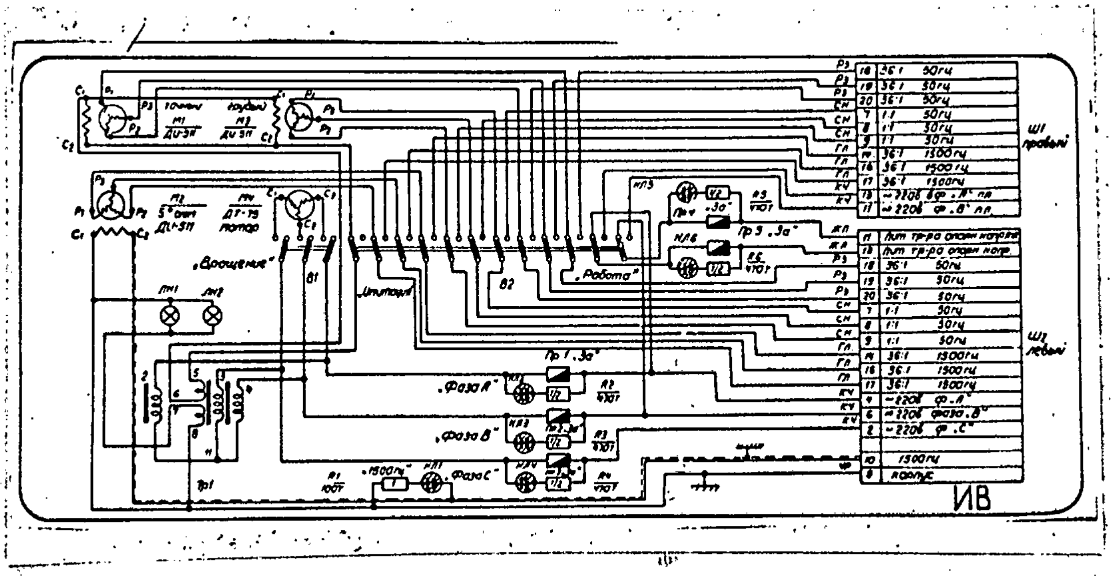

Fig. 21. Schematic Diagram of Unit IV.

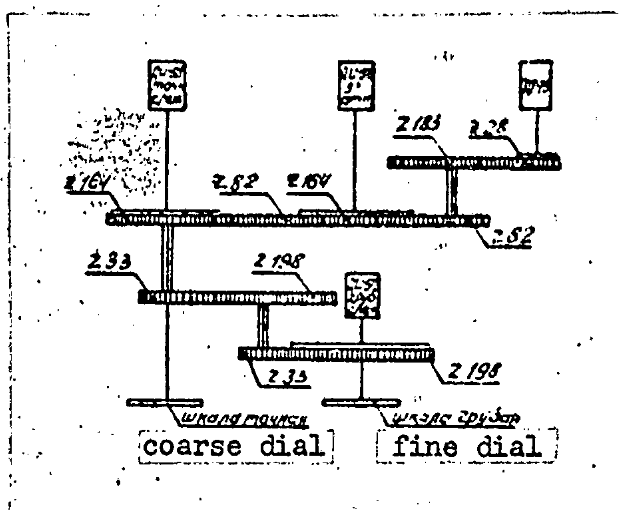

Fig. 22. Kinematic Diagram of Unit IV.

6. Secondary Selsyn Unit VD-1.

Function. Unit VD-1 (Figures 23 and 24) generates voltages for the azimuth sweeps in the height measurement and azimuth-range displays, voltages for shaping the 30-degree markers in unit OA-5-1, and synchronization voltages for rotation of the azimuth sweep in the KPN displays of system RL-30-1.

Technical data. Unit VD-1 generates two three-phase voltages which are taken from type DI-511 and DI-521 selsyn generators. The rotor of selsyn generator DI-521, which supplies the azimuth sweeps, rotates synchronously and in phase with the rotation of the antenna; the rotor of selsyn generator DI-511 for the 30-degree markers rotates at a speed 6 times greater than the speed of rotation of the antenna.

In addition, unit VD-1 also generates two voltages which are taken from the type SK-MG sine-cosine selsyns. The rotor of the coarse-reading SK-MG selsyn rotates synchronously and in phase with the antenna, while the rotor of the fine-reading SK-MG selsyn rotates at a speed 13 times greater than the speed of rotation of the antenna.

Description of the schematic diagram of the unit. Figure 25 gives (p 68) the schematic diagram of unit VD-1. The unit consists of two selsyn groups: the servomotor group, and the secondary selsyns group.

The servomotor group provides continuous tracking and generation of the angle of rotation of the antenna system with the maximum possible accuracy. It is the terminal actuating component in the network of the power servosystem. The basic elements of this group are two type SS-405 selsyns (coarse and fine tracking -- M4 and M5) and a two-phase induction motor, type ADP-362 (M3).

The voltages to the three-phase stator windings of both selsyns are taken from the three-phase rotor windings of the corresponding selsyns in unit FD-02 or unit IV. The three-phase windings of the coarse and fine selsyns in unit FD-02 or IV, connected to the three-phase windings of the corresponding SS-405 selsyns, electrically transmit the angle of rotation of the antenna to the receiving instrument.

If the rotor of the receiving selsyn is located in such a position that the field of the rotor winding is perpendicular to the field of the stator winding, the misalignment voltage induced in the rotor winding will equal zero. This characterizes a matching condition of the SSP system.

Diagrams showing changes in misalignment voltage relative to the position of the transmitting selsyn rotor are given in Figure 26.

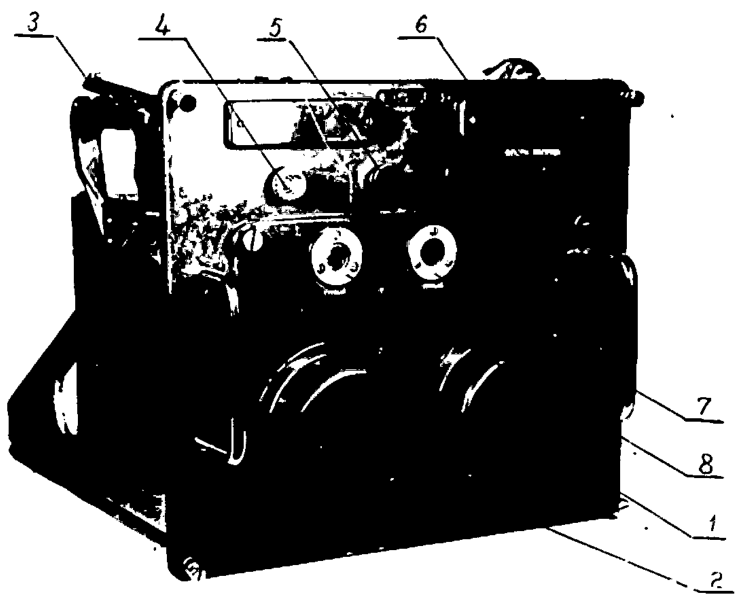

Fig. 23. Unit VD-1 (View From Front).

1 - 30-degree marker selsyn generator; 2 - sweep selsyn generator; 3 - catch of unit; 4 - 1,500-cps voltage indicator light; 5 - illuminating light; 6 - reference voltage indicator light; 7 - window of coarse-reading dial; 8 - window of fine-reading dial.

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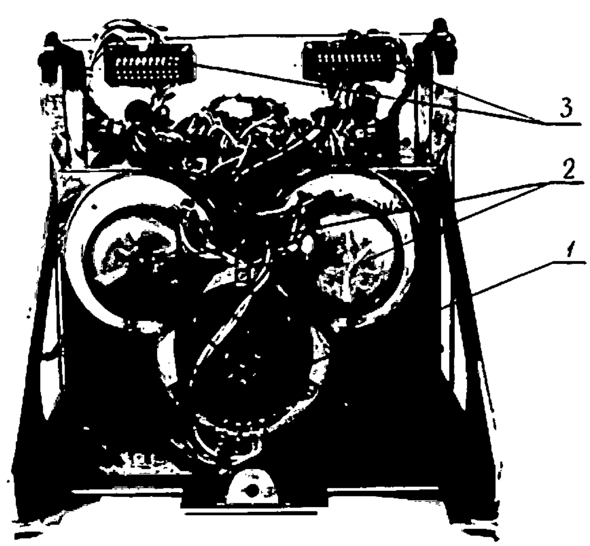

Fig. 24. Unit VD-1 (Rear View).

1 - motor ADP-362; 2 - type SK-MG selsyns; 3 - plugs.

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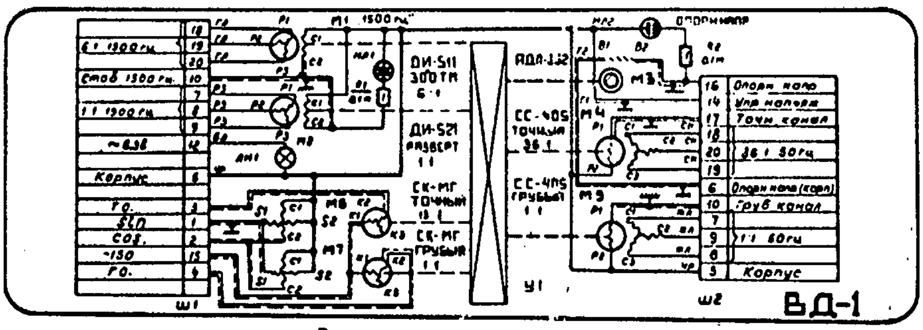

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Fig. 25. Schematic Diagram of Unit VD-1.

If the rotor of the transmitting selsyn is turned through a certain angle relative to the rotor of the receiving selsyn (that is, if they are misaligned), then the field of the stator windings of the transmitting selsyn will be turned through the same angle and the voltage induced in rotor winding (its phase and amplitude) will change depending upon the angle and the direction of misalignment. The misalignment voltage is fed from the single-phase rotor windings to the corresponding amplification channels of the servosystem (servoamplifier). (p 71)

The amplified voltage passes from the output of the amplifier to the control winding (G1-G2) of motor ADP-362.

The excitation winding of the motor (V1-V2) is supplied by a reference voltage of 110 v, 50 cps, which is sent through the servo-amplifier unit from the reverence voltage transformer in cabinet ZN-F1.

Motor ADP-362 turns the rotors of the SS-405 selsyns through a reduction gear and generates a misalignment angle between the transmitting selsyns of unit FD-02 (or IV) and the SS-405 selsyns. At the same time, the motor turns the rotors of secondary selsyns DI-511, DI-521, and SK-MG through a reduction gear.

In the second selsyn group of unit VD-1 are selsyn generator M2, which shapes the voltage for azimuth sweep circuits in units RU-1 and RA of displays IIV-1 and IAD-1, selsyn generator M1, which generates the voltage for shaping the 30-degree markers in unit OA-5-1, and selsyns M6 and M7, which shape the synchronization voltages for rotation of the azimuth sweep in the RL-30-1 equipment.

The single-phase windings of the selsyn generators are supplied by 75 volts at 1,500 cps from unit GCh. A voltage at the same frequency is induced in the three-phase winding of the rotor. When the rotor of the selsyn generator turns, the amplitude of the voltage in each winding changes sinusoidally. After each half turn of the selsyn generator rotor, when the value of the amplitude passes through zero, there occurs a 180° jump in phase of the 1,500 cps voltage.

The three-phase voltage is taken from the rotor winding of the selsyn generator and is applied to the stationary three-phase winding of the stator of the selsyn transformer. An electromotive force is induced in the single-phase winding of the selsyn transformer rotor by currents flowing in the windings of its stator. (p 72)

The relationship between the amplitudes of currents flowing in the windings of the selsyn transformer stator depends on the orientation of the rotor of the selsyn generator relative to its stator.

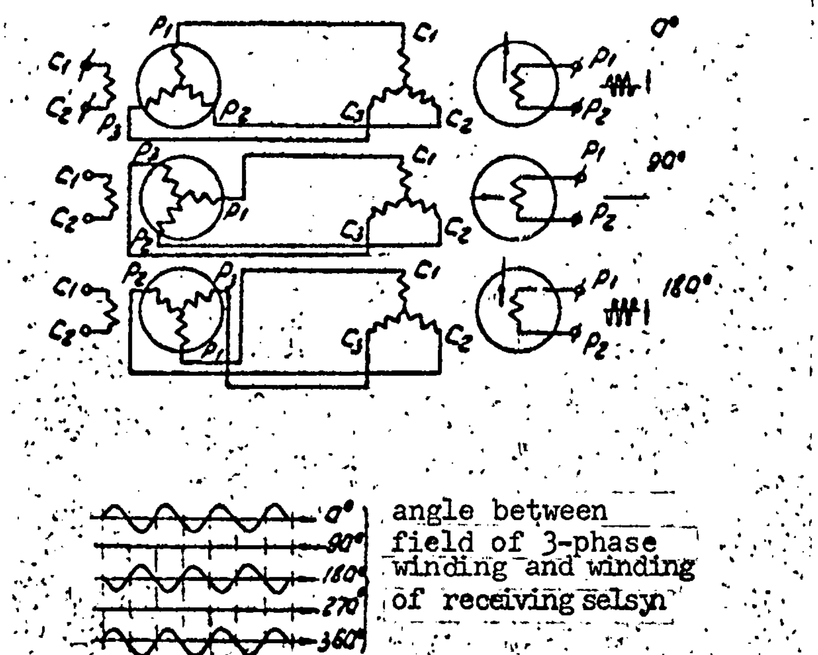

Fig. 26. Diagram of Misalignment Changes Relative to Position of Transmitting Selsyn Rotor.

The relationship between the e.m.f. induced in the winding of the selsyn transformer rotor and the currents flowing in its stator windings depends on the value of these currents and on the orientation of the selsyn transformer rotor with respect to its stator; that is, in the final analysis, it depends on the mutual orientation of the rotors of the selsyn generator and the selsyn transformer.

The sweep voltage is applied from the rotor winding of the selsyn generator (M2) to the stationary three-phase windings of the selsyn transformer stators in units RU-1 and RA.

The voltage in the single-phase windings of the selsyn transformer rotors in these units is used to control the azimuth sweep circuits.

The voltage used to shape the 30-degree markers is taken from the rotor winding of selsyn generator M1 and applied to the stationary three-phase stator winding of the 30-degree marker selsyn transformer (in unit OA-5-1). The voltage of the single-phase rotor winding of the selsyn transformer is used to shape the 30-degree azimuth markers.

The sine and cosine windings of each of the SK-MG selsyns are fed voltages at a frequency of 43 cps which are shifted 90° in phase with respect to each other. A voltage of constant amplitude is produced at the output of the coarse selsyn, while its phase is determined by the angle of rotation of the antenna; the phase angle (with respect to the 43-cps reference voltage of the RL-30-1 apparatus) is equal to the space angle of rotation of the antenna. (p 73)

The output voltage of the fine selsyn is also constant in amplitude, and its phase changes 13 times faster than the voltage of the coarse transmitting selsyn.

The output voltages of the SK-MG selsyns are applied to the RL-30-1 apparatus where they are converted to pulse voltages.

Unit VD-1 contains a miniature bulb LN1 to illuminate the dials of the coarse and fine scales and two lights NL1 and NL2 which signal the presence of the 1,500-cps voltage and the reference voltage in the unit.

Design features of the unit and kinematic diagram of the reduction gearing. Unit VD-1 is in the form of a self-contained unit resting on an angle-iron chassis. The cast silumin housing containing the reduction gearing, selsyns, and motor is attached to the horizontal panel of the chassis.

A kinematic diagram of the reduction gearing is given in Figure 27.

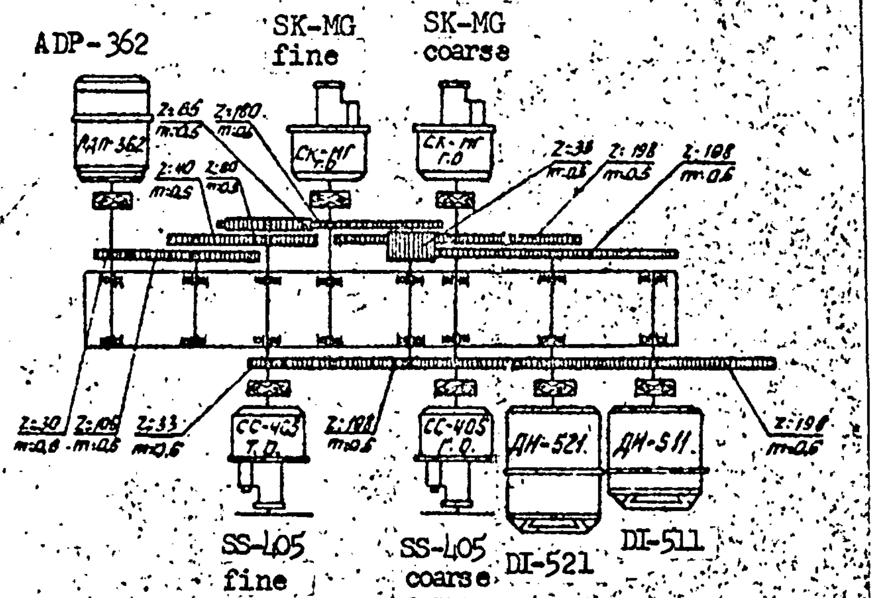

Fig. 27. Kinematic Diagram of Reduction Gearing of Unit VD-1.

The gear ratio of the reduction gearing is selected so that for one revolution of the rotor of the SS-405 coarse-tracking selsyn (that is, for one revolution of the antenna), the rotors of the selsyn generator from which the azimuth sweep voltage is taken and the SK-MG coarse-tracking selsyn make one revolution, the rotor of the selsyn generator which shapes the 30-degree markers makes 6 revolutions, and the rotor of the SK-MG fine-tracking selsyn makes 13 revolutions.

The selsyns are connected to the reduction gearing by means of a flexible coupling.

Unit VD-1 is equipped with coarse- and fine-tracking dials which are viewed through windows on the front panel of the chassis.

In addition, the front panel contain neon signal lights and doors (p 75) which permit access to the dials for the purpose of adjustment.

The unit has two plug connectors. The weight of the unit is 34 kg.

7. Servoamplifier Unit US.

Function. The servoamplifier unit US (Figure 28) is used to amplify the misalignment voltages received from the rotor windings of both selsyns of unit FD-02 or IV by the servomotor groups of unit VD-1 or by BSM in unit TI-1, and to convert these voltages to a voltage used to control the actuating motor.

Technical data. The tracking error of the SSP system, which is dependent on the sensitivity of unit US, does not exceed 6'. Tracking error in the coarse channel does not exceed 2-3^{o}; the time required for the system to enter synchronization does not exceed 15 seconds.

Block Diagram of the unit. Figure 29 gives a block diagram of unit US.

The unit consists of the flowing elements:

-- correcting network (differentiating network);

-- misalignment voltage amplifier for the fine-tracking channel;

-- circuit for eliminating false zeroes;

-- misalignment voltage amplifier for the coarse-tracking channel;

-- channel switch;

-- second amplifier stage;

-- phase-inverter stage;

-- output stage.

The voltage from the fine selsyn of the servo drive is applied through the correcting network to the misalignment voltage amplifier stage for the fine-tracking channel. The voltage from the coarse selsyn is applied to the misalignment voltage amplifier stage of the coarse channel; the false zero elimination voltage is also applied to this stage. (p 78)

A voltage is applied to the second amplifier stage either from the fine channel amplifier or from the coarse channel amplifier, depending upon the size of the misalignment angle between the transmitting selsyns of unit FD-02 or IV and the receiving selsyns. The channels are switched automatically.

A push-pull power amplifier is used at the output of unit US to provide sufficient power to control the actuating motor. Voltage is applied directly to one arm of the output stage from the amplifier stage and through the phase-inverter stage to the other arm.

The actuating motor of the servo system is supplied by the voltage arriving from unit US. The voltage applied to the control winding of the motor is shifted 90° in phase relative to the reference voltage which supplies the excitation winding (sections 4 and 5).

Description of the schematic diagram of the unit. Figure 30 gives a schematic diagram of unit US.

The misalignment voltage of the fine channel passes from plug Sh1 (contact 17) through capacitor C2 to the input of the differentiating network, which consists of resistors R2, R3, and capacitors C3, C4.

The differentiating network shifts the phase of the voltage passing through it by 90°. Phase correction is made by changing resistor R2 "STABILITY CONTROL."

With equal rotation of the transmitting selsyns, it is possible to consider the misalignment voltage as a sinusoidal voltage with a constant amplitude. The amplification stage for the fine channel misalignment voltage is based on tube V1a. To the grid of this tube is applied the input misalignment voltage (from divider R1, R3) and the voltage which has been shifted 90° in phase (from the output of the differentiating network). The phase-shifted voltage does not influence the operation of the motor, since it is in phase with the reference voltage which supplies the excitation winding of the actuating motor and does not create a torque. (p 80)

When the system enters synchronization, when the speed of rotation of the transmitting selsyns changes, with fluctuations in the synchronous drive, and in other similar situations, the misalignment voltage may be considered a sinusoidal voltage with a changing amplitude. In this case,

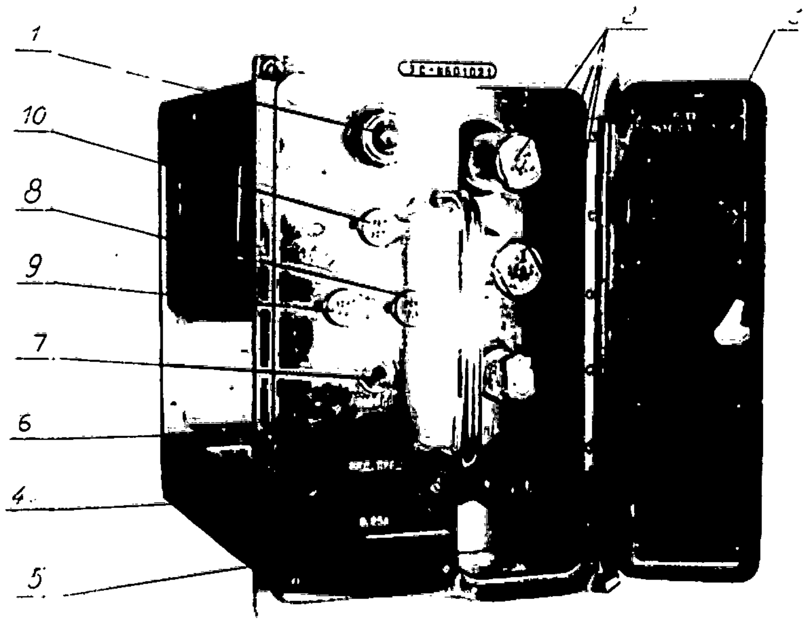

Fig. 28. Unit US.

1 - channel-switching light; 2 - tubes in tube channel; 3 - label on door; 4 - fuse; 5 - plug cover; 6 - fuse condition indicator; 7 - motor toggle switch; 8 - coarse channel gain control; 9 - fine channel gain control; 10 - stability control.

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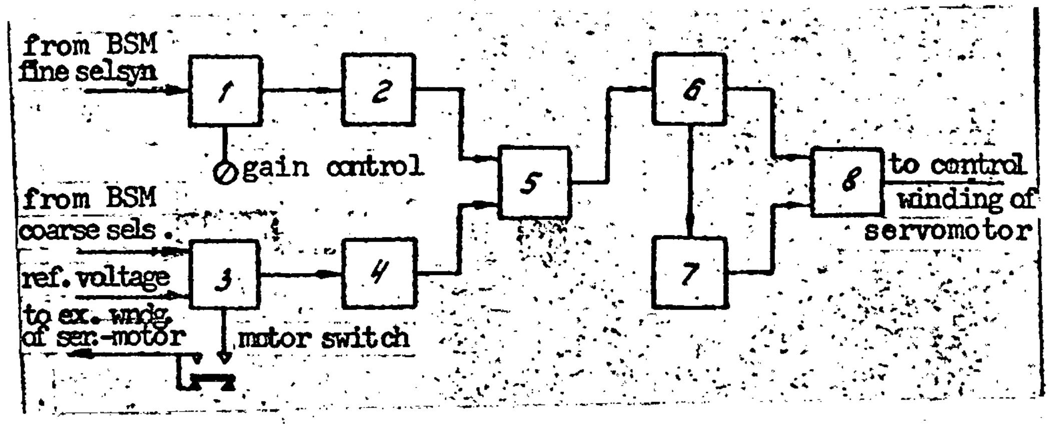

Fig. 29. Functional Diagram of Unit US.

1 - correcting network; 2 - misalignment voltage amplifier for fine-tracking channel; 3 - false zero-eliminating network; 4 - misalignment voltage amplifier for coarse-tracking channel; 5 - channel switch; 6 - second amplifier stage; 7 - phase-inverter stage; 8 - output stage.

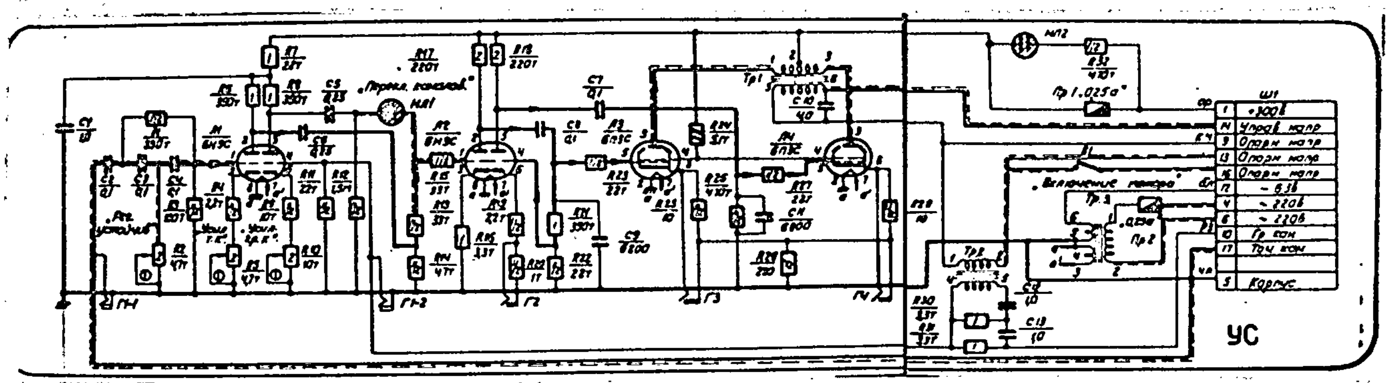

Fig. 30. Schematic Diagram of Unit US.

the grid of tube V1a is fed a misalignment voltage (from divider R1, R3) and a voltage from the differentiating network which has been shifted 90° in phase, as well as an additional voltage which is proportional to the rate of change of the amplitude of the input voltage and is in phase with the misalignment voltage. The additional voltage is added to the misalignment voltage and creates an additional torque for the motor. The amplified misalignment voltage is taken from resistor R6 of the plate load of the tube and passes through capacitor C6 and resistors R13, R15 to the grid of tube V2a (6N9S).

The gain of the stage is controlled by changing resistor R5 which changes the negative feedback.

The amplification stage of the coarse channel misalignment voltage (p 81) operates with tube V1b. The misalignment voltage of the coarse-tracking channel is taken from plug Sh1 (contact 10) and applied to the grid of tube V1b. The amplified signal of the coarse-tracking channel, taken from resistor R8, passes through capacitor C5 to neon bulb NL1.

When misalignment of the synchronization system is greater than 2-3°, the potential across the terminals of bulb NL1 reaches the firing potential. The neon bulb ionizes and the synchronization signal voltage of the coarse-tracking channel, which in this case will be the main voltage, passes to the amplification stage (tube V2a).

In order to prevent synchronization at a false point (at the point of a temporarily stable condition), a small 50-cps a-c voltage taken from the secondary winding of transformer Tr2 is applied to the input of the amplification stage for the coarse-tracking misalignment voltage in parallel with this voltage. This additional voltage must be in phase with the voltage which supplies the SSP selsyn transmitters. This function is performed by the phase-inverting network (capacitors C12, C13 and resistors R30, R31), which is connected to the secondary winding of transformer Tr2 (taps 4-5). The value of the additional voltage which is added to the main misalignment voltage must be selected so that the shift of zero positions is approximately [?]5° for one half-period and 175° for the other half-period (Figure 31).

In order to prevent creep, which may occur when the cables are disconnected from the SSP system, the additional voltage is set at a somewhat smaller value of 0.9 to 1 v. A stable position is achieved by turning the selsyn stators and aligning the zero position of the fine-tracking channel with one of the displaced zero positions of the coarse- (p 83) tracking channel. The other zero position will then be unstable for both channels simultaneously.

Gain of the coarse channel is controlled by changing the negative feedback of the stage with the cursor of resistor R10.

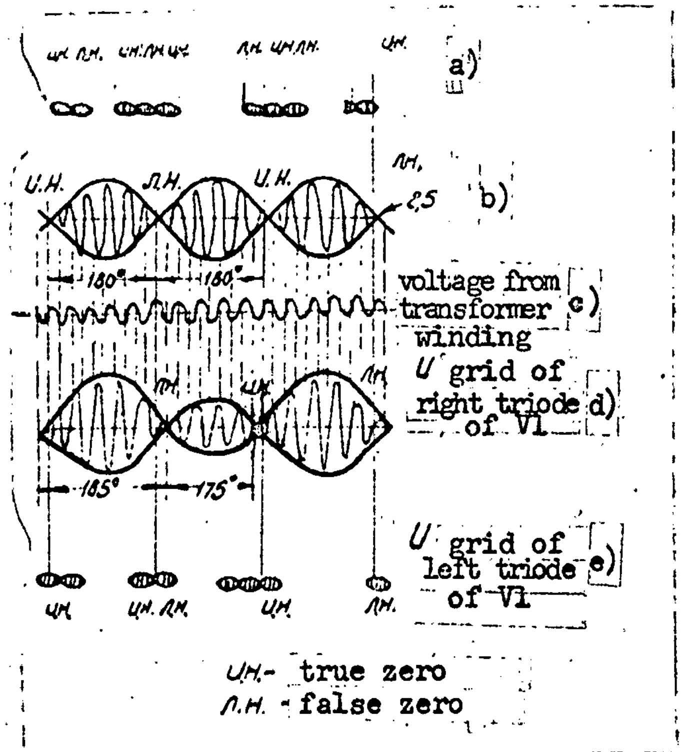

Fig. 31. Derivation of Resultant Voltage With Zeros Shifted by 175 and 185 Degrees.

a - voltage in selsyn of fine-tracking channel; b - voltage in selsyn of coarse-tracking channel c - auxiliary 50-cps control voltage; d - resultant voltage of coarse channel; e - voltage in selsyn of fine-tracking channel.

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Resistor R7 and capacitor C1 serve as the decoupling filter in the plate supply circuit of tube V1.

A voltage from resistors R13, R14, and R15 is applied to the grid of the amplification stage of tube V2a. Resistor R16, which provides the negative feedback, is connected to the cathode of the tube.

Voltage is applied from the plate load of V2a (resistor R17) through blocking capacitor C8 and resistor R23 to the grid of tube V3 of the output stage, and from the middle point of a divider consisting of resistors R21 and R22 to the grid of the phase-inverting stage V2b.

The output voltage of the phase-inverting stage is opposite in phase to the output voltage of the second amplifier stage. This voltage is taken from the plate load of tube V2b (R18) and is fed through blocking capacitor C7 and resistor R27 to the grid of tube V4 of the output stage. Resistors R19 and R20, which provide the negative feedback, are connected to the cathode of tube V2b. The output stage of the servoamplifier operates with tubes V3 and V4. The output voltage passes from the secondary winding of transformer Tr1 (tap 6) to plug Sh1 (pin 14) and to the control winding of the actuating motor. Capacitor C10 serves for correction of the reactance of the load. (p 84)

Switch V1 in the excitation winding circuit of the actuating motor is located on the front panel of the unit and is used to stop rotation of the motor during adjustment of the SSP system. Fuse Pr1 (0.25 a) is connected in series in the +300 v supply circuit. In the event of a short-circuit, neon bulb NL2 lights and denotes that the fuse has burned out.

Monitoring the operation of the unit. The following test jacks are located in the tube section of unit US:

G1-1 -- for monitoring the input voltage of the fine-tracking channel and the tracking error;

G1-2 -- for monitoring the input voltage of the coarse-tracking channel and the "zero-eliminating" voltage;

G-2 -- for monitoring the operation of phase-inverting stage V2;

G-3 and G-4 -- for monitoring the operating mode of the push-pull output stage V3 and V4.

Design of the unit. Unit US is designed in the form of a self-contained instrument on a standard chassis. Four tubes (6N9S -- 2 each; 6P3S -- 2 each) and five test jacks are located in the tube channel of the unit. On the front panel is a neon light MN3 for switching channels, the motor switch, fuse indicator MN-5, and a 0.25-amp fuse. In addition, the shafts of three potentiometers (stability control and gain of the coarse and fine channels) are accessible on the front panel. The unit weighs 10.5 kg.

8. Higher-Frequency Generator Unit GCh. (p 85)

Function. The higher-frequency generator GCh (Figure 32) generates a voltage at a frequency of 1,500 cps which supplies the selsyns of main selsyn unit FD-02, secondary selsyn unit VD-1, rotation simulator IV, and the azimuth sweep units of cabinets IAD-1 and IIV-1 (units RA and RU-1).

The use of a 1,500-cps voltage is necessitated by the demand for accuracy of the system. This frequency must be several times greater than the repetition rate of the trigger pulses.

Technical data. Unit GCh generates voltage at 1,500 cps ±20%. The The control range of the output voltage permits setting the amplitudes of the stabilized output voltage at 75 v, 1,500 cps, and the unstabilized output voltage at 100 v, 1,500 cps.

The change in amplitude of the output voltage when the load is dropped does not exceed 0.5% for a stabilized output and 10% for the unstabilized.

The output power of unit GCh permits connecting up to four type DI-511 selsyn transmitters loaded with four type DI-511 receiving selsyns, two at each output, respectively.

Functional diagram of the unit. Figure 33 gives a functional diagram of unit GCh. The unit includes:

-- master oscillator;

-- amplitude stabilization stage;

-- amplifier;

-- output power amplifier.

The master oscillator generates a voltage at a frequency of 1,500 cps.

A special stabilization circuit is used to stabilize the amplitude of (p 88) the master oscillator in GCh. The master oscillator voltage is applied to the amplifier and then the output stage, which represents a power amplifier.

The amplifier has 100% negative feedback for correction of possible distortions of the output voltage and to maintain constant amplitude with fluctuations in the load and changes in supply voltages.

The unit has two separate outputs from one of which a stabilized voltage is applied to unit VD-1. The other output is used to supply units FD-02, IV, RU-1, and RA. To reduce the effect of load capacitances of the cables which carry the 1,500-cps voltage, a resistor is connected in series with this output of GCh which causes a change in the output voltage when there are changes in the load.

The unit has one control "1,500 CPS AMPLITUDE" with which the amplitude of the output voltage of unit GCh is set.

Description of the schematic diagram of the unit. Figure 34 gives the schematic diagram of unit GCh.

The master oscillator is self-excited with cathode coupling and uses tube V1. The oscillator generates oscillations at the frequency of the plate circuit. The tube oscillates as a result of the fact that the circuit is shunted by a negative resistance in the form of a twin triode with a cathode coupling circuit. The oscillator circuit consists of capacitors C3 and C4 and inductance L1 enclosed in a carbonyl iron core.

By using the core to change the inductance of the circuit, it is possible to select the frequency of the generated voltage. The total inductance of choke L1 is approximately 900 millihenries. (p 90)

The cathode resistance of the oscillator is tube V2a, which is controlled by the grid circuit and is used as a variable resistance.

A negative potential is maintained at the cathode of V2a. A rectified voltage of negative polarity is applied to the grid of the tube from the plate of tube V2b. The right half of tube V2 is connected to the diode. The output voltage of unit GCh is applied to its cathode. This voltage is taken from the secondary winding of transformer Tr1 (contact 5).

A negative voltage, smoothed by a filter consisting of resistor R8 and capacitor C7, is taken from the plate of the diode. If the output voltage of the master oscillator is changed, for example, increased, the negative voltage at the plate of V2b and at the grid of V2a increases and the resistance of V2a becomes greater.

This causes a decrease in the current through tube V1, that is, a decrease in the amplitude of oscillations of the master oscillator.

Similar compensation also occurs when the amplitude of the output voltage of the master oscillator is decreased. The voltage applied to the cathode of V2a is the reference voltage and determines the amplitude of the oscillations which are generated. When this voltage is changed, the amplitude of the 1,500-cps output voltage changes. The value of the reference voltage is controlled with potentiometer R7. The sinusoidal oscillations of the master oscillator pass from the plate of V1a through blocking capacitor C6 to the grid of amplifier tube V3. The output voltage of unit GCh is applied to the cathode of the tube through (p 91) parallel-connected resistors R14, R15, R16, and R17 from the secondary winding of transformer Tr1; this voltage coincides in phase with the voltage of the oscillatory circuit of the oscillator applied to the control grid of V3. This circuit connection creates a negative feedback which compensates for distortions caused by the amplifier stage, the output stage, and the output transformer and provides a small internal resistance for the oscillator.

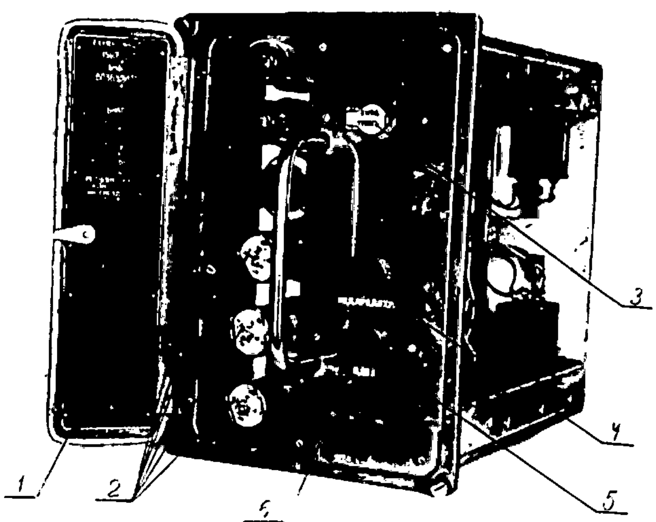

Fig. 32. Unit GCh.

1 - label on door; 2 - tubes in tube channel; 3 - amplitude control; 4 - fuse condition indicator; 5 - fuse; 6 - plug cover.

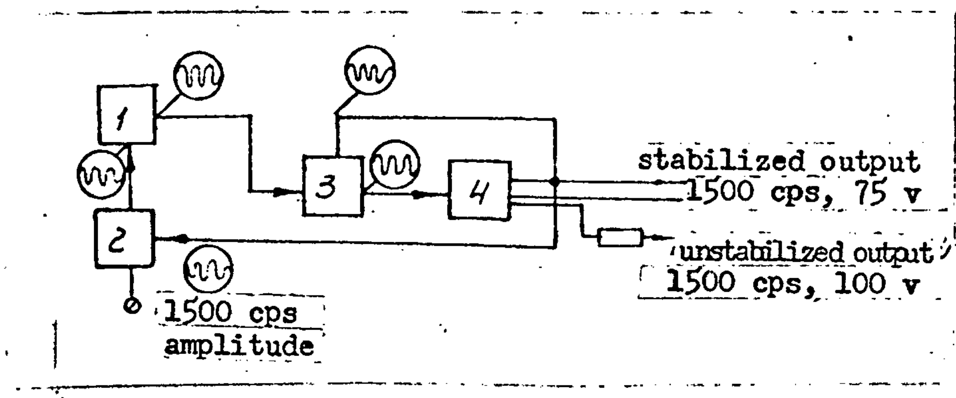

Fig. 33. Functional Diagram of Unit GCh.

1 - master oscillator; 2 - amplitude stabilization stage; 3 - amplifier;
4 - output stage.

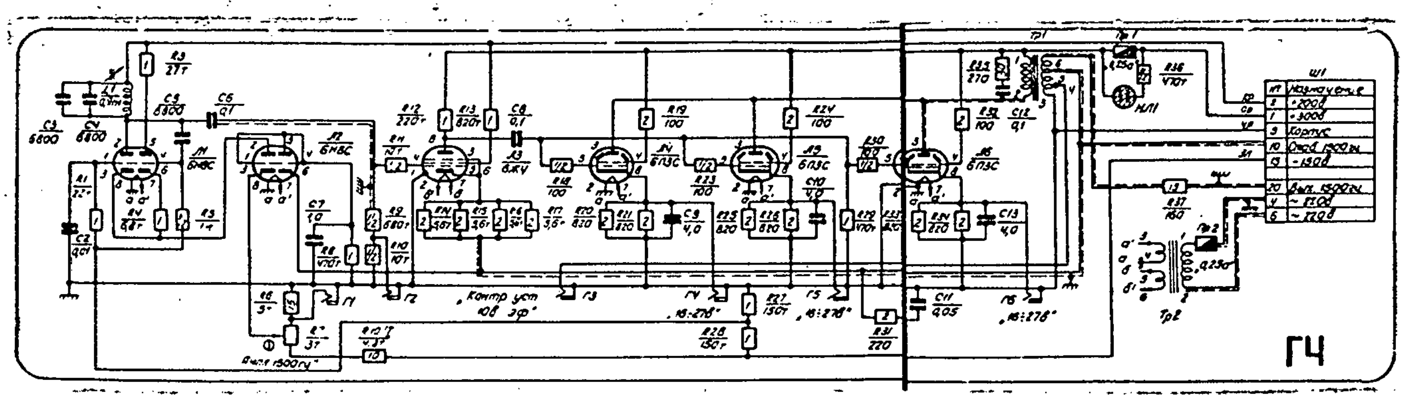

Fig. 34. Schematic Diagram of Unit GCh.

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Voltage is taken from plate load R12 of the amplifier stage and applied through blocking capacitor C8 to the control grids of the output stage tubes. The output stage represents a power amplifier with a transformer output. The tubes of the output stage (V4, V5, and V6) are connected in parallel to increase the power of output oscillations. The primary winding of transformer Tr1 serves as the plate load of the stage. Bias at the control grids of tubes V4, V5, and V6 is applied automatically from individual cathode resistors (R20, R21, R25, R26, R33, R34) shunted by capacitors C9, C10, and C13.

The 1,500-cps output voltage is taken from the secondary winding of output transformer Tr1 and applied to unit VD-1 and through resistor R37 to units FD-02, IV, RA, and RU-1.

Transformer Tr1 shifts the phase of the output voltage relative to the input voltage. To compensate for this phase shift, networks consisting of resistors and capacitors are connected in parallel with the windings of the transformer (R35 and C12 are connected to the primary winding, R31 and C11 are connected to the secondary winding). This reduces distortion of (p 92) the shape of the 1,500-cps voltage.

Monitoring the operation of the Unit. Unit GCh is monitored with the aid of six test jacks:

G-1 -- for monitoring the voltage form of the oscillator at the cathode of V1 (operating mode of the stabilization circuit);

G-2 -- for monitoring the voltage form at the grid of tube V3;

G-3 -- for monitoring the voltage amplitude at the output;

G-4, G-5, and G-6 -- for monitoring d-c voltages of the output stage tubes at the cathodes of tubes V4, V5, and V6.

Design of the unit. Unit GCh is built in the form of a self-contained instrument mounted on a standard chassis. The tube channel contains six tubes (two 6N8S; one 6Zh4; three 6P3S) and six test jacks. On the front panel are a 0.25-amp fuse, neon bulb MN-5 to show the condition of the fuse, and the shaft of the potentiometer which regulates the amplitude. The unit has one plug connector. Weight of the unit is 9 kg.

9. Azimuth Scale Marker Unit OA-5-1

Function. The OA-5-1 azimuth scale marker unit (Figure 35) generates electrical scale pulses for the 5-degree and 30-degree azimuth markers.

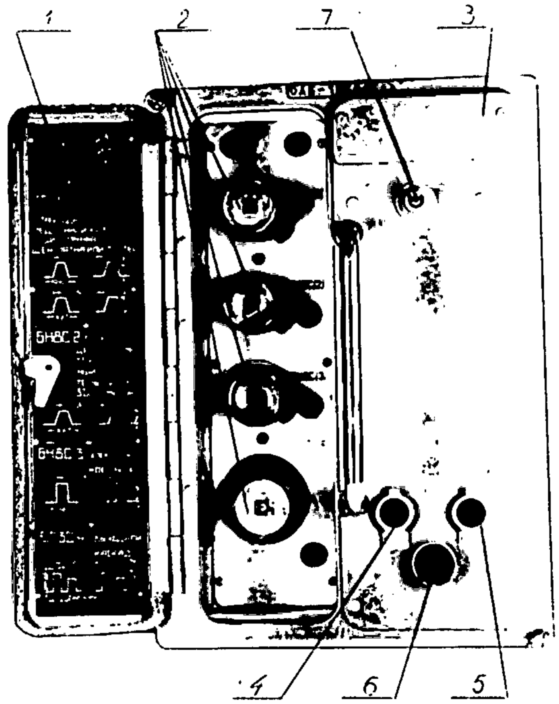


Fig. 35. Unit OA-5-1.

1 - label on door; 2 - tubes in tube channel; 3 - plug cover; 4 - 5-degree marker amplitude control; 5 - 30-degree marker amplitude control; 6 - illuminating bulb holder; 7 - operating mode switch.

Technical data on the unit. The duration of the pulses generated by the unit is equal to the time interval between two trigger pulses. The amplitudes of the pulses at the output may be controlled within limits of not less than:

a) 4 ÷ 8 v (5-degree markers);

b) 8 ÷ 15 v (30-degree markers).

Functional diagram of the unit. Figure 36 gives a functional diagram of unit OA-5-1. The unit consists of the following two parts:

a) the 5-degree azimuth marker-shaping circuit;

b) the 30-degree azimuth marker-shaping circuit.

The 5-degree marker-shaping circuit. Voltage at a frequency of 1,500 cps, whose amplitude changes at a frequency 36 times greater than the frequency of rotation of the antenna, is applied to the three-phase stator winding of selsyn transformer M2 located in unit OA-5-1. Voltage from the single-phase winding of the rotor is applied to the input of the elevation pulse-shaping stage (plate detector). At those moments when the 1,500-cps voltage envelope passes through zero values, voltage pulses (elevation pulses) are formed in this stage. The width of these pulses is determined by the operating mode of the tube in the pulse-shaping stage.

The pulses are sent from the pulse-shaping stage to the selector stage, to which are also applied trigger pulses. The operating mode of the tube in this stage is selected so that it will conduct only when the elevation pulse coincides with the trigger pulse. (p 96)

When these pulses are coincident, positive pulses appear in the cathode circuit of the selector stage which are then applied to an electronic relay circuit.

The electronic relay generates positive square pulses with a duration equal to the time interval between two trigger pulses, while the spacing between the pulses is equal to the time required for the antenna to turn through 5°.

These pulses pass through the output stage (cathode follower) to the displays of the station.

The 30-degree marker-shaping circuit. Voltage at a frequency of 1,500 cps, whose amplitude changes at a frequency 6 times greater than the frequency of rotation of the antenna, is applied to the three-phase winding of selsyn transformer M1 located in unit OA-5-1.

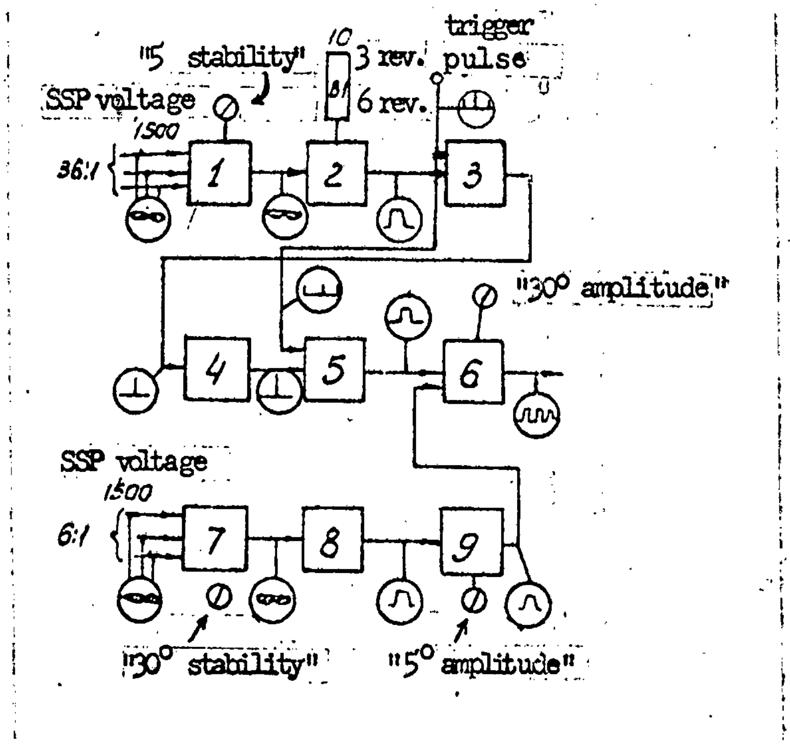


Fig. 36. Functional Diagram of Unit OA-5-1.

1 - selsyn transformer SS-405 for 5-degree markers; 2 - plate detector; 3 - selector stage; 4 - delay line; 5 - electronic relay; 6 - output stage; 7 - selsyn transformer SS-405 for 30-degree markers; 8 - plate detector; 9 - cathode follower; 10 - operating mode switch V1.

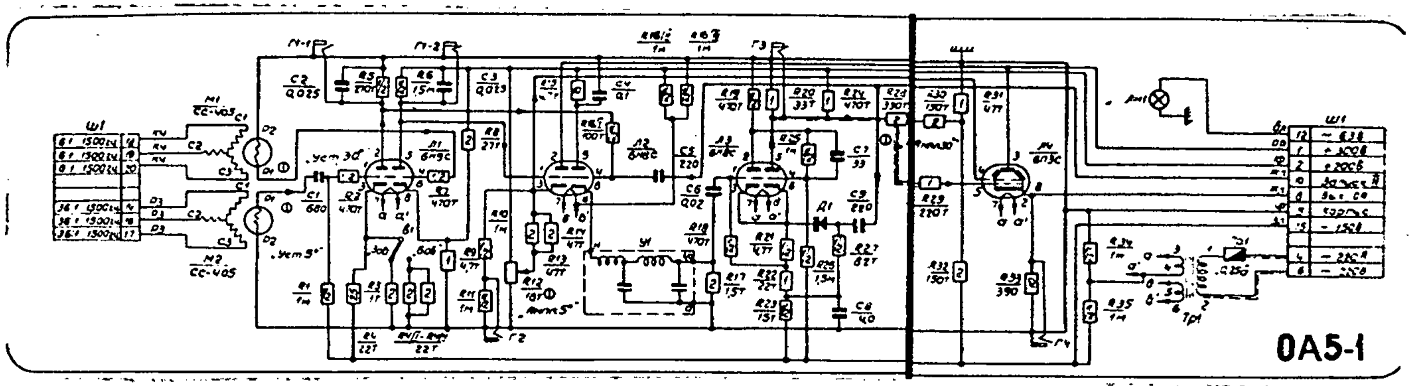


Fig. 37. Schematic Diagram of Unit OA-5-1.

Voltage from the single-phase winding of the rotor is applied to the input of the elevation pulse-shaping stage (plate detector). At those moments when the 1,500-cps voltage envelope passes through zero values, elevation pulses are formed in this stage. The width of these pulses is determined by the operating mode of the tube in the pulse-shaping stage.

The elevation pulses are applied through a cathode follower to the output stage of the unit. These pulses increase the voltage at the screen grid of the output stage tube. The amplitude of the output pulses is increased at the same time.

Thus, from the cathode of the output stage are taken . . .

[Note: page 97 of original text missing]

Only those trigger pulses which coincide in time with an elevation pulses are repeated at the cathode load of the selector stage (delay line U1 and resistor R17); there are 2 to 3 such pulses (on the upper base of the trapezoid). (p 99)

These pulses pass to an electronic relay based on tube V3.

Let us first assume that there are no trigger pulses flowing to the cathode of tube V3.

In a quiescent state the right triode (V3b) is open and the left triode (V3a) is blocked due to the voltage drop between the right triode and common cathode resistor R21. At this time capacitor C6 charges to a voltage of approximately 100 v. The triode (V3a) opens upon the arrival of a positive pulse at its control grid. The potential at the plate of tube V3a drops. The right triode is blocked.

Capacitor C6 begins to discharge through the grid circuit of tube V3a. The potential at the grid of V3a begins to drop at a rate determined by the time constant of RC. The value of resistance R is the sum of the resistance of the grid-cathode gap of tube V3a, resistors R21, R22, and R23, (which are series-connected to the cathode of the tube), and resistor R17. The capacitance is formed by capacitor C6.

The voltage at the plate of V3a increases, causing V3b to open and the voltage at the cathode to increase as a result of the current in V3b.

Tube V3a is blocked and V3b opens. A positive square pulse whose duration is determined by the time constant of RC, that is, the parameters of the circuit, is formed at the plate of tube V3b.

After the right triode of V3b opens, the potential at the common point of connection of resistors R18, R21, and R22 becomes equal to approximately 100 v and capacitor C6 begins to charge at a rate determined by the time constant of RC. (p 100)

In this case, R is the sum of series-connected resistors R18, R22, R23, and R17. The capacitance is formed by capacitor C6. The time constant of RC is chosen great enough so that the increase in potential at capacitor C6 occurs sufficiently slowly, and, after the first trigger, the circuit may again be triggered only after a time interval equal to 6 or 7 intervals between trigger pulses.

In order to establish the duration of the square pulse taken from the plate of tube V3b, trigger pulses are applied to the cathode of the electronic relay tube through crystal diode D1, which eliminates the effect of the relay on the trigger circuit. In fact, the electronic relay is triggered upon the arrival of a pulse from the selector stage at the control grid of tube V3a. The time constant of RC is selected so that reversal of the electonic relay in the absence of stopping pulses occurs after a time interval which exceeds the interval between two trigger pulses. However, the first positive pulse which arrives at the cathode of the electronic relay after it has triggered will perform this reversal. Thus, due to the presence of stopping pulses, a positive square pulse will be taken from the plate of tube V3b whose duration equals the fixed interval between two trigger pulses.

The simultaneous action on the electronic relay of trigger pulses from the selector stage and stopping pulses impedes the triggering of the relay. Therefore, delay line U1 is connected to the cathode of the tube in the selector stage. The trigger pulse now arrives at the control grid of the electronic relay tube after a delay of 3 to 4 microseconds with respect to the moment of arrival of the stopping pulse. (p 101)

The stopping pulse does not prevent the electronic relay from triggering. The nature of the signals passing to the electronic relay is shown in Figure 38. The figure shows: a) trigger pulses arriving at the selector stage; b) trigger pulses having passed through the selector stage; c) stopping pulses arriving at the cathode of the electronic relay; d) azimuth marker pulse.

The electronic relay pulse moves from the plate of tube V3b to the output stage of the unit -- the control grid of tube V4. The output stage is based on a cathode follower circuit.

<u>The 30-degree marker pulse-shaping circuit.</u> Voltage from the single-phase rotor winding of selsyn transformer M1 is applied to the control grid of the tube in the pulse-shaping stage (V1b). The pulse-shaping stage is in the form of a plate detector circuit.

The detector load (R6, C3) is connected between the plate of the tube and the +200 v bus. An elevation pulse, whose width is determined by the d-c voltage at the cathode of the tube (divider R8, R9), appears at the load of the plate detector. The width of the elevation pulse is chosen equal to approximately 5° at its base. The positive elevation pulse is passed directly from the plate of the tube to the control grid of the cathode follower (V2a). The positive pulse then passes from the cathode of this tube to the screen grid of the output stage tube of the unit (tube V4). Positive pulses from the electronic relay of the (p 103) 5-degree marker-shaping circuit are applied to the control grid of this tube.

An example of the idealized characteristics of a 6P3S tube is given in Figure 39. For 5-degree markers, the voltage at the screen grid of the output stage tube of the unit equals U_{e2}. It is determined by the position of the cursor of potentiometer R12. With the arrival of a pulse from the 30-degree marker-shaping circuit (at azimuths which are multiples of 30 degrees), the voltage at the screen grid increases to a maximum value U_{e1}. The pulse of the 5-degree marker-shaping circuit, taken at this time from the cathode of the output tube, increases in amplitude and forms the 30-degree marker. The amplitude of the 5-degree marker pulses is controlled by changing the positive voltage at the screen grid of the output tube using potentiometer R12.

The amplitude of the 30-degree marker pulses is controlled by changing the amplitude of the pulse arriving at the control grid of the output stage of the unit (potentiometer R28). In the case of idealized characteristics of output tube 6P3S (Figure 39), both controls are independent of each other. Changing the position of the cursor of potentiometer R28 does not change the amplitude of the 5-degree markers, since the voltage at the control grid of tube V4 when the value of the screen voltage is small is fixed by the grid current. The 30-degree marker is shaped when the voltage at the screen grid of V4 is maximum.

In this case the output tube operates without grid currents and the amplitude of the grid pulse determines the amplitude of the 30-degree markers. At the same time, changing the position of the cursor of potentiometer R12 (that is, changing the value of voltage U_{e2}) has no effect (p 105) whatever on the value of the 30-degree marker pulse.

For practical purposes, the "5° AMPLITUDE" control in unit OA-5-1 has no influence on the amplitude of the 30-degree markers, while adjustment of the "30° AMPLITUDE" control also changes the amplitude of the 5-degree markers.

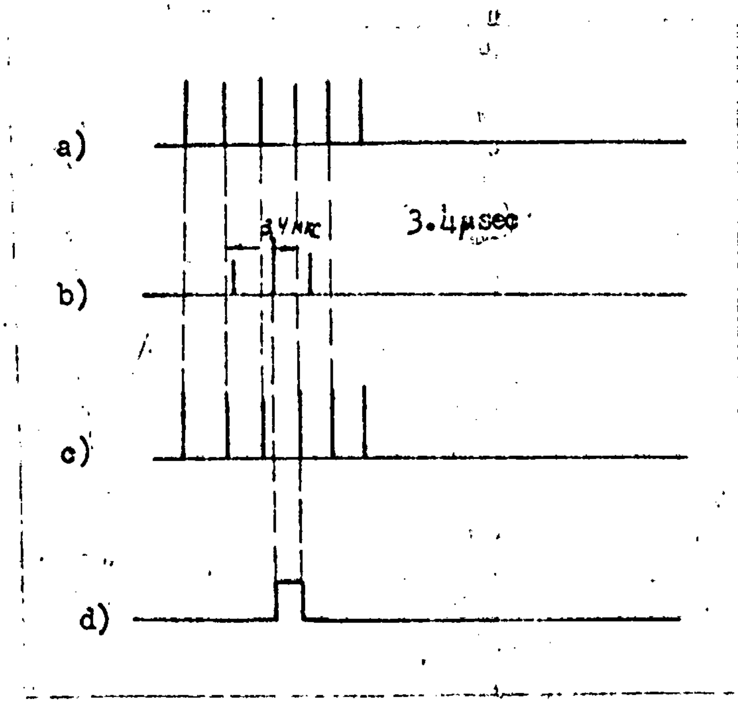


Fig. 38. Signals Received by Electronic Relay.

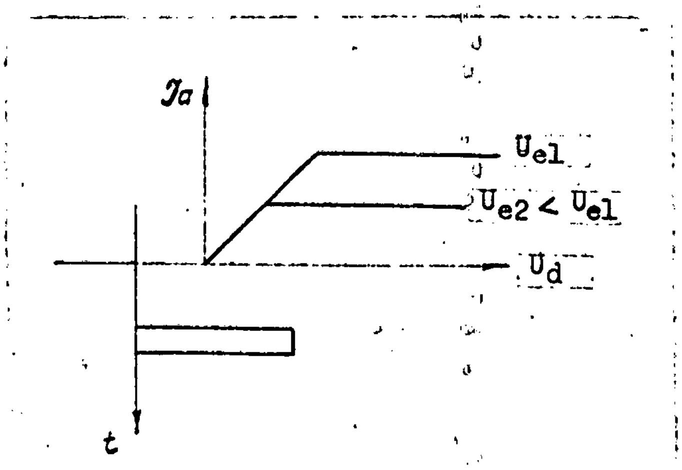


Fig. 39. Idealized Characteristics of a 6P3S Tube.

Monitoring the operation of the unit. Unit OA-5-1 is monitored with the aid of five test jacks:

G1-1 -- for monitoring the elevation pulse of the 5-degree marker at the plate of tube V1a;

G1-2 -- for monitoring the elevation pulse of the 30-degree marker at the plate of tube V1b;

G-2 -- for monitoring the pulse at the screen grid of tube V4 in the output stage of the unit;

G-3 -- for monitoring the electronic relay pulse at the plate of tube V3b;

G-4 -- for monitoring marker pulses at the cathode of tube V4 in the output stage of the unit.

Design of the unit. Unit OA-5-1 is built in the form of a self-contained instrument mounted on a standard chassis. The tube channel contains four tubes (one 6N9S; two 6N8S; and 6P3S) and five test jacks. On the front panel of unit OA-5-1 are operating mode toggle switch V1, an illuminating light, and the shafts of two potentiometers for controlling the amplitude of the 5-degree and 30-degree markers. The unit has one plug connector. Weight of the unit is 9 kg.

10. Azimuth Scale Marker Unit OA-1-1

Function. The OA-1-1 azimuth scale marker unit (Figure 40) generates electrical scale pulses for the 1-degree azimuth markers.

Technical data on the unit. The duration of pulses generated by the unit equals the time interval between two trigger pulses. Pulse amplitude at the output may be controlled within limits of not less than 2 to 9 v. (p 107)

Functional diagram of the unit. Figure 41 gives a functional diagram of the unit. As in unit OA-5-1, voltage at a frequency of 1,500 cps is used to produce these scale markers; the amplitude of the voltage changes at a frequency 36 times greater than the frequency of rotation of the antenna. The voltage passes through zero values of the voltage envelope at time intervals corresponding to 5^{o}. Generation of the 1-degree markers requires four voltages at 1,500 cps whose envelopes pass through zero values with a shift of 1^{o}. Type ED-101 selsyns with two three-phase windings are used to obtain this voltage.

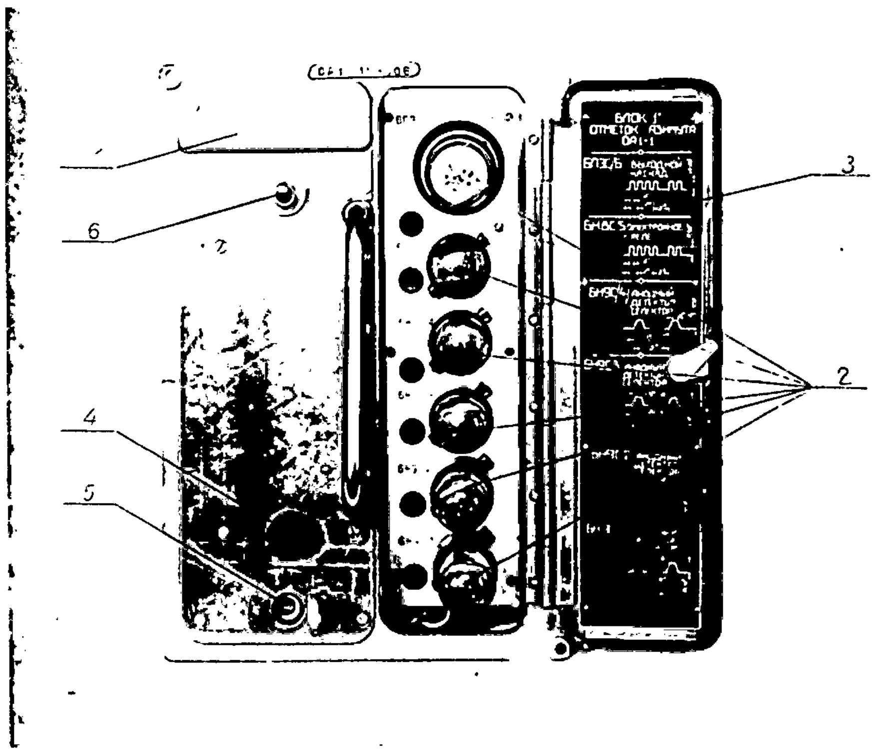


Fig. 40. Unit OA-1-1.

1 - plug cover; 2 - tubes in tube channel; 3 - label on door; 4 - illuminating bulb holder; 5 - amplitude control of 1-degree markers; 6 - operating mode switch V1.

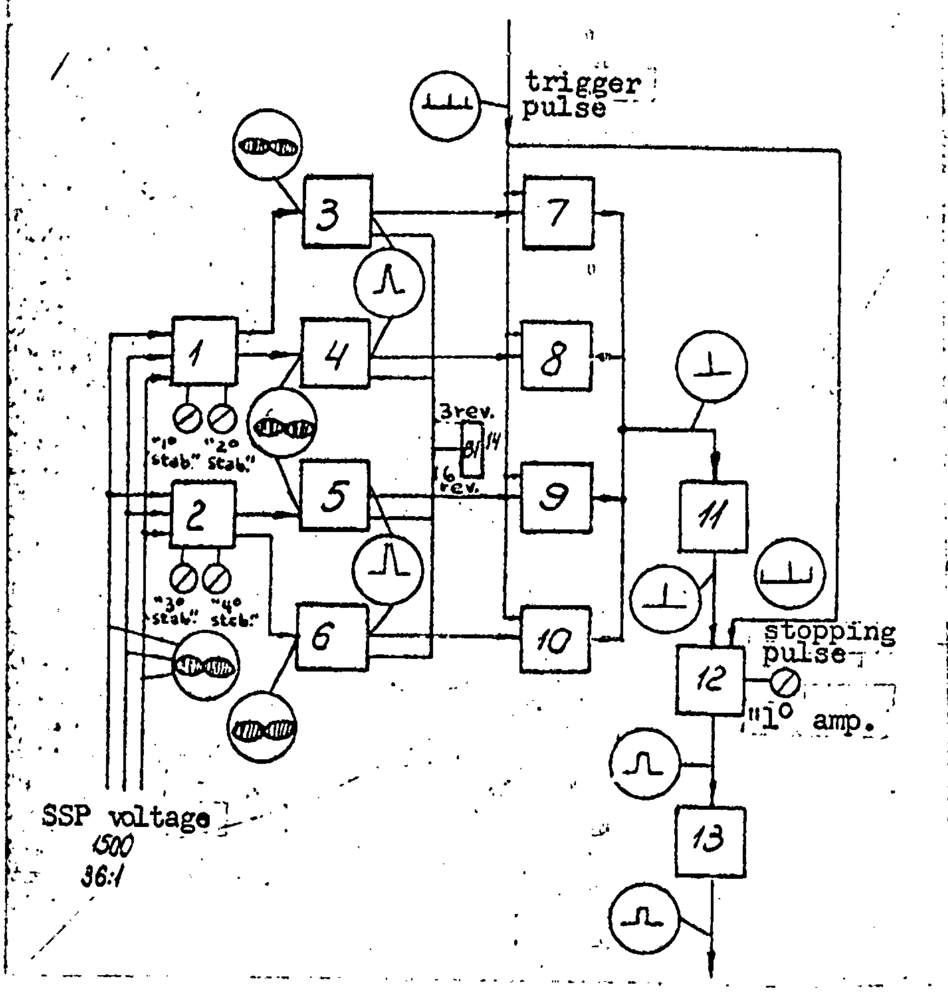


Fig. 41. Functional Diagram of Unit OA-1-1.

1 - selsyn transformer ED-1-1 of first and second 1-degree markers; 2 - selsyn transformer ED-101 of third and fourth 1-degree markers; 3 - plate detector of 1-degree markers; 4 - plate detector of 2-degree markers; 5 - plate detector of 3-degree markers; 6 - plate detector of 4-degree markers; 7 - selector stage of 1-degree markers; 8 - selector stage of 2-degree markers; 9 - selector stage of 3-degree markers; 10 - selector stage of 4-degree markers; 11 - delay line; 12 - electronic relay; 13 - output stage; 14 - operating mode switch.

One of the windings of rotor P1 of each selsyn is grounded. Voltage U_{r3} taken from the winding of P3 is shifted in phase by an angle of $1^{o}40'$ with respect to voltage U_{r2}, which is taken from the winding of P2 (Figure 42). At the intermediate points of section P2-P3, the voltage envelope U_{int} is shifted with respect to voltage envelope U_{r3} by an angle lying within limits of 0-100'.

Two voltages shifted in phase by 1^{o} are taken from each of the selsyns M1 and M2 (U_{r3} from the winding of P3 and U_{int} from an intermediate point selected on section P2-P3). The rotors of selsyns M1 and M2 are positioned so that voltage U_{r3} of selsyn M2 is, in turn, shifted with respect to voltage U_{int} of selsyn M1 by an angle equal to 1^{o}.

The four voltages taken from selsyns M1 and M2, shifted by an angle of 1^{o} with respect to each other, are applied to the inputs of the elevation pulse-shaping stages (plate detectors). (p 110)

At the moments when the envelopes of the four 1,500-cps voltages pass through zero values, these stages generate voltage pulses (elevation pulses) which are distributed between two 5-degree markers. The width of the elevation pulses is determined by the operating mode of the tubes in the pulse-shaping stages. The elevation pulses are applied from the pulse-shaping stages to selector stages to which are also applied trigger pulses. When these pulses coincide, the selector stage generates positive pulses which are fed to an electronic relay circuit. The electronic relay generates positive square pulses which have a duration equal to the time interval between two trigger pulses. These pulses fall between two 5-degree markers at intervals of 1^{o}. The pulses are absent at azimuths which are multiples of 5^{o}, since only four marker-shaping voltages are applied to the circuit.

These pulses pass through the output stage (cathode follower) to the displays of the station.

The unit has five controls.

The intervals between output pulses of the unit are adjusted by the controls "1^{o} ADJ.," "2^{o} ADJ.," "3^{o} ADJ.," "4^{o} ADJ." The "1^{o} AMPL." control is used to change the amplitude of the 1-degree markers at the output of the unit.

<u>Description of schematic diagram</u>. Figure 43 gives a schematic diagram of unit OA-1-1. The differential selsyns M1 and M2 are at the input of the circuit. One of the windings of rotor P1 of each selsyn is grounded. Variable resistors R1 and R2 are connected between the other two windings of P2 and P3. The position of the cursor of potentio-

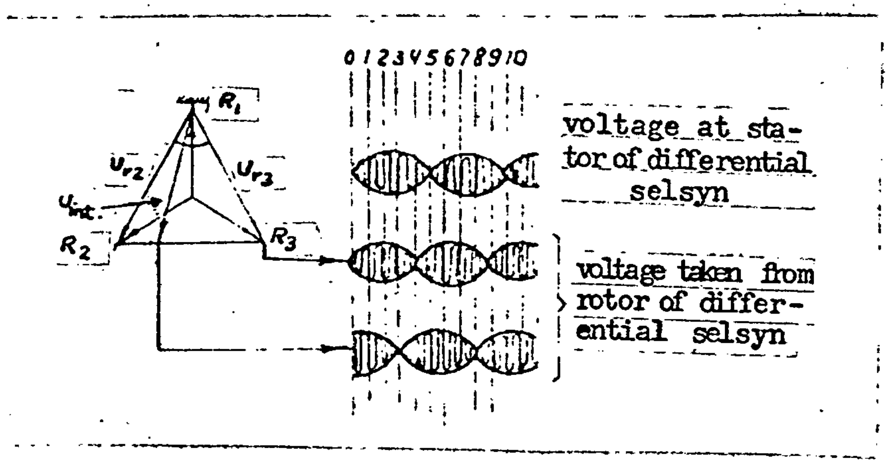


Fig. 42. Vector Diagram of Voltages at Differential Selsyn.

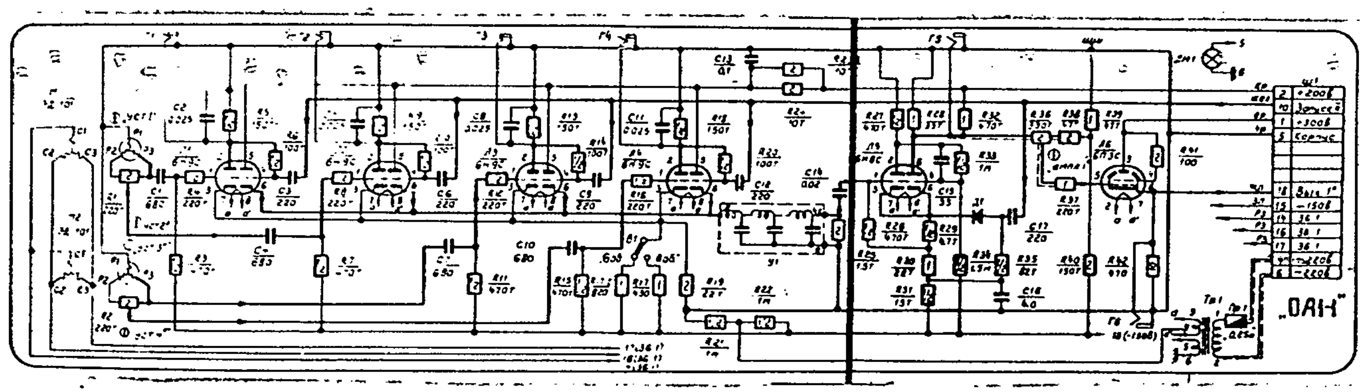


Fig. 43. Schematic Diagram of Unit OA-1-1.

meters R1 and R2 determines the phase shift between the voltage taken from the cursor and the voltage taken from the winding of P3. Four voltages are taken from the rotor windings of P3 of selsyns M1 and M2 and the cursors of potentiometers R1 and R2; the voltages are shifted in phase by 1° with respect to each other, which is dependent upon the setting of the selsyn rotors and the cursors of the potentiometers (Figure 44). These voltages are applied to the control grids of four identical elevation pulse-shaping stages (V1a, V2a, V3a, and V4a). (p 112)

Voltage is applied to the grid of the first stage from rotor P3 of selsyn M1, to the grid of the second stage from the cursor of potentiometer R1, to the grid of the third stage from rotor P3 of selsyn M3 of selsyn M2, and to the grid of the fourth stage from the cursor of potentiometer R2.

The elevation pulse-shaping stages are based on a plate detector circuit. The load of each detector (R5, C2-R9, C5-R13, C8-R18, C11) is connected between the plate of the tube and ground. An elevation pulse is produced at the load of each detector whose width is determined by the d-c voltage at the cathode of the tube (divider R17, R17/I, R19). The width of the elevation pulse is chosen equal to approximately 30' at its base and is maintained at this level at antenna rotation speeds of 3 rpm and 6 rpm with the appropriate switching of operating mode toggle switch V1.

The positive elevation pulses from the plates of tubes V1a, V2a, V3a, and V4a are supplied to the control grids of the selector stages (V1b, V2b, V3b, and V4b). In addition, trigger pulses are also applied to the control grids of these tubes. The selector stages operate as coincidence stages.

The operating modes of tubes V1b, V2b, V3b, and V4b are selected so that only those trigger pulses which coincide in time with an elevation pulse are repeated at the cathode load of the selector stages (delay line U1 and resistor R25); there are 2 to 3 such pulses.

These pulses are fed to an electronic relay. The relay uses tube V5 with the same type of circuit as the electronic relay of unit OA-5-1. The electronic relay pulses pass from the plate of tube V5b to the output stage of the unit -- the control grid of tube V6.

The output stage is a cathode follower circuit. [p 114)

The amplitude of the 1-degree markers is controlled by changing the amplitude of the pulse at the control grid of the output stage of the unit; this is done with the cursor of potentiometer R36.

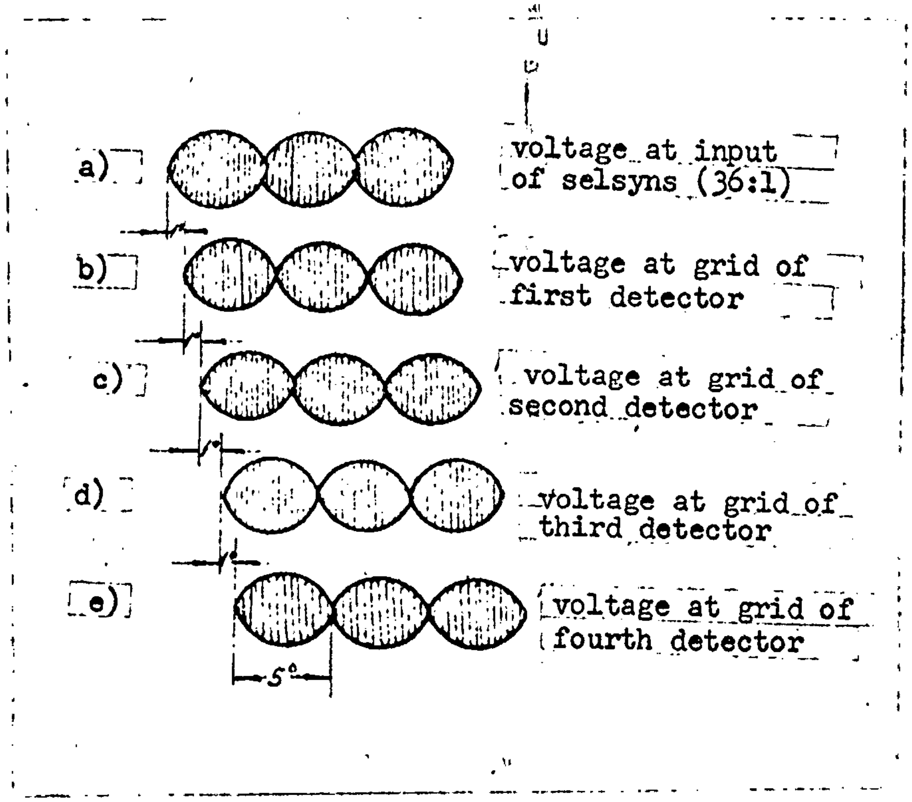


Fig. 44. Voltages in ED-101 Selsyns.

Monitoring the operation of the unit. Unio OA-1-1 is monitored with the aid of six test jacks:

G1 -- for monitoring the elevation pulse at the plate of tube V1a;

G2 -- for monitoring the elevation pulst at the plate of tube V2a;

G3 -- for monitoring the elevation pulse at the plate of tube V3a;

G4 -- for monitoring the elevation pulse at the plate of tube V4a;

G5 -- for monitoring the electronic relay pulse at the plate of tube V5b;

G6 -- for monitoring the marker pulse at the cathode of the output stage tube V6.

Design of the unit. Unit OA-1-1 is built in the form of a self-contained instrument mounted on a standard chassis. The tube channel contains 6 tubes (four 6N9S; one 6N8S; one 6P3S) and 6 test jacks. On the front panel of the unit are operating mode toggle switch V1 and a light for illuminating the controls.

The shaft of the potentiometer used to adjust the amplitude of the 1-degree markers extends through the front panel. The unit has one plug connector. Weight of the unit is 9.5 kg.

11. Input Unit VU

Function. Input unit VU (Figure 45) serves for the preliminary separation of the useful signal from the denser part of the receiver set noises and the conversion of these isolated signals to pulses of identical amplitude and identical duration.

The unit contains switches which can be used to connect the outputs of the noise-protection circuits to the DUS-1 cabinet alone or to all the indicators of the station. (p 116)

Technical data on the unit. Unit VU clips the noisy portion of the signal. The size of the clipped portion is regulated. The signals create pulses with an amplitude of not less than 30 v and a duration of 1.5 to 2.5 microseconds at the output of the unit.

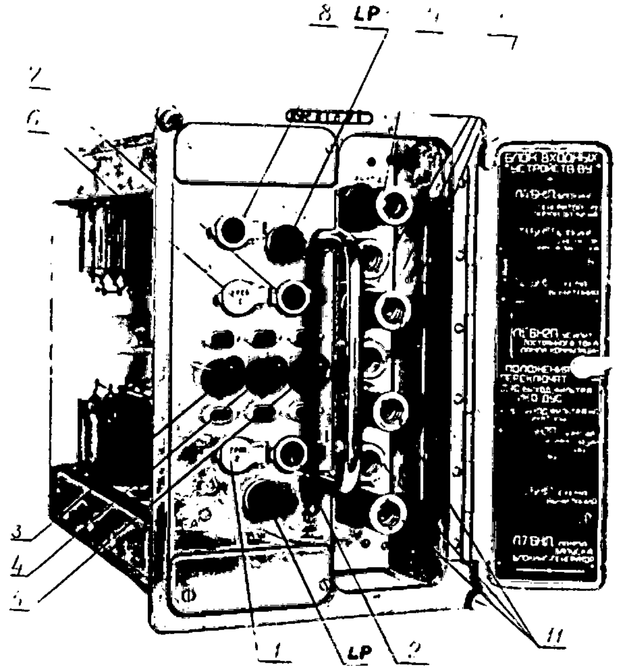


Fig. 45. Unit VU.

1 - level control for channel II; 2 - sensitivity control for blocking oscillator of channel II; 3 - switch for channel II; 4 - switch for channel III; 5 - switch for channel I; 6 - level control for channel I; 7 - sensitivity control for blocking oscillator of channel I; 8 - sensitivity control for blocking oscillator of channel III; 9 - tubes of channel III; 10 - tubes of channel I; 11 - tubes of channel II.

The unit has the capability of mixing the signals passing through channel II with signals of channel I and applying them jointly to unit IU-1.

Functional diagram of the unit. Figure 46 gives a functional diagram of the input unit. The unit has three channels; channels I and II are identical and consist of:

a) diode limiter 1;

b) amplifier-mixer;

c) subtraction circuit;

d) diode limiter 2;

e) amplifier;

f) triggered blocking oscillator (pulse-shaping device).

Channel III (reserve) consists of:

a) amplifier;

b) triggered blocking oscillator (pulse-shaping device). The input video signal of channel I (II) [note: Henceforth, designations of elements of channel II will be given in parentheses after the designation of the corresponding elements of channel I in the descriptions of units VU, IU-1, and GR.] is applied to diode limiter 1 and to the subtraction circuit.

The average level of the input signal is limited in diode limiter 1-I (1-II). The more compressed portion of the noises lying below the average level (negative portion) is applied to the amplifier mixer where it is integrated and mixed with the switching pulse from unit GR. DUring the presence of the switching pulse (return sweep), the passage of video signals to the integrating circuit tube is halted. (p 117)

After the amplifier-mixer, the integrated noises pass to the subtraction circuit where they are used as a regulating voltage. This voltage automatically regulates the triggering level of the subtraction circuit with respect to the average level of the input signal. Hence, the useful signal which exceeds the average noise level is separated in this manner from the noise signals. (p 118)

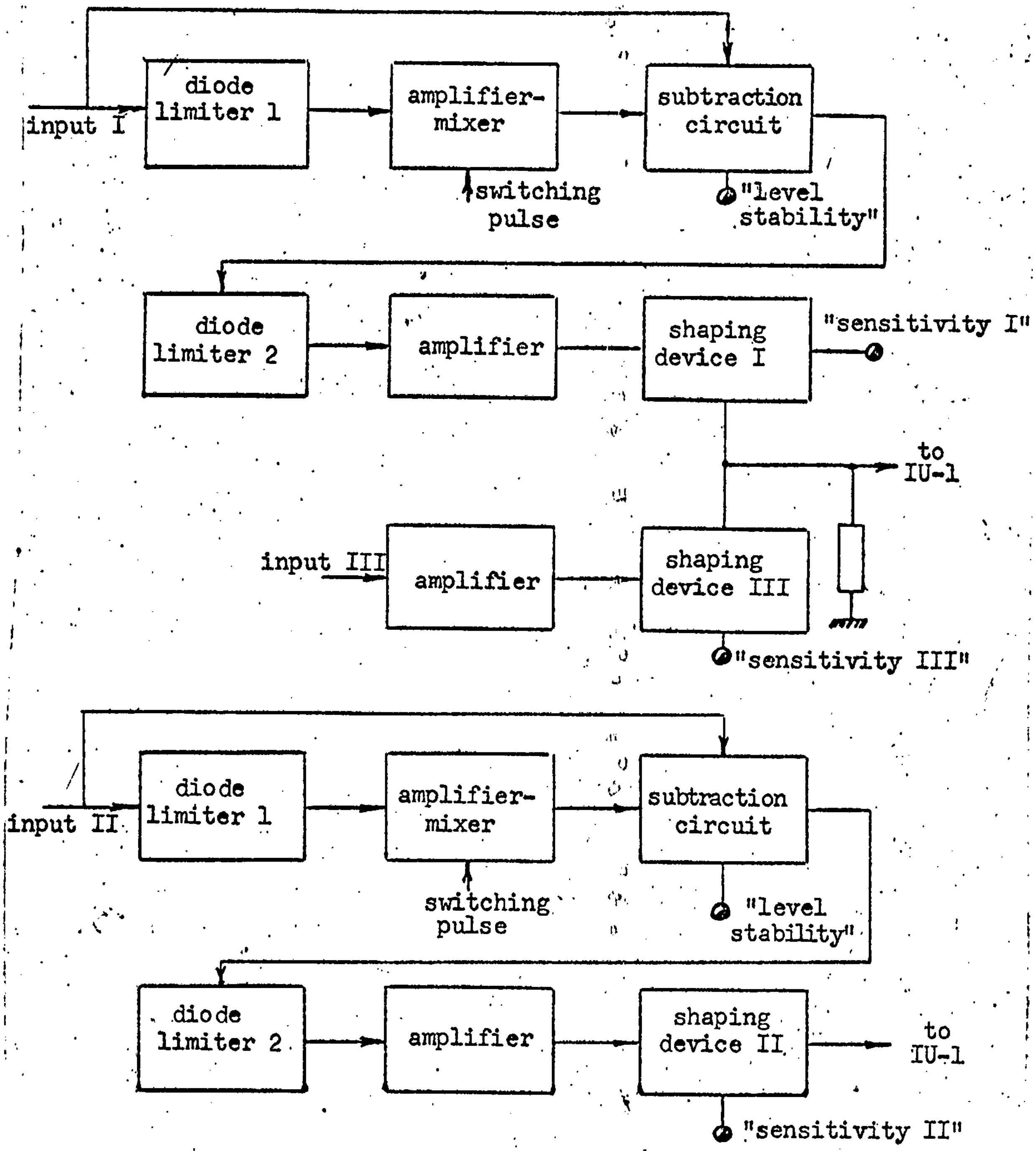


Fig. 46. Functional Diagram of Unit VU.

The operating mode of the subtraction circuit is established by means of the control "Level I" ("Level II"). The video signals taken from the output subtraction circuit also contain an a-c component of the control voltage. Therefore, the video signals from the output of this circuit are fed to a diode limiter 2-I (2-II) which does not pass the a-c component.

From the diode limiter the video signals are applied to the amplifier and then to the pulse-shaping device; all signals at the output of this device have constant amplitude and duration.

A triggered blocking oscillator with a small recovery time is used as the pulse-shaping device in this case. The triggering level of the blocking oscillator is varied by means of the control "Sensitivity I" ("Sensitivity II").

Operation of the device is monitored with the "Sensitivity" meter on the front panel of unit IU-1. The meter is connected to the cathode circuit of the blocking oscillator of channel I or II in unit VU (depending upon the position of the switch "Monitor" in unit IU-1). The readings of the "Sensitivity" meter, which measures the average value (d-c component) of the output pulses where the latter have constant amplitude and (p 119) duration, are proportional to the average frequency of occurance of these pulses at the output of the blocking oscillator.

The video signals from the output of the pulse-shaping device, in the form of pulses of constant amplitude and duration, are applied to unit IU-1.

The noise-protection apparatus is capable of mixing signals of channel III with signals of channel I for the purpose of protecting the circuit against non-synchronous pulse noises in channel III. The signals arriving at channel III must have an amplitude of not less than 3 volts.

Mixing is carried out as follows: the signals of channel III are fed to the blocking oscillator tube. This triggered blocking oscillator with a small recovery time has a common load with the blocking oscillator of channel I. When the blocking oscillator of channel III triggers, the pulse is sent to the common load.

Description of the schematic diagram. A schematic diagram of unit VU is given in Figure 47.

Video signals from the output of signal mixer unit SS-1 are applied to the operating mode switch of noise-protection apparatus VI (V3) as well as through cappicitor C1 (C13) to the diode limiter. Two (p 121) germanium crystal diodes D1 and D2 (D7 and D8) function as the diode limiter.

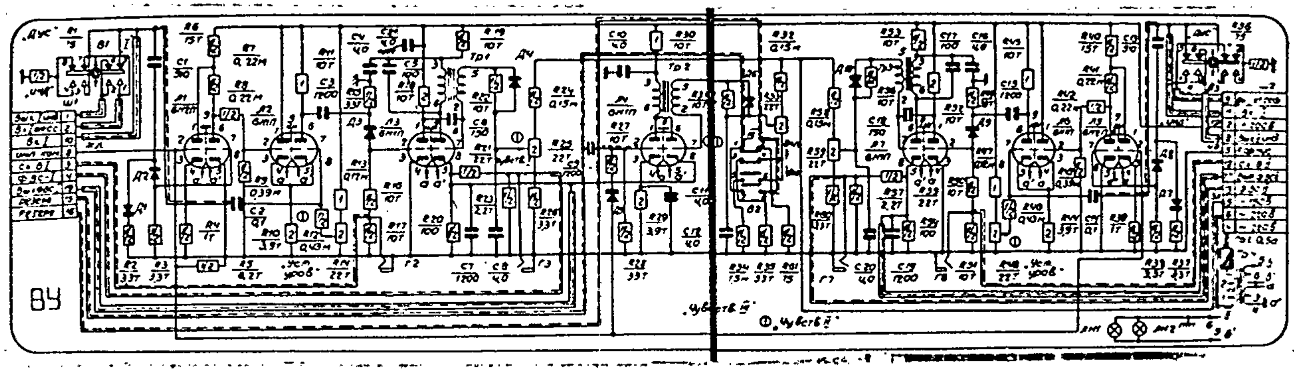


Fig. 47. Schematic Diagram of Unit VU.

The two diodes are connected to capacitor C1 (C13) with the polarity of their electrodes in opposition; the diodes have equal loads R2 = R3 = 3.3 kilohms (R37 = R38 = 3.3 kilohms). Since the loads of the diodes are equal, the charging and discharging time constants of capacitor C1 (C13) are approximately equal as a result of which the signal is limited to an average value.

Let us examine the operation of the diode limiter (Figure 48).

When a sinusoidal voltage is applied to its input, D1 is open during the positive half of the sinusoid and a positive half-wave voltage appears at its load R2. This charges capacitor C1, which has a time constant

$$T = C1 \cdot R_{equiv.1}; \; (T = C13 \cdot R'_{equiv.1}),$$

where $R_{equiv.1}$ = R2 + Ri of diode D1 $\approx$ R2; ($R'_{equiv.1}$ = R37 + Ri of diode D7 $\approx$ R37), since Ri of the open diode is small and may be disregarded.

Diode D2 is closed during the positive sinusoid.

During the presence of a negative half-wave, diode D1 is blocked and diode D2 (D8) is open and a negative voltage half-wave appears at its load R3 (R38). Capacitor C1 (C13) then discharges through resistance

$$R_{equiv.2} = R3 + Ri \text{ of diode D2} \approx R3; \; (R'_{Equiv.2} = R38 + Ri \text{ of diode D8} \approx R38).$$

The capacitor discharges completely during the negative half-wave. In this case limiting occurs at the zero level. When non-symmetrical signals are applied to the input of the limiter, the limiting level is automatically set at the average level, regardless of the amplitude of the signals, in view of the equality of resistors R2 and R3. (p 123)

In this case, signals located above the average level of the input signal appear at load R2, and signals below the average level appear at load R3.

The more compressed portion of the noises, located below the average level of the output video signal, is taken from resistor R3 (R38) and applied to the right half of tube V1 (V5), type 6N2P.

The load of the right half of tube V1(V5) is large; therefore, due to the presence of spurious capacitance, integration (averaging) of the noises occurs at the plate of the tube.

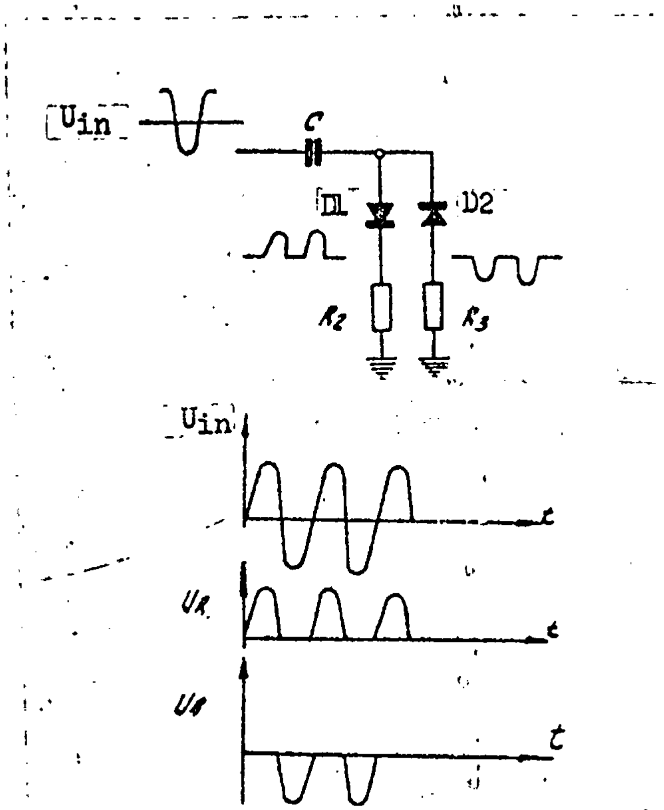


Fig. 48. Principle of Operation of the Diode Limiter.

The left half of tube V1 (V5) is used to block echo signals during the return sweep. Its plate is connected to part of the plate load of the right half of tube V1 (V5), and a switching pulse is applied to its grid from part of the cathode load of the sweep relay (kipp relay) of unit GR.

At the common plate load R6 (R40) of V1 (V5) there occurs an addition of the switching pulse voltage and the voltage of the more dense portion of the noise, which is proportional to the average value of the input signal, thereby forming a control voltage.

During the presence of the switching pulse, the left half of V1 (V5) is blocked and the voltage at common plate resistor R6 (R40) increases sharply, increasing the value of the control voltage.

This voltage is taken from the right half of tube V1 (V5) and sent through divider R8 and R9 (R42 and R43) to the grid of the left half of V2 (V6). (p 124)

The value of resistors R8 and R9 R42 and R43) determines the operating point of the left half of tube V2 (V6).

The triodes of tube V2 (V6) have a common cathode load.

The left half of V2 (V6) operates as a cathode follower.

The control voltage, which is proportional to the average value of the input video signal, is applied to the grid of the left half of V2 (V6). Approximately the same voltage appears at the cathode load. The input video signal is sent through blocking capacitor C2 (C14) to the grid of the right half of tube V2 (V6).

The right half of tube V2 (V6) is blocked.

The blocking voltage is provided by the voltage at the cathode of this tube created by the plate current in the left half of tube V2 (V6). Compensation for negative blocking voltage is provided by the application of a positive voltage from potentiometer R14 (R48). The initial cut-off level is also established in this manner. With the arrival of an output video signal at the grid of the right half of V2 (V6), the pulse voltage, which exceeds the control voltage at the cathode, triggers the right half of V2 (V6), and output pulses appear at load R11 (R45).

Figure 49 (a and b) shows the approximate shape of the voltages at the grids of the right and left halves of tube V2 (V6), and Figure 49 (c) shows the voltage at the output of the subtraction circuit.

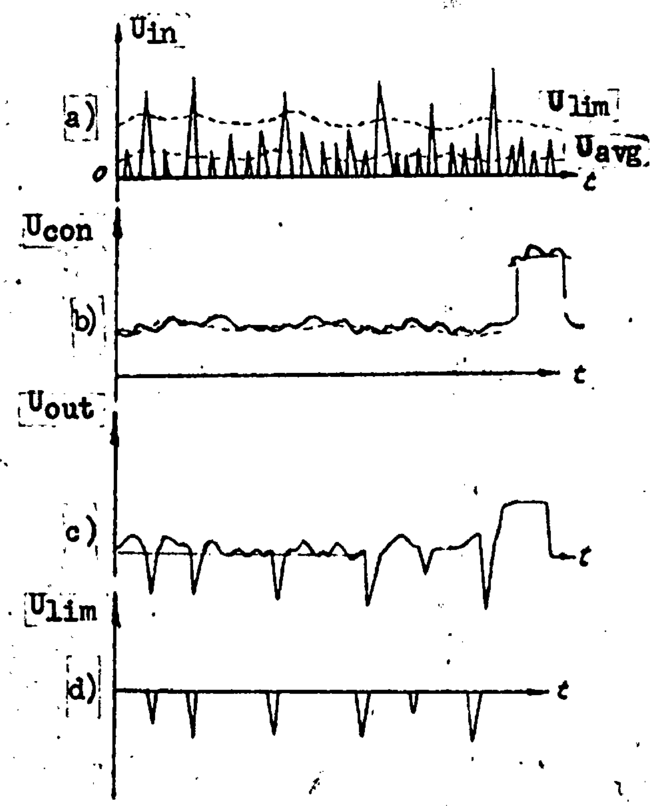


Fig. 49. Shape of Voltages at the Grids of Tube V2 (V6) and at the Output of the Subtraction Circuit.

During a return sweep, a positive pulse of large amplitude appears at the grid of the left half of V2 (V6); the pulse is repeated at the cathode of the right half of V2 (V6) and strongly blanks the tube. Video signals will not now pass to the output of the subtraction circuit. (p 126)

Operation of the subtraction circuit when the amplitude of the input video signal changes is illustrated in Figure 50. It is seen from this diagram that when the amplitude of the noise pulses increases, the number of noise peaks passing to the output of the subtraction circuit does not increase. An increase in the amplitude of the noise causes an increase in the amplitude of the negative portion of the noise passing to the grid of the right half of V1 (V5) from the diode limiter. This involves an increase in the control voltage taken from the plate of the right half of V1 (V5). Since the control voltage acts on the cathode of V2 (V6), the input signal limiting level provided by this tube becomes greater. The number of noise pulses exceeding the limiting level and passing to the output of the subtraction circuit remains unchanged despite the increase in their amplitude (Figure 50 b).

The limiting level is controlled with variable resistor R14 (R48) "Level I" ("Level II") which changes the bias at the grid of the right half of tube V2 (V6).

Negative polarity signals from the plate of the right half of tube V2 (V6) pass through capacitor C3 (C15) to the second diode limiter. This diode limiter is required in order to eliminate the a-c component of the control voltage in the subtraction circuit (Figure 49 d).

The second diode limiter is based on crystal diode D3 (D9). The signal is taken from the diode limiter and applied to the grid of the left half of tube V3 (V7), which is an amplifier. (p 128)

V3 (V7) is a 6N1P tube. Operation of the subtraction circuit is monitored from unit KO-3. This is accomplished by sending signals from part of the load of diode limiter D3 (D9), namely, from resistor R17 (R51) to unit KO-3.

As was noted above, the input unit must provide a constant amplitude and duration of the pulses at its output. This function is performed by the pulse-shaping device. The pulses are shaped by a triggered blocking oscillator based on the right half of tube V3 (V7).

The blocking oscillator is triggered when positive pulses taken from plate load R18 (R52) of the left half of tube V3 (V7) are applied to the grid of the right half of the tube through capacitor C6 (C18).

The blocking oscillator generates pulses having a duration on the order of 1.5 to 2.5 microseconds. Diode D4 (D10) is connected in parallel with leakage resistor R22 (R56) for the purpose of accelerating

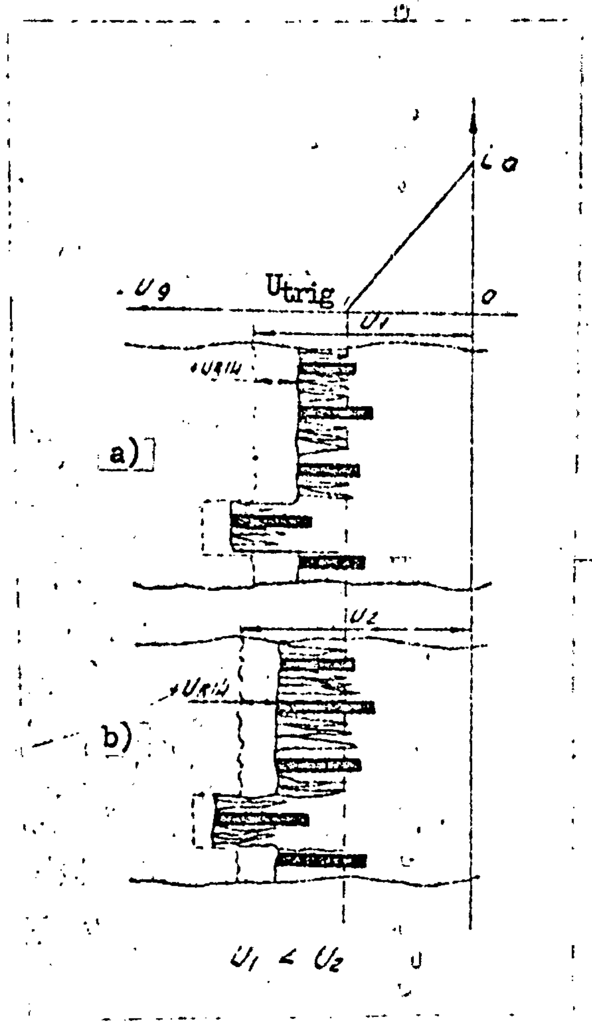


Fig. 50. Operation of the Subtraction Circuit When the Value of the Input Video Signal Changes.

the discharge of the capacitance in the grid circuit of the blocking oscillator tube formed by the input capacitance of the tube, the capacitance of the transformer winding to ground, and the capacitance of the wiring.

The discharge time of the above spurious capacitances determines the minimum possible repetition period of the pulses. Use of the diode in the grid circuit permits a considerable reduction of the time constant of capacitive discharge, since the diode opens at the moment of discharge and the discharge occurs through resistance:

$$R_{equiv.} = \frac{R22 \times Ri \text{ of diode } D4}{R22 + Ri \text{ of diode } D4} \; ; (R'_{equiv.} = \frac{R56 \times Ri \text{ of diode } D10}{R56 + Ri \text{ of diode } D10})$$

Thus, it is possible to reduce the transient process in the blocking oscillator to a considerable degree and to obtain a minimum repetition period for the pulses generated by the blocking oscillator. (p 129)

Potentiometer R25 "Sensitivity I" (R59 "Sensitivity II") is used to change the bias at the control grid of the blocking oscillator tube, that is, the triggering level of the blocking oscillator. This level determines the minimum amplitude of the pulses at which the blocking oscillator is triggered and, consequently, makes it possible to change the number of output pulses of the blocking oscillator which are sent to the integrating tube.

The average repetition rate of the blocking oscillator output pulses is controlled with instrument IP-1, "Sensitivity," located in unit IU-1. The instrument measures the d-c voltage component in the cathode circuit of the blocking oscillator tube and characterizes the average pulse repetition rate in a piece-wise manner (when the amplitude and duration of the output pulses are constant). The pulses taken from the cathode load R20 (R54) have positive polarity and an amplitude on the order of 40 volts. The output pulses of the blocking oscillator are controlled by unit KO-3. Pulses from cathode load R20 (R54) are applied to unit KO-3 through divider R21-R23 (R55-R57).

The channel III signals are sent through coupling capacitor C9 to the left half of tube V4, which is the trigger tube of the blocking oscillator in channel III (the right half of tube V4). The blocking oscillator of channel III is based on the same type of circuit as the blocking oscillators in channels I and II. Potentiometer R33, "Sensitvity III," changes the trigger level of the right half of tube V4. Since (p 130) cathode resistor R20 of the blocking oscillator in channel III is also the cathode resistor of the blocking oscillator in channel I, the output signals of both channels are mixed at the common load and follow through channel I to the output of unit VU. Signals of channel III are switched by means of toggle switch V2.

In unit VU are two operating mode toggle switches (V1 and V3) for the station displays. These switches receive the return signals from the SS-1 signal mixer units and signals which pass through the non-synchronous noise-protection apparatus. When the switches are in the position "DUS", the return signals from SS-1 are fed directly to the station displays and are terminated with equivalent loads in RShch-4; signals from IU-1 are applied directly to the DUS-1 (remote control cabinet) display. When the switches are in the position "IND," the return signals from SS-1 are terminated with equivalent loads in unit VU itself. All station displays, including the DUS-1 cabinet, receive signals from unit IU-1.

Monitoring the operation of the unit. Unit VU is monitored by means of an external oscillograph through the following four test jacks:

G2 (G6) -- for monitoring the subtraction circuit;

G3 (G7) -- for monitoring the operation of the blocking oscillator.

Design of the unit. The unit is built in the form of a self-contained instrument mounted on a standard chassis.

The tube channel contains 7 bantam tubes and 4 test jacks. On the front panel are the shafts of 5 potentiometers, three toggle switches, and two illuminating bulbs.

Unit VU is linked to the other units in the cabinet by means of two plugs. Small parts (resistors and capacitors) are located on wiring boards within the unit. The filament transformer is placed inside the unit.

The unit weighs 7.6 kg.

12. Integrator Unit IU-1

Function. A valid signal in unit IU-1 (Figure 51) is separated from pulsating, unsynchronized interference with the aid of storage tubes. LN-7 tubes are used for this purpose.

Technical data on the unit. The IU-1 unit must pass signals which are synchronized with the start of the sweep of unit GR and reject signals which are not synchronized with it. When a sinusoidal voltage is applied to unit IU-1 from unit GR, spiral sweeps should appear on the LN-7 tubes of unit IU-1 which can be observed on special tubes having a luminophor (LZhYe-3M) instead of a signal plate.

The signal at the input to the unit has an amplitude of not less than 20 volts with a duration of 1.5 to 2.5 microsec. At the output the

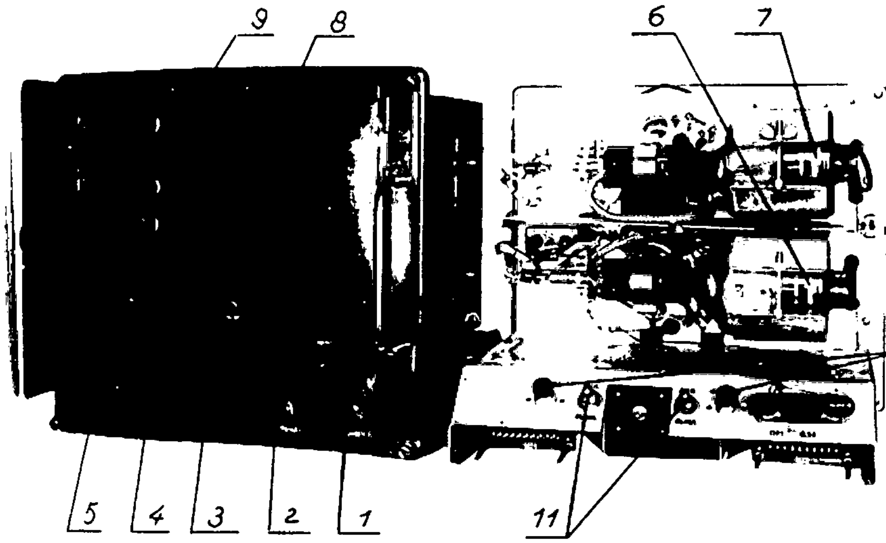


Fig. 51. Unit IU-1.

1 - channel I limit control; 2 - beam current control for channel I tube; 3 - control switch for channels I and II; 4 - beam current control for channel II; 5 - channel II limit control; 6 - channel I tube; 7 - channel II tube; 8 - cover for dial light of instruments which measure sensitivity of blocking oscillator and tube beam current; 9 - U-OCh amplifier subassembly for channel I; 10 - focus control for channels I and II; 11 - toggle switches for focusing channels I and II. (Right side of figure shows unit with cover removed.)

amplitude of the signal should be 3 to 8 v with a load of 75 ohms. The output signal of unit IU-1 is delayed about 2 microsec (25 ohms) relative to the input signal due to the passage of the signal through the circuit.

Functional diagram of the unit. A functional diagram of unit IU-1 is shown in Figure 52.

The unit has two identical channels, 1 and 2, consisting of the (p 134)
following components: d-c restorer circuit, LN-7 type tubes, and subassembly U-OCh.

There are two devices which regulate the beam current of the tubes and the sensitivity of the shaping equipment of unit VU. The "CONTROL" switch switches the components of unit IU-1 and the control circuit of the 1st and 2nd channels in unit KO-3.

Shaped video signals of equal amplitude and duration are fed from unit VU through a coupling capacitor to the d-c restorer circuit and then to the modulator of the LN-7 tube.

The LN-7 tube converts periodically repeating video signals into signals of negative polarity, and random signals into signals of positive polarity.

The converted signals pass to the amplifier (subassembly U-OCh) which separates the valid signal from signals caused by pulsating interference and amplifies it.

The "BEAM CURRENT 1", "BEAM CURRENT 2", "FOCUS 1", and "FOCUS 2", controls of the unit govern the operating mode of the tube, and the "LIMIT 1" and "LIMIT 2" controls regulate the level of limiting random signals in the U-OCh subassembly.

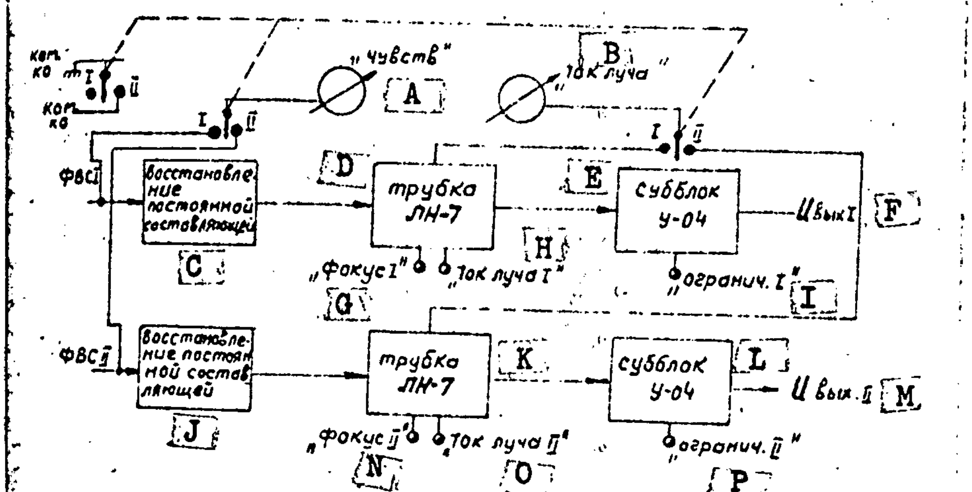
Principle of operation of the LN-7 type storage tube. Interference on the radar scope is decreased by means of storage tubes, utilizing the fact that during multiple storage of operating cylces of the radar (integrating), periodically repeating signals (signals reflected from targets, nearby objects, etc.) can be distinguished from interference.

(p 135)

LN-7 tubes are used as storage tubes. The general appearance of the LN-7 tube, its basic dimensions and electrical characteristics are shown in Figure 53.

The tube consists of an electron gun, a screen, cylindrical collector, and loop.

Input signals are fed to the modulator of the electron gun. To increase the resolution of the tube, a spiral scan is used, i.e., the electron beam scans the screen in a spiral pattern (Figure 54). The scan of the LN-7 tube is started by a trigger pulse from the radar. The output signals are taken from load resistor Rn connected to the signal plate circuit



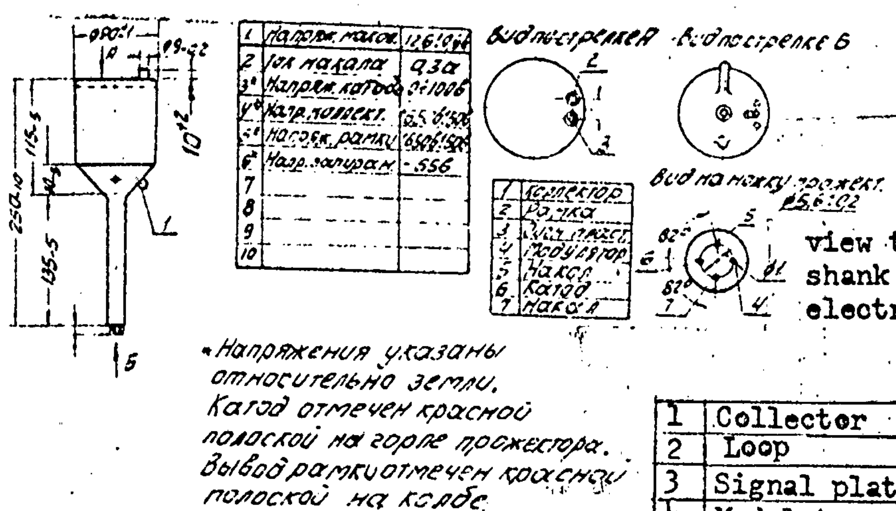
A "sensitivity"
B "beam current"
C DC restorer
D LN-7 tube
E U-OCh sub-assembly
F output 1
G "focus 1"
H "beam current 1"
I "limit 1"
J DC restorer
K LN-7 tube
L U-OCh sub-assembly
M output 2
N "focus 2"
O "beam current 2"
P "limit 2"

Fig. 52. Functional Diagram of Unit IU-1.

1	Filament voltage	12.6 ± 0.6 v
2	Filament current	0.3 a
3*	Cathode voltage	0 - 100 v
4*	Collector voltage	+650 ± 50 v
5*	Loop voltage	+650 ± 50 v
6*	Cut-off voltage	-55 v
7		
8		
9		
10		

View along arrow A

View along arrow B



view toward shank of electron gun

1	Collector
2	Loop
3	Signal plate
4	Modulator
5	Filament
6	Cathode
7	Filament

*Voltage indicated is relative to ground. Cathode is indicated by red stripe on neck of electron gun. Terminal of loop is indicated by red stripe on bulb.

Fig. 53. General View of LN-7 Tube.

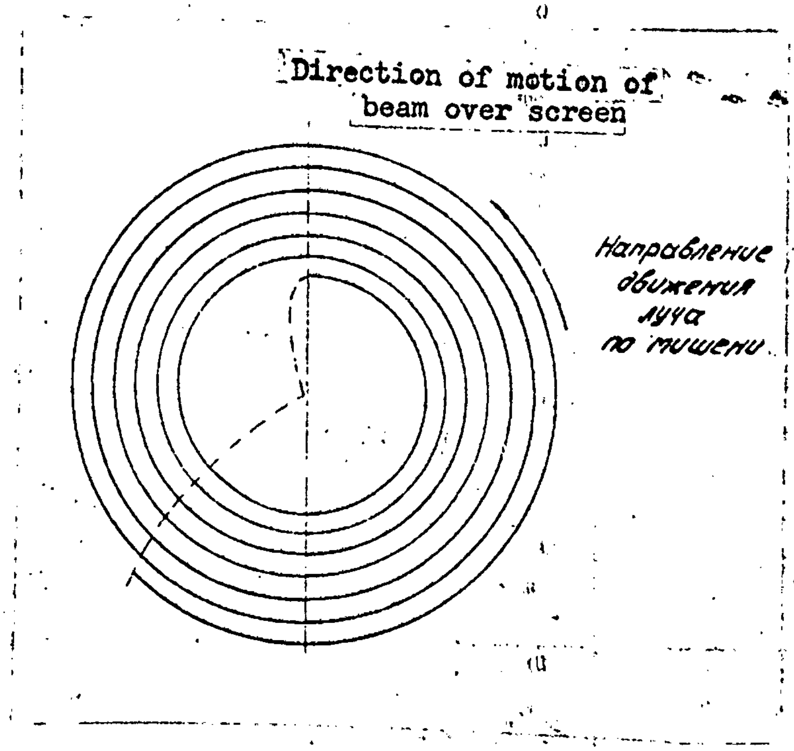


Fig. 54. Spiral Scan.

(Figure 55).

The screen of the tube is separated from the signal plate by a dielectric layer. The surface of the screen consists of a large number of elements insulated from each other and having a coefficient of secondary emission greater than one. The coefficient of secondary emission B_e is equal to:

$$B_e = \frac{Pv}{P_p}, \quad (I)$$

where P_p is the number of primary electrons striking the screen and Pv is the number of secondary electrons emitted from the screen.

If such an insulated surface is subjected to a bombardment of electrons, the number of electrons emitted by it will be greater than the number of electrons striking it. The secondary electrons are directed toward the anode, which acts as a collector electrode (collector). This produces a capacitive current i_k in the collector which flows through load resistor R_n.

The current in the load (i_n) will depend on the difference between the capacitor current (i_k) of the collector and the capacitor primary current (i_p). (p 139)

$$i_n = i_k - i_p, \quad (II)$$

We introduce the concept of an effective coefficient of secondary emission B_d, which is equal to :

$$B_d = \frac{Pk}{P_p} \text{ or } B_d = \frac{i_k}{i_p}, \quad (III),$$

where: P_k is the number of secondary electrons striking the collector;

P_p is the number of primary electrons striking the screen;

i_k is the instantaneous value of the capacitor current of the collector;

i_p is the instantaneous value of the capacitor primary current.

During the bombardment of the surface of the screen by primary electrons (Figure 55), the value of B_d varies with the potential of that area of the screen relative to the potential of the collector and may be greater or less than unity.

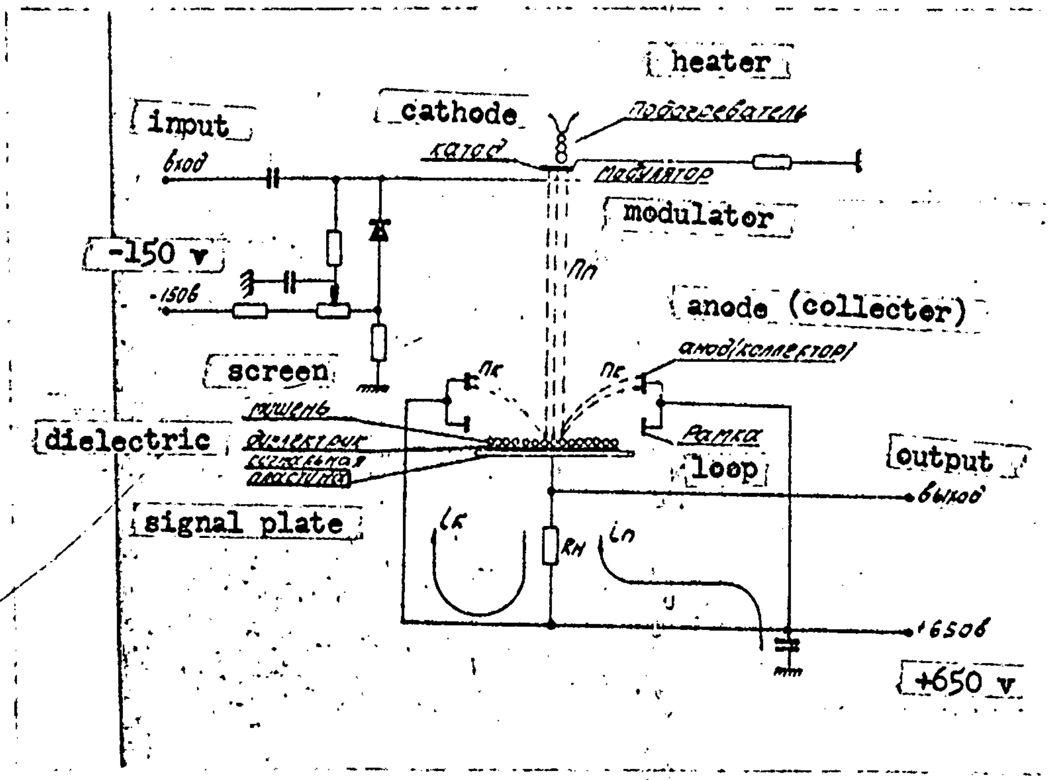


Fig. 55. Principle of Operation of LN-7 Tube.

Relation II can be expressed as:

$$i_n = \frac{i_k}{i_p} i_p - i_p, \text{ but since } \frac{i_k}{i_p} = B_d,$$

it is possible to write $i_n = (B_d - 1)i_p$, (IV)

At the instant the control pulse arrives, the intensity of the beam increases and, due to this, that area of the screen subjected to radiation by primary electrons acquires a positive potential relative to the adjacent area of the screen, since secondary electrons escape from the former area to the collector. At this instant a positive signal ($i_k > i_p$) originates at the load, which is connected to the circuit of the signal plate.

When succeeding pulses arrive at the same place on the screen, the positive potential at that point will increase until the difference in potentials between the collector and screen decreases and an equality of (p 140) currents ($i_p = i_k$) is reached, at which time the number of electrons arriving at the screen will equal the number striking the collector. With a further increase in the positive potential at the point on the screen, i_k will be less than i_p: i.e., the number of electrons arriving at the screen will be greater than the number striking the collector. This condition is called "redistrubition of secondary electrons" and depends on the velocity of the secondary electrons escaping from the metal; in turn, the velocity of the secondary electrons escaping from the metal depends on the angle of ejection, the depth from which they are ejected, and the physical characteristics of the metal itself. The velocities of the escaping electrons are generally on the order of several volts.

Figure 56 depicts the area of the screen bombarded by primary electrons and having a positive potential of 5v relative to the collector. In it are indicated the equipotential lines of a retarding field existing between the screen and collector.

As a result of the retarding field, such electrons having initial ejection velocities not exceeding 5 v return to the screen and strike that part which was subjected to the bombardment as well as the other areas of the screen surrounding it (at a distance roughly equal to the diameter of the electron beam).

The electrons whose velocity exceeds 5 v strike the collector and generate a capacitive current in it. Figure 57 shows the area of the screen bombarded by primary electrons, the distribution of the secondary electrons on this area of the screen, and the variation of potential there and on the surrounding areas. (p 143)

From the foregoing, it should be realized that all parts of the screen take part in the generation of the output signal insofar as the signal plate is the common plate for all the elementary capacitors. Thus in formula IV:

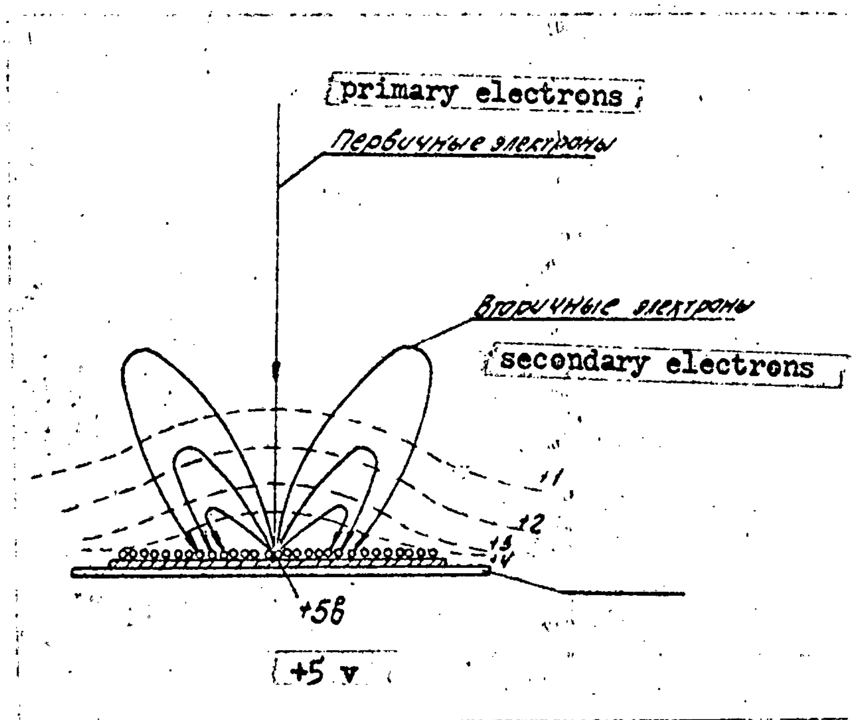


Fig. 56. Redistribution of Secondary Electrons.

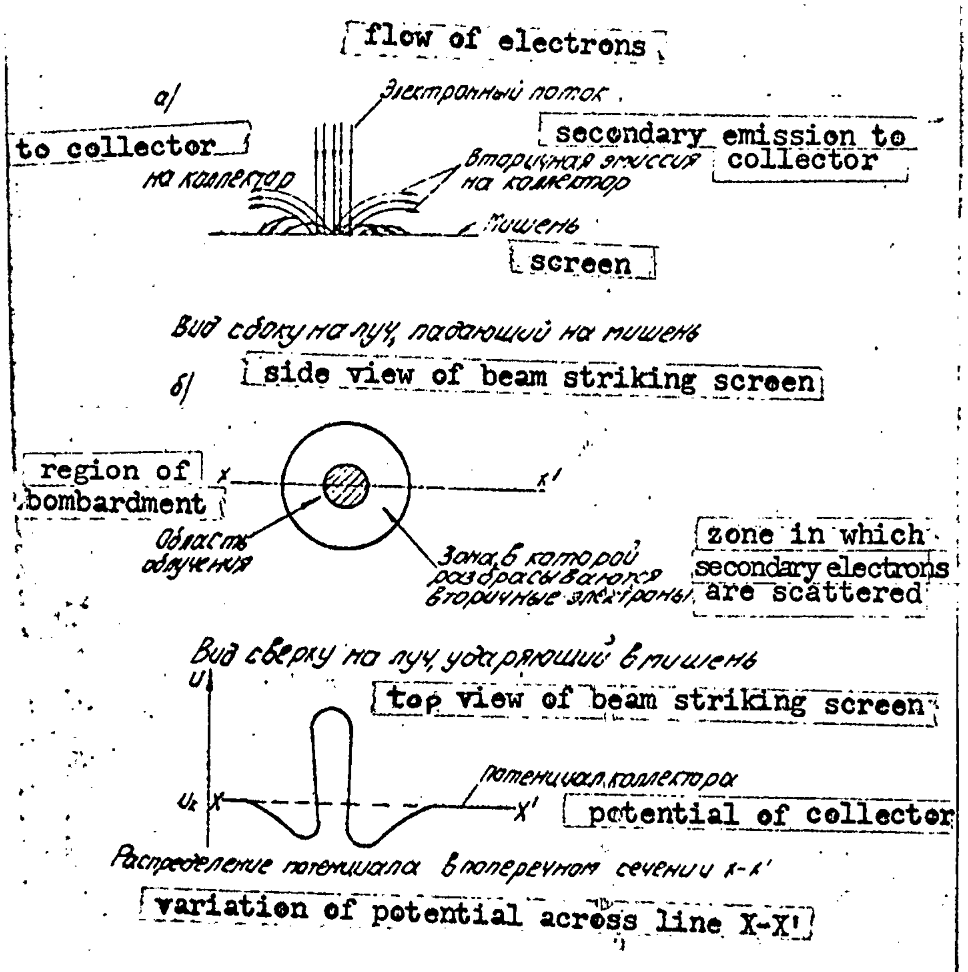


Fig. 57. Distribution of Secondary Electrons on Screen.

$$i_n = (B_d - 1)i_p$$

it is necessary to introduce a correction factor taking into account the effect of the secondary electrons returning to the surrounding areas of the screen on the instantaneous value of the load current.

With this coefficient taken into account, the formula will have the form:

$$i_n = (B_d - 1)i_p - K.$$

The coefficient K attains its maximum value where $B_d < 1$. A graph giving the dependence of the polarity of the output signal on B_d (without taking K into account) is shown in Figure 58.

Let us consider some point A on the screen of a tube. We will suppose that at the instant a beam passes through this point a control signal is sent to the modulator of the tube (Figure 59). The potential of this point increases and a positive signal is generated on the signal plate, since the majority of secondary electrons enter the collector ($B_d > 1$).

In the next scan cycle with the appearance of the control pulse at the instant the beam passes through point A, the potential of this point increases still more; but, at the same time, the output signal decreases, since a smaller quantity of electrons will enter the collector and i_k decreases.

In the next scan cycle with the appearance of the control pulse at (p 146) the instant the beam passes through point A, the potential of this point increases still more; and for a particular value of this potential the majority of secondary electrons returns to the given point and surrounding area of the screen ($B_d < 1$), while only an insignificant number strikes the collector. At the same time, the output signal decreases to zero ($B_d = 1$) and then becomes negative: i.e., the effective coefficient of secondary emission becomes less than unity ($B_d > 1$).

The increase in positive potential of point A (and correspondingly in the negative output signal) continues until a state of equilibrium is reached, at which time the increase in positive potential at point A is compensated (prior to the arrival of the beam) by the secondary electrons striking point A from other points of the screen.

By varying the operating mode of the tube it is possible to vary the rate of increase of positive potential at point A. For example, varying the beam current of the tube makes it possible to vary the number of cycles after which the output signal will change its polarity and become negative.

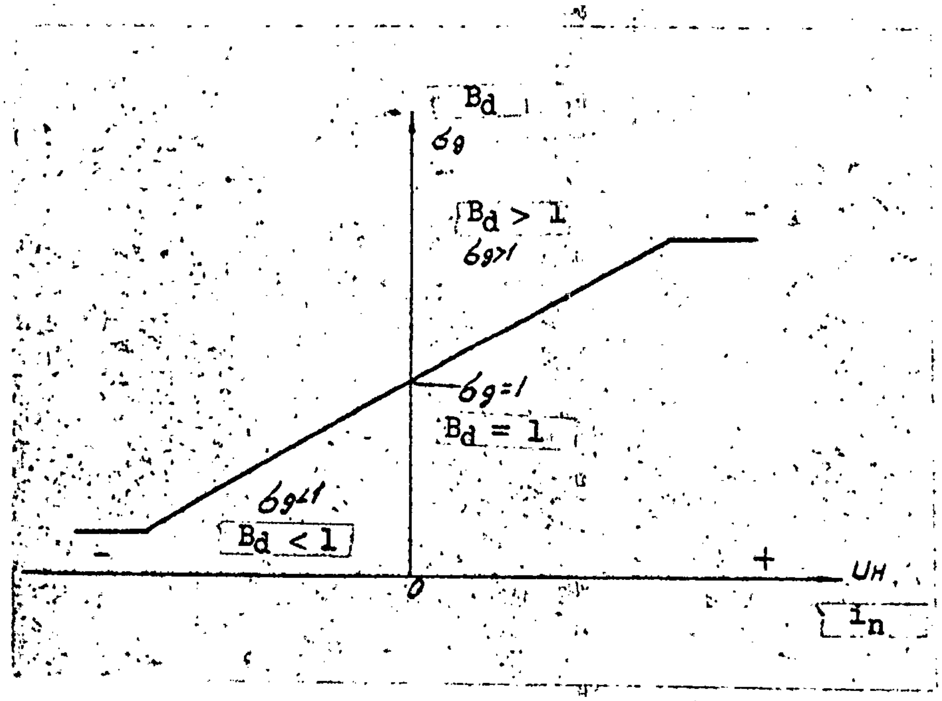


Fig. 58 Graph Showing Relationship of Polarity of Output Signal to B_d.

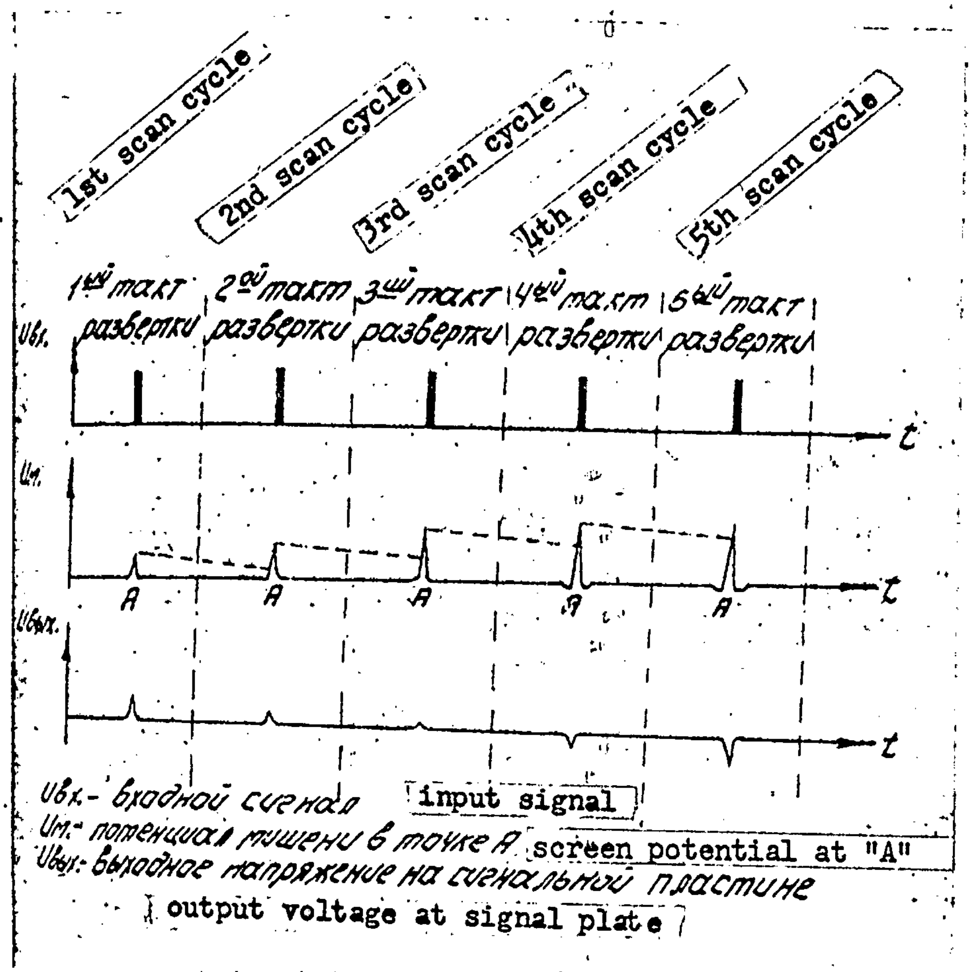


Fig. 59. Variation of Signal Polarity.

In Figure 59 the polarity of the signal changes with the 4th pulse passing through point A on the screen. In the event that the control pulses are stopped at the instant the beam passes through point A, the positive potential at that point will quickly decrease, due to the arrival of primary electrons and also secondary electrons ejected from other (p 147) areas of the screen by the beam.

As is well known, several operating cycles of the radar elepse before a valid return can be obtained from a target. The number of pulses reflected from a target depends on the width of the antenna radiation pattern, the frequency of the main bangs, the antenna rotation rate, target characteristics, and other factors.

For the majority of radars this number can range from 3 or 4 up to 10 to 15.

Returns from a given target will always strike one particular point on the screen and generate negative output signals on the output tube. The probability of noisy pulses and pulses caused by different disturbances striking the screen at the same point in successive scan cycles is small; therefore, in the great majority of cases the output signals of the tube concerned with these pulses will have positive polarity.

When the integrator tube is operating properly, all pulses -- interference, noise, and valid returns -- strike its modulator with the same amplitude and duration. Thus, when signals containing valid returns as well as noisy pulses and pulses caused by other interference are fed to the tube modulator, it is possible to distinguish the valid pulses from the others by their different polarity at the output of the tube. In Figure 60 are shown input signals in three successive scan cycles. In the same figure are also shown a graph of the potential and the output pulses on (p 149) the signal plate during the third scan cycle.

<u>Description of schematic diagram of the unit.</u> A schematic diagram of unit IU-1 is given in Figure 61.

Shaped pulses from unit VU pass through decoupling capacitor C2 (C3) to the modulator of the LN-7 integrator tube. To restore the d-c component after the decoupling capacitor, diode D1 (D2) is connected in parallel to the leak resistor of modulator R7 (R8). The operating mode of the integrator tube is changed by varying the bias voltage at the tube modulator by means of two controls -- "Beam Current 1" (R12) and "Beam Current 2" (R15), located on the front panel of unit IU-1. This voltage is controlled by the IP2 "Beam Current" instrument located on the front panel of unit IU-1.

The emission of the oxide-coated cathode will change in time even with a constant input; consequently, a d-c beam is needed for proper operation of the LN-7 tube. Resistor R9 (R10) is connected to the cathode of the LN-7 tube to stabilize the beam current.

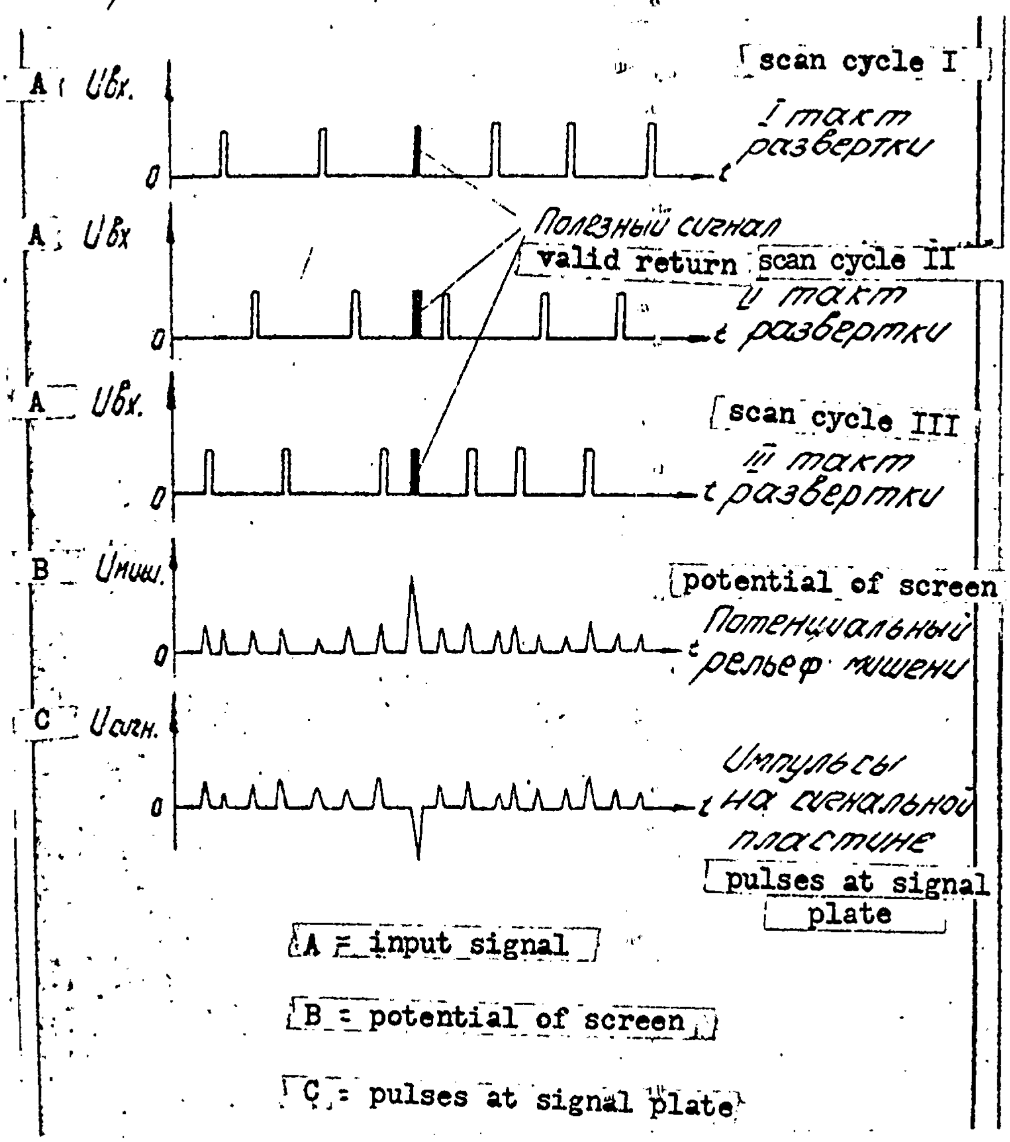


Fig. 60. Input Signals in Three Successive Scan Cycles.

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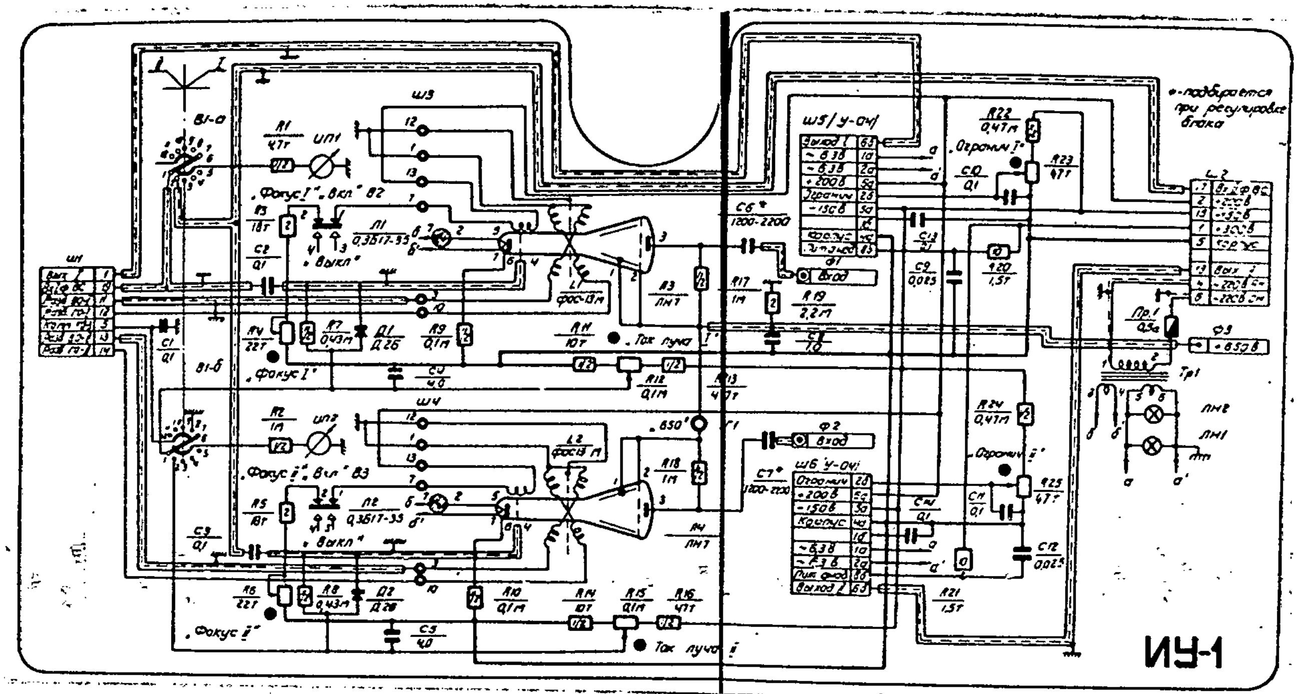

Fig. 61. Schematic Diagram of Unit IU-1.

The signals from load resistor R17 (R18) of the LN-7 tube are fed to subassembly U-OCh through capacitor C6 (C7).

A large value (11.0 megohm) of load resistance R17 (R18) has been chosen to minimize the voltage ripple at the signal plate due to fluctuation of the voltage supplied to the tube (+650 v). Circuit R17 (R18), C6 (C7) of unit IU-1 and R1 of subassembly U-OCh forms a divider which decreases the +650 ripple voltage at the input of the U-OCh amplifier several times. (p 151)

The scan over the screen of the tube is made in a spiral pattern. The sweep voltage is generated in unit GR and applied to unit IU-1 through connector Sh1 and then through internal connectors Sh3 and Sh4 to the FOS-13M deflecting system. The focusing current of the LN-7 tube is changed by means of variable resistor R4, "FOCUS 1" (R6, "FOCUS 2").

Switches V1-a and V1-b are used to connect test instruments IP-1 and IP-2 and also to connect the input of the vertical amplifier of unit KO-3K to the appropriate test circuits of channels 1 or 2.

Construction of the Unit. Unit IU-1 is mounted on a special chassis. On the vertical panel are located two LN-7 tubes with deflecting systems. The tubes are covered by a special housing for protection against external fields. On this same panel is a +650-volt test jack. Behind the unit on the inclined part of the horizontal panel are located potentiometers "FOCUS 1" and "FOCUS 2". The two U-OCh subassemblies are situated in vertical channels enclosed by doors.

The U-OCh subassemblies are removable and interchangeable and are connected to the circuit of unit IU-1 by means of a 16-blade receptacle and high-frequency RK-19 cables.

Underneath the horizontal panel are two wiring plates for the circuit wiring. On the forward panel are two 100-microampere M-592 type test instruments; a two-winding, double-pole switch for switching the instruments by channel; instrument dial lights with special covers; and the potentiometers of the "beam current" and "limiting" controls. (p 152)

A voltage of +650 v is fed to a special high-voltage contact.

The weight of the unit is 8.5 kg.

Subassembly U-OCh

Function. Subassembly U-OCh (Figure 62) is designed to amplify the signals and to separate valid returns from interference.

Technical data on the subassembly. The amplification factor of the U-OCh subassembly with the "Amplification" potentiometer slide in the extreme right position is not less than 1000.

The band-pass of the subassembly allows the passage of a signal with a duration of up to 0.3 microsec. The maximum amplitude of the signal at the output can be as much as 8 v with a load of 75 ohms.

Functional diagram of the subassembly. A functional diagram is shown in Figure 63.

The subassembly consists of the following: amplifier I, diode limiter, amplifier II, amplifier III, and cathode follower.

Signals from the output of the integrator tube of a given channel pass through a high-frequency connector to subassembly U-OCh, which serves to amplify the signals and separate the valid returns from interference. (p 155)

Distortion of the higher frequencies is corrected in the input circuit of the first stage. The amplified returns and noise are fed to the controlled diode limiter, which allows the valid returns to be separated from the noise. The limiting is varied by means of the "Limiting 1" ("Limiting 2") control located on the front panel of subassembly IU-1.

Returns of positive polarity pass from the diode limiter to the second stage of the amplifier.

Signals of negative polarity pass from the output of the second stage to the 3rd amplifying stage and then to the output stage, which is a cathode follower.

The amplifying stage and cathode follower have negative feedback, which serves to widen the band-pass for the entire amplifying equipment, and to obtain the desired amplitude.

The amplitude of the returns is adjusted in the amplifying stage by means of the "Amplification" control located on the chassis of subassembly U-OCh.

Description of the schematic diagram of the subassembly. A schematic diagram of the subassembly is given in Figure 64.

Integrated signals of channels I and II, taken from resistors R17 (R18) of unit IU-1, are applied to the corresponding amplifiers of U-OCh.

The input stage of subassembly U-OCh is based on tube V1, type 6Zh5P. This stage provides correction of frequency distortions introduced by the input circuit, consisting of equivalent load resistance (p 157)

$$R_{equiv.} = \frac{R17 \times R1}{R17 + R1},$$

where R17 is the resistance from unit IU-1 and R1 is the resistance from subassembly U-OCh, and spurious capacitances formed by the output capacitance of the signal plate, the capacitance of the wiring, and the

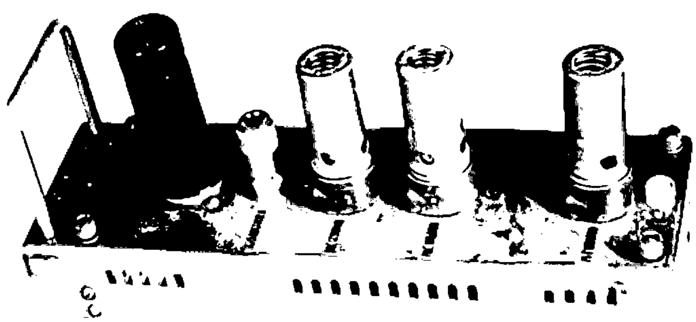

Fig. 62. Subassembly U-OCh.

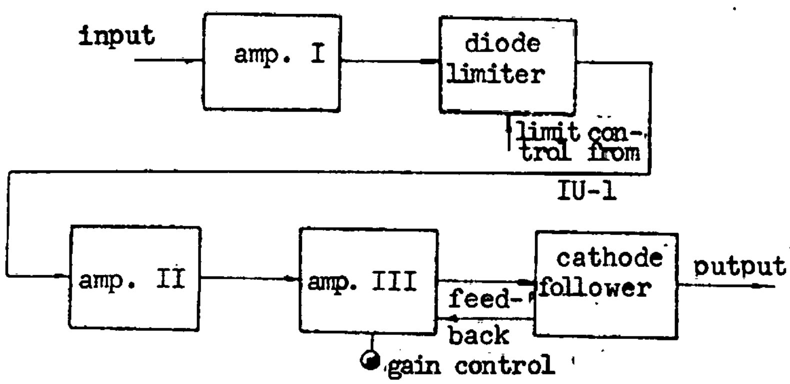

Fig. 63. Functional Diagram of Subassembly U*OCh.

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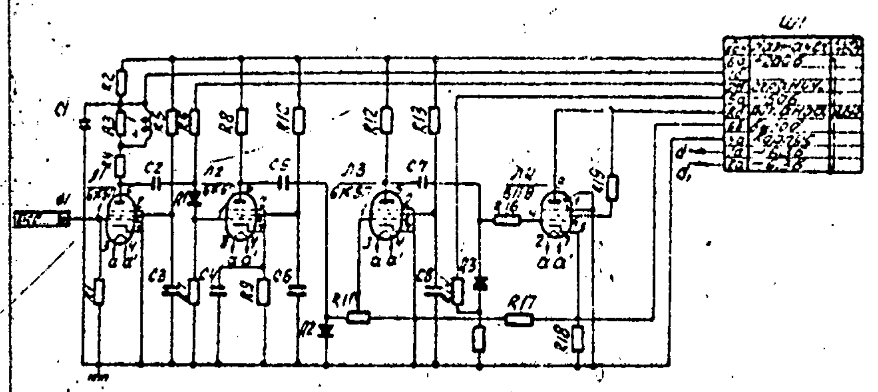

Fig. 64. Schematic Diagram of Subassembly U-OCh.

Correction for these distortions is accomplished with the aid of a network connected to the plate circuit of tube V1 in series with the plate load. Tube V1 operates with zero bias at the first grid.

As was pointed out above, the signals taken from tube LN-7 have two polarities (the useful pulses have a negative polarity and the noise has, as a rule, positive polarity), and a diode limiter is connected to the grid circuit of tube V2 to extract the useful signal. The signals taken from the plate of tube V1 through capacitor C2 to diode D1 are clipped at the bottom.

A germanium crystal diode D1 is used as the diode.

The limit level of signals of channel I (II) is varied by means of the "Limit I" - R24 ("Limit II" - R26) control located on the front panel of unit IU-1. The negative voltage taken from these potentiometers is applied to subassembly U-OCh and through resistor R6 to the diode limiter. (p 158)

When the negative voltage is changed, the limit level changes.

The positive signal taken from the diode load is applied directly to the grid of tube V2 (6Zh5P). Tube V2 operates as an amplifier. An automatic bias circuit is connected to the cathode circuit of tube V2.

The signal passes from the plate of tube V2 through blocking capacitor C5 to the grid of the amplifier stage, which is based on tube V3 (6Zh5P).

A "Gain" control in the control grid circuit of V3 is used to vary the amplitude of the pulses taken from the cathode load of tube V4.

Signals from the plate load of V3 are fed through blocking capacitor C7 to the control grid of the output cathode follower, which uses tube V4 (type 6P9).

A negative bias voltage from a divider consisting of resistors R14 and R15 is applied through the back resistance of diode D3 and resistor R16 to the control grid of tube V4. The cathode resistance of tube V4 is selected at 560 ohms. (p 159)

When a cable with a 75-ohm load is connected, the amplification factor of tube V4 is approximately 0.23.

The output signals from the cathode load of tube V4 are fed to the output of subassembly U-OCh.

The d-c component from the tube current in a load equal to the equivalent resistance of the cable (75 ohms) is zero. Diodes D2 and D3 serve as the d-c restorer after capacitors C5 and C7.

Design of subassembly U-OCh. Subassembly U-OCh is built in the form of a block with dimensions of 242 x 75 x 25 mm, within which are located the mounting elements. The subassembly is attached to the chassis of unit IU-1 with four screws.

Subassembly U-OCh is connected to the circuit of unit IU-1 by a 16-contact plug connector.

Four tubes and the gain control resistance are located on the chassis of the subassembly.

The weight of the unit is 0.5 kg.

13. Spiral Sweep Generator Unit GR

Function. The spiral sweep generator (Figure 65) generates a current which moves the electron beam in the type LN-7 tube along a spiral trajectory on the scope.

Technical data on the unit. The blocking oscillator of unit GR repeats the pulses applied to it at frequencies from 300 to 450 cps.

With a trigger pulse frequency of 375 cps, the pulse-stretching circuit generates pulses whose duration is controlled between 1,700 and 2,400 microseconds. A shock excited oscillator generates sinusoidal oscillations at a frequency of approximately 5 kc. (p 160)

Sinusoidal voltages for the horizontal and vertical sweep are taken from the outputs of the unit.

The "SWEEP AMPLITUDE" control is used to change the amplitude of the oscillations of the shock excited oscillator

$$\frac{U_{max}}{U_{min}} \geq 1.25 \ (\geq 1.94 \text{ db}).$$

The "SWEEP SPACING" control permits setting the ratio of

$$\frac{U_{max}}{U_{min}} = 1.4 \div 1.6,$$

where U_{max} is the amplitude of the first period of the shock excited oscillator circuit and U_{min} is the amplitude of the last period of the circuit (the minimum and maximum limits of the "SWEEP SPACING" control are not specific).

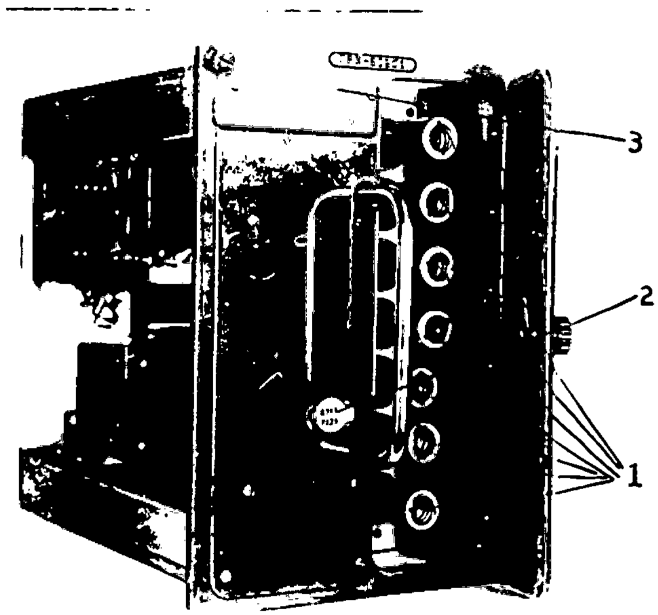

Fig. 65. Over-All View of Unit GR.

1 - tubes in tube channel; 2 - sweep duration control; 3 - plug cover.

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The "PHASE" control together with the "HORIZONTAL GAIN I" ("HORIZONTAL GAIN II") control are used to produce a spiral sweep with an ellipticity not greater than

$$\frac{a}{b} = 1.25, \text{ where}$$

a -- the length of the major axis of the ellipse;

b -- the length of the minor axis of the ellipse.

Functional diagram of the unit. A functional diagram of unit GR is given in Figure 66.

The unit consists of:

a) blocking oscillator;

b) multivibrator (kipp relay);

c) shock excited oscillator with cathode follower for damping compensation; (p 163)

d) vertical deflection amplifier of channel I (II);

e) phase-shifting network;

f) cathode follower;

g) horizontal deflection amplifier of channel I (II).

The first stage of the spiral sweep generator is the blocking oscillator, which is synchronized by the station trigger pulses.

Negative pulses from the blocking oscillator trigger the kipp relay which generates square pulses. The duration of the pulses generated by this relay determines the duration of the spiral sweep and is varied with the "SWEEP DURATION" control. Negative pulses from the output of the relay are applied to the input of the shock excited oscillator.

The voltage at the output of the oscillator is in the form of pulse-modulated sinusoidal oscillations. The amplitude of these oscillations has a maximum at the beginning and is then damped almost linearly. Oscillations at the output of the shock excited oscillator are changed with the "SWEEP AMPLITUDE" control. Voltage from the output of the oscillator is applied to a cathode follower which compensates for damping of the oscillations.

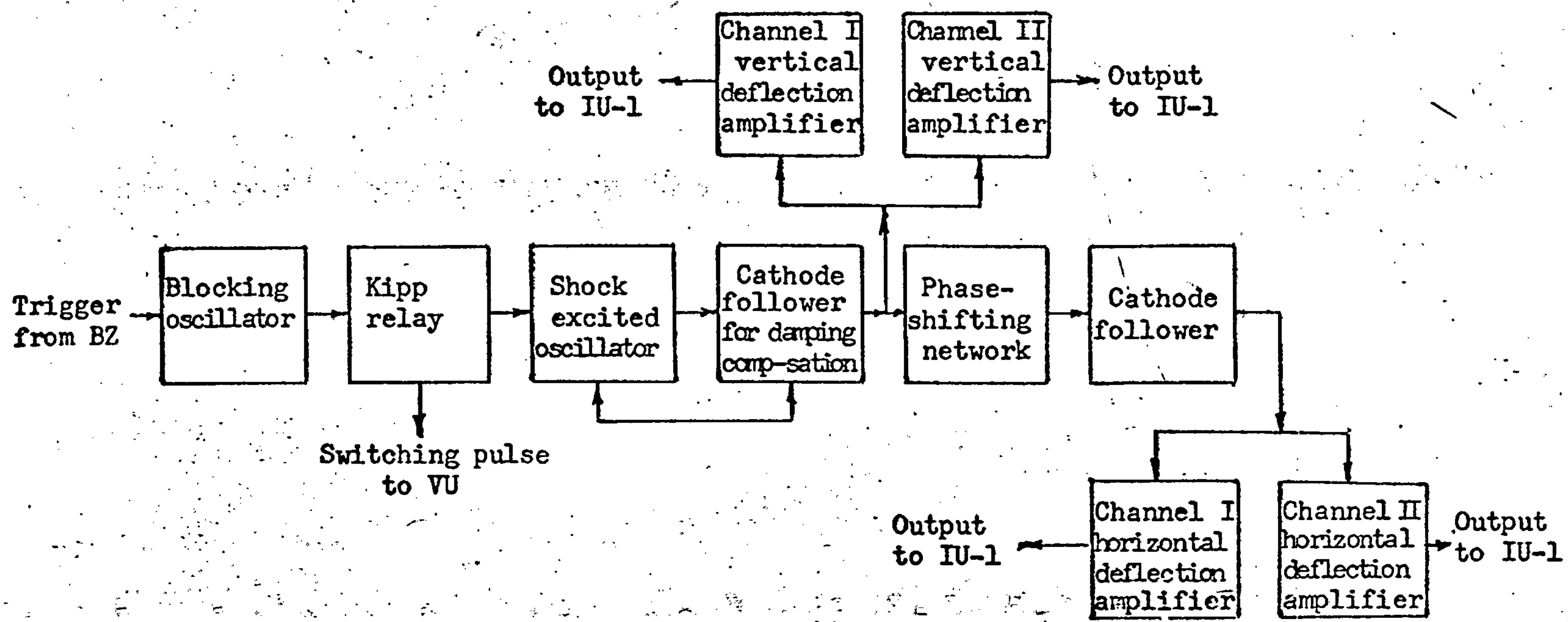

Fig. 66. Functional Diagram of Unit GR.

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The rate of change of the amplitude for a period of one cycle (damping of the oscillations of the shock excited oscillator) may be varied with the "SWEEP SPACING" control. (p 164)

Voltage from the cathode follower is applied to the vertical deflection amplifiers of channels I and II. This same voltage is sent to the phase-shifting network where the voltage is shifted approximately 90°. The value of this phase shift may be varied with the "PHASE" control.

Voltage from the output of the phase-shifting network is sent to the cathode follower and then to the horizontal deflection amplifiers of channels I and II. The amplification factor of these amplifiers may be changed with the "HORIZONTAL SWEEP GAIN I" and "HORIZONTAL SWEEP GAIN II" controls.

The voltages from the outputs of the horizontal and vertical deflection amplifiers of channels I and II are applied to the deflection system of the integrating tube. Currents in the horizontal and vertical deflection coils are shifted by 90° with respect to each other and change according to a law which causes the electron beam of the integrating tube to follow the same spiral trajectory with each scanning cycle.

Description of the schematic diagram of the unit. A schematic diagram of unit GR is given in Figure 67.

The station trigger pulse which enters the input of unit GR is fed through capacitor C4 to the grid of the blocking oscillator (the left half of tube V2 -- 6N1P). When the trigger pulses are applied to unit GR, they synchronize the blocking oscillator and cause it to generate pulses at the repetition rate of the trigger pulses. Negative pulses taken from plate load R9 of the blocking oscillator are sent through capacitor C2 to the plate of the kipp relay (the left half of tube V1, (p 166) type 6N1P) and through capacitor C1 to the grid of the right half of tube V1.

The kipp relay is in a stable condition when the left half of tube V1 is blocked and the right half is unblocked. A negative pulse at the grid of the right half of V1 blocks this half and the circuit moves to the other state, wherein the left half of V1 is unblocked and the right half is blocked.

Capacitor C1 begins to discharge and increases the voltage at the grid of the right half of V1. When the grid potential reaches the firing potential of the tube, the circuit reverts to the original state. The change from one state to the other occurs in an avalanche method.

The duration of the sweep trigger pulse may be changed within limits of 1.7 to 2.4 microseconds by means of variable resistor "SWEEP DURATION." The length of the sweep (with respect to time) is determined by the duration of the kipp relay pulse.

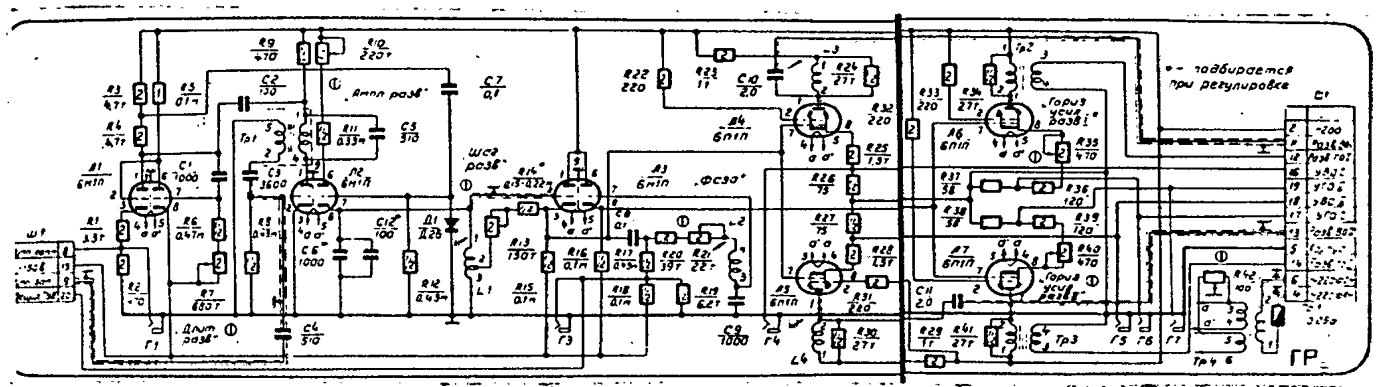

Fig. 67. Schematic Diagram of Unit GR.

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The cathode circuit of the left half of tube V1 contains a divider R1, R2 from which the kipp relay pulses are applied to unit VU for the purpose of blocking return signals at the moment the spiral sweep begins to return.

The plate circuit of the left half of V1 contains a divider R3, R4 from which a negative kipp relay pulse is sent through capacitor C7 to the grid of the shock excited oscillator (right half of tube V2). Restoration of the d-c component by crystal diode D1 (after capacitor C7) provides a constant initial amplitude of the oscillations generated in (p 167) the shock excited oscillator circuit when the trigger pulse repetition rate changes.

The shock excited oscillator, with positive feedback to compensate for damping of oscillations in the circuit, uses the right half of tube V2 (6N1P).

With the arrival of a negative pulse at the grid of the right half of V2 from the kipp relay circuit, the tube is blocked and free oscillations are set up in the cathode circuit of the tube. The initial amplitude of these oscillations is controlled with resistor R10 ("SWEEP AMPLITUDE"). At the moment the negative pulse is removed, the tube is umblocked and shunts the circuit with its output resistance, thus stopping oscillations in the circuit.

In order to control damping, oscillatory circuit L1, C6, C12 is connected to the grid of the left half of tube V3 (6N1P), which operates as a cathode follower on the linear portion of the characteristic.

Oscillations from the cathode of tube V3 (left half) are sent through resistors R14 and R13 and back into the circuit. The positive feedback formed in this manner is used to compensate for losses in the circuit and to produce the necessary pattern of amplitude changes in the oscillatory circuit.

The circuit is tuned to a frequency of 5 kc. The voltage produced by the shock excited oscillator is sent from resistor R19 to unit KO-3. (p 168) A pulse-modulated sinusoidal voltage from cathode load R15 of tube V3 (left half) is applied to the grids of vertical deflection output stages V4 and V5 of channels I and II and to a phase-shifting network consisting of resistors R20, R21, capacitor C9, and inductance L2. The voltage taken from capacitor C9 is shifted in phase by 90° with respect to the input voltage. Correction for this phase shift within small limits is provided by variable resistor R21 marked "PHASE". The phase-shifted pulse-modulated voltage is applied to the grid of the right half of tube V3, which functions as a cathode follower. The pulse-modulated sinusoidal voltage is sent from the cathode of this tube to the control grids of the horizontal deflection output stages V6 and V7 of channels I and II.

The vertical deflection output stage of channel I (II) uses tube V4 (V5), type 6P1P, and operates in a choke-coupled output circuit. The operating mode of tube V4 (V5) is chosen with the aim of providing minimum distordion of the vertical sweep in tube 2. A feedback resistance consisting of resistors R25, R26 (R27, R28) is used in the cathode circuit of tube V4 (V5) to stabilize the gain and decrease nonlinear distortions.

The output voltage taken from plate load L3, R23 (L4, R29) of tube V4 (V5) is applied through capacitor C10 (C11) to the vertical deflection coils. The shape of the current in the deflection coils is the same as that of the sinusoidal oscillations at the grid of tube V4 (V5). (p 169)

The horizontal deflection output stage of channel I (II) uses tube V6 (V7), type 6P1P, and operates with a transformer-coupled output. The operating mode of tube V6 (V7) is chosen so as to reduce distortion of the horizontal sweep to a minimum. Variable resistor "HORIZONTAL GAIN II" ("HORIZONTAL GAIN II") in the cathode circuit of tube V6 (V7) is used to control the horizontal deflection gain.

The operation of tube V4 and V5 (V6 and V7) is monitored in unit KO-3. This is done by sending signals from resistors R26, R37 (R27, R38), located in the cathode circuits of the tubes, through a plug connector to unit KO-3. The resistance of the deflection coils is matched with the resistance of the plate load of tube V6 (V7) by means of transformer Tr2 (Tr3), whose ratio equals:

$$P = \frac{W_1}{W_2} = \frac{3350}{100} = 33.5 ,$$

where W_1 is the number of turns of the primary winding and W_2 is the number of turns of the secondary winding.

The sinusoidal voltage taken from the secondary winding of the transformer is applied to the horizontal deflection coils. The shape of the currents in the deflection coils repeats the shape of the sinusoidal oscillations at the grid of tube V6 (V7).

Since the currents in the deflection coils have the shape of pulse-modulated sinusoidal oscillations with a decaying envelope and are shifted 90° in phase with respect to each other, the electron beam in the tube will (p 170) trace a spiral line.

Monitoring the operation of the unit. The following test jacks are used when monitoring the operation of unit GR with a portable oscillograph:

G1 -- for monitoring the switching pulse;

G3 -- for monitoring the shock excited oscillator;

G4, G5 -- for monitoring the vertical deflection gain of channel I (II);

G6, G7 -- for monitoring the horizontal deflection gain of channel I (II).

Design of the unit. Unit GR is built in the form of a self-contained instrument mounted on a standard chassis. The tube channel contains 7 bantam tubes (three 6N1P; four 6P1P) and 6 test jacks.

The shafts of 6 potentiometers, 5 of which are covered by a face plate, extend through the front panel of the unit. The exposed shaft is the "SWEEP DURATION" control. On the chassis of the unit are three transformers -- one filament transformer and two transformers for the horizontal deflection amplifiers, as well as one pulse excitation circuit with a carbonyl core, three inductance coils with carbonyl cores, a blocking transformer, and two 2-microfarad capacitors.

Small components (resistors and capacitors) are located on a mounting plate within the unit. The unit has one plug connector. Weight of the unit is 7.5 kg.

14. Test Unit KO-3

Function of the unit. Unit KO-3 (Figure 68) is used to check the operation of the following units: BZ, OA-1-1, OA-5-1, GR, IU-1, and VU. (p 172)

The checks are made with a type 7LO-55 cathode-ray tube. In addition, a stabilized voltage of +650 v is generated in the unit for the purpose of supplying the LN-7 tubes in unit IU-1.

Functional diagram of the unit. Figure 69 gives a functional diagram of unit KO-3.

The unit consists of the following components:

-- sawtooth voltage generator;

-- horizontal deflection amplifier;

-- vertical deflection amplifier;

-- cathode-ray tube with a power supply circuit;

-- switches.

The sawtooth voltage generator generates a voltage which changes linearly with respect to time; the voltage is applied to the input of the horizontal deflection amplifier.

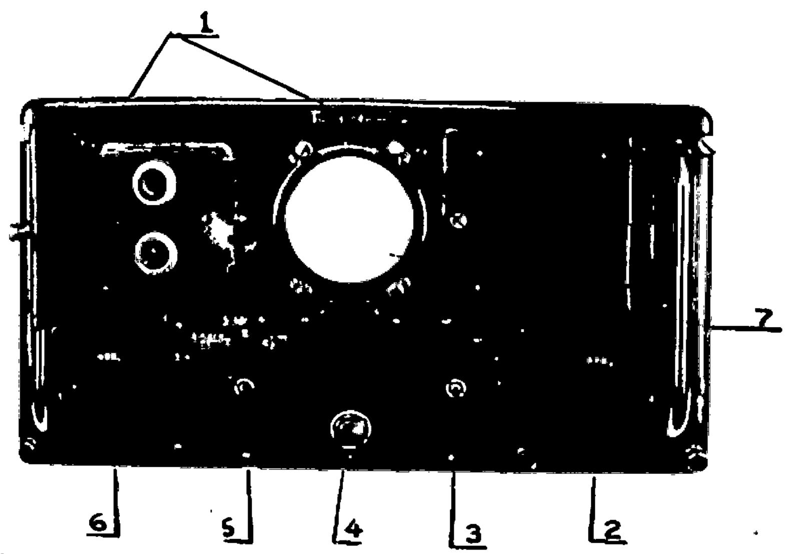

Fig. 68. Unit KO-3.

1 - covers for tube channels; 2 - brightness control; 3 - test switch for units IU-1, VU, and GR; 4 - test switch for units BZ, OA or IU-1, VU, and GR; 5 - test switch for units BZ and OA; 6 - focus control; 7 - screen of test oscilloscope.

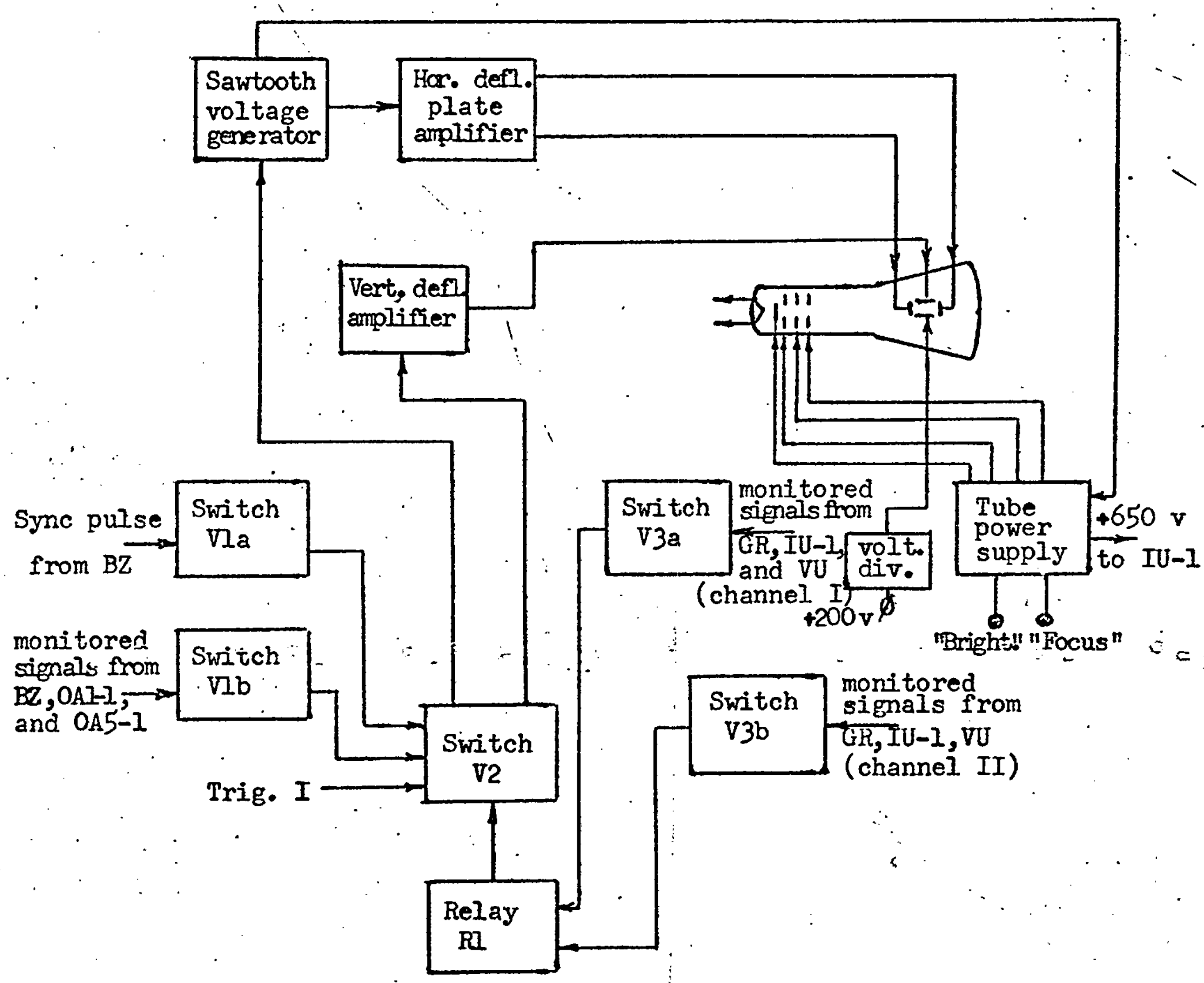

Fig. 69. Functional Diagram of Unit KO-3.

Two voltages, equal in value and opposite in sign, are taken from the output of the amplifier and applied to the horizontal deflection plates of the cathode-ray tube. These voltages create a sweep trace on the screen of the tube.

The test voltages are taken from different points of the circuits in units BZ, OA-1-1, OA-5-1, GR, VU, and IU-1 and are sent through switches V1, V2, and V3 to the input of the vertical deflection amplifier. Voltages from the output of this amplifier are applied to the vertical deflection plates of the tube. The power supply circuit generates voltages of -400 v and +650 v for the cathode-ray tube. The +650 v voltage is stabilized and is also used in unit IU-1. (p 174)

Description of the schematic diagram of the unit. A schematic diagram of unit KO-3 is given in Figure 70.

Tube V1, a self-excited multivibrator with cathode coupling, is used as the sawtooth voltage generator. Let us examine the operation of this circuit with switch V2 in the position "BZ, OA."

At some moment of time let tube V1b be blocked and V1a be unblocked. A large current will flow through V1a and create a voltage in the cathode resistance (R5, R6) which blocks V1b.

At this time, one of the capacitors C17, C18, C19, C20, C21, C22, or C23 will charge, depending on the position of switch V1.

When the voltage in the capacitor reaches the firing potential of tube V1b, the latter will be unblocked. Voltage at the plate of V1b will drop and this will be transmitted through resistor R1 and capacitor C1 to the grid of tube V1a and block it. Then, one of the capacitors C17, C18, C19, C20, C21, C22, or C23 will discharge through the grid circuit of tube V1b.

Since the capacitor charges through the resistance, the discharge process occurs much more rapidly than the charging process. After the capacitor discharges, tube V1b is blocked and V1a is unblocked. The capacitor again begins to charge and the entire process is repeated. Turning the knob on the switch changes the capacitance of the charging capacitor, and this changes the speed of the sweep. (p 176)

Six sweep speeds are provided for in the unit. In the case of the first five sweeps (capacitors C19, C20, C21, C22, and C23), the oscillator is synchronized by external pulses. The synchronizing pulse is applied through the charging capacitance to the grid of the oscillator. The sixth sweep is not synchronized.

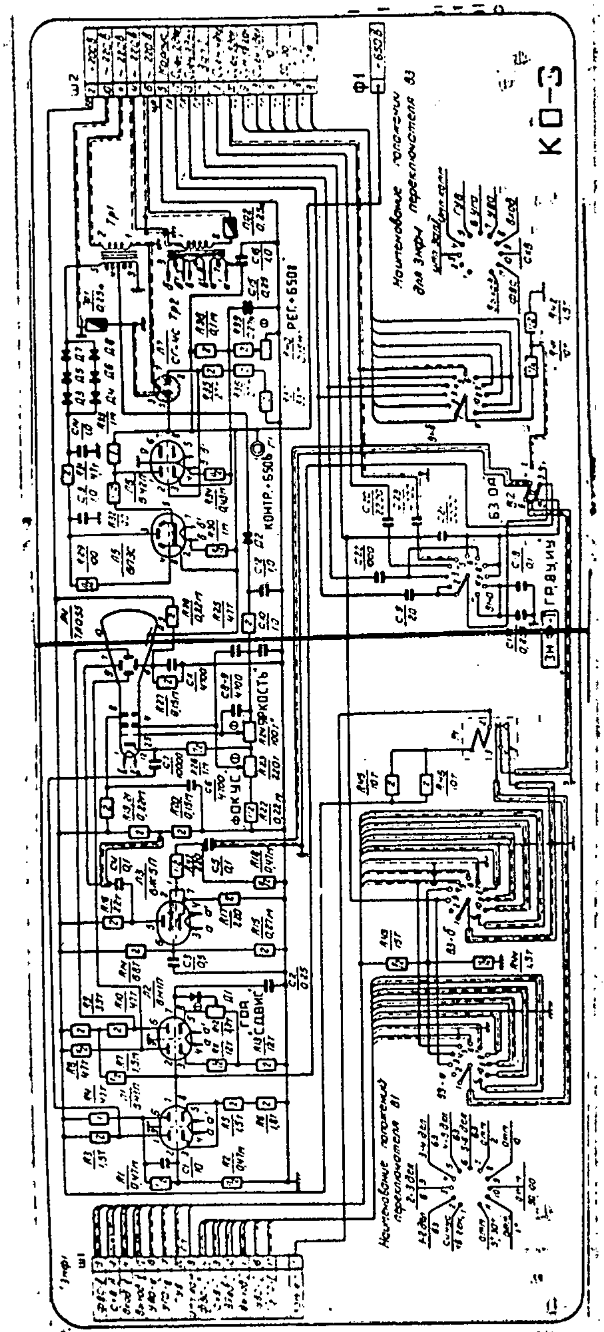

Fig. 70. Schematic Diagram of Unit KO-3.

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The sawtooth voltage is taken from charging capacitors C17, C18, C19, C20, C21, C22, or C23 depending on the position of switch V1 and is applied to the grid of the amplifier for the horizontal deflection plates (tube V2). The sawtooth voltage is linearized through the use of feedback -- the charging capacitor is connected to the plate circuit of the right half of the amplifier tube. The output voltage of the amplifier is sent directly to the horizontal deflection plates of the tube. When the switch is in the position "GR, VU, IU," the circuit generates one sweep trace (capacitor C21) which is synchronized by the trigger pulse (Zap, I).

The monitored voltages from units BZ, OA-1-1, and OA-5-1 are sent to the amplifier input for the vertical deflection plates (tube V3, type 6Zh5P) through switch V1, voltage dividers R41, R42, and switch V2 ("BZ, OA" monitor).

The sinusoidal voltage to the quartz oscillator in unit BZ is checked when switch V1 is in the first position. In this case the sinusoidal voltage of the quartz oscillator is applied to the grid of the vertical deflection plate amplifier. The sweep trace is synchronized by pulses of the second divider stage (1:5); therefore, five periods of the sinusoidal voltage from the quartz oscillator are layed on the sweep trace. (p 177)

Operation of the divider stages of unit BZ is monitored with the switch in the second, third, fourth, fifth, and sixth positions.

In this case, pulses from each stage are applied to the grid of the vertical amplifier and synchronization is provided by a pulse from the subsequent divider stage.

The 2-km and 1-degree marker dial is checked with the switch in the seventh position.

The 10-km marker dial is checked with the switch in the eighth position.

The 50-km and 100-km marker dial is checked with the switch in the ninth position.

The azimuth marker unit is checked with an unsynchronized sweep, which corresponds to the tenth and eleventh positions of the switch. The frequency of this sweep is selected close to that of the output pulses of units OA-1-1 and OA-5-1. One-degree marker pulses are sent simultaneously with the 2-km marker pulses. The 1-degree markers move across the screen of the oscillograph. The 5-degree markers also move across the screen, while at the moment of appearance of the 30-degree markers, the amplitude of the pulses on the screen increases.

When the voltages of units GR, VU, and IU-1 are monitored, the voltages are applied to the input of the vertical deflection amplifier through switches V3 and V2 ("GR, VU, IU" monitor).

Relay R1, which is controlled by the "MONITOR" channel switch located in unit IU-1, is used to select the channel to be tested (channel I or II). (p 178)

The trigger pulse from unit BZ is checked with switch V3 in the third position.

The switching pulse from unit GR is checked with the switch in the fourth position.

The fifth, sixth, and seventh positions are used to check the sinusoidal voltage from the shock excited oscillator and the voltage after the horizontal and vertical deflection amplifiers of channel I or II from unit GR.

The eighth position is used to check the voltages after the subtraction circuits of unit VU.

The voltage after the blocking oscillator of unit VU is checked with the switch in the ninth position.

Output voltages of unit IU-1 are checked with the switch in the eleventh position.

Examples of voltage forms seen on the screen of the tube relative to the position of the switches are given on photographically copied labels in the tube channels.

<u>Rectifier circuit of unit KO-3</u>. The rectifier circuit includes the following basic elements: filament transformer, plate transformer, rectifier, filter, and voltage stabilizer. The filament voltage for all tubes is taken from the filament transformer.

Transformer Tr1 with 3 windings is used as the plate transformer. A supply voltage of 220 volts, 50 cps is applied to the primary winding (p 179) of the transformer (taps 1-2). The two secondary windings are connected in series. The voltage from taps 3-5 is used to supply the +650 v rectifier. An a-c voltage from taps 4-3 is applied to the -400 v rectifier. The plate transformer is hermetically sealed.

The +650 v rectifier is based on a half-wave circuit with six selenium rectifiers. The rectified voltage is filtered by a Π-section filter consisting of capacitors C13, C14 and resistor R31. The rectified voltage is applied to the electronic voltage stabilizer.

Tube V5 (6P3S) is used as the regulator stage of the stabilizer.

The control system of the stabilizer is a single-stage d-c amplifier which uses one triode of tube V6 (6N2P).

The reference voltage source of the control stage is an SG4S (V7) stabilovolt (voltage stabilizer tube).

Resistors R38, R39, R40 are used as a divider for the reference voltage. Potentiometer R40 is used to adjust the +650-v voltage within limits of ±30 v.

The +650 v stabilized voltage is taken from the cathode of the regulator stage of tube 6P3S (V5) and applied to the plate of the cathode-ray tube in unit KO-3 and through a special high-voltage plug to unit IU-1.

The -400 v rectifier is also based on a half-wave circuit. The a-c voltage from the secondary winding of Tr1 (taps 3-4) is applied to selenium rectifier D2. (p 180)

The rectified voltage is fed to a Π-section filter consisting of capacitors C10, C12 and resistor R25.

The -400 v rectified voltage is taken from capacitor C10 and fed to the cathode of the cathode-ray tube in unit KO-3. Thus, the voltage between the cathode and plate in the cathode-ray tube will be on the order of 1,050 volts.

<u>Design of unit KO-3</u>. Unit KO-3 is located in the central compartment of the cabinet. The unit is mounted on an angle-iron chassis. Tubes are arranged in a tube channel. On the front panel are doors which cover the tube channels and the type 7LO-55 tube screen. Also on the front panel are two switches, one toggle switch, the shafts of two potentiometers, and handles for removing the unit.

Small components are wired on a mounting plate within the unit.

The transformer and other elements of unit KO-3 are attached to the chassis.

Unit KO-3 weighs 8.5 kg.

CHAPTER THREE (p 181)

PLAN POSITION INDICATOR IKO-1

1. General Information Concerning Operation of the Indicator

The plan position indicator IKO-1 (Figure 71) is designed for the observation of all detected targets and for determination of their range and azimuth. In addition, the IKO-1 can be used to solve problems involving the directing of ones fighter aircraft to the planes of the enemy. The IKO-1 ensures the continuous observation of detected targets within the limit of the station's range. The plan position of the detected air targets is displayed on its screen automatically, in a form convenient for visual observation. The plan position indicator is an oscilloscopic device having a PPI scan and an intensity spot signal. Its basic unit is a cathode-ray tube: the plan position of the detected targets is displayed on the tube screen. The sweep along the radius of the tube screen is proportional to the range scale. It is started by a pulse which starts the transmitting device as well; therefore the position of each spot in the sweep line on the screen correspondends to a definite range. Sweep is effected by the current fed to the deflecting system of the cathode-ray tube. The scan along the circumference (the rotation of the radial sweep) is proportional to the azimuth scale.

The sweep is brought into rotation by the synchronous transmission system of the antenna's turn angle; therefore, the position of the radial sweep on the screen correspondends to the direction of the antenna's electrical axis.

The voltages of the reflected signals and range and azimuth markers act on the control electrode of the cathode-ray tube. In the absence of these signals the electron beam is cut off by the positive voltage at the tube cathode so that there is no image on the screen. With the arrival of each signal the potential of the control cathode rises slightly, causing the appearance of an electron beam in the form of a shining spot on the tube screen. The position of the shining spot depends on the instantanious values of the deflecting field induced by the range-marker and azimuth-marker systems. (p 183)

The reflected signals create a display on the screen in the form of dots: range-scale markers--in the form of a series of concentric rings, corresponding to the fixed ranges; and azimuth-scale markers--in the form of radially diverging lines, corresponding to the fixed angles of rotation of the antenna.

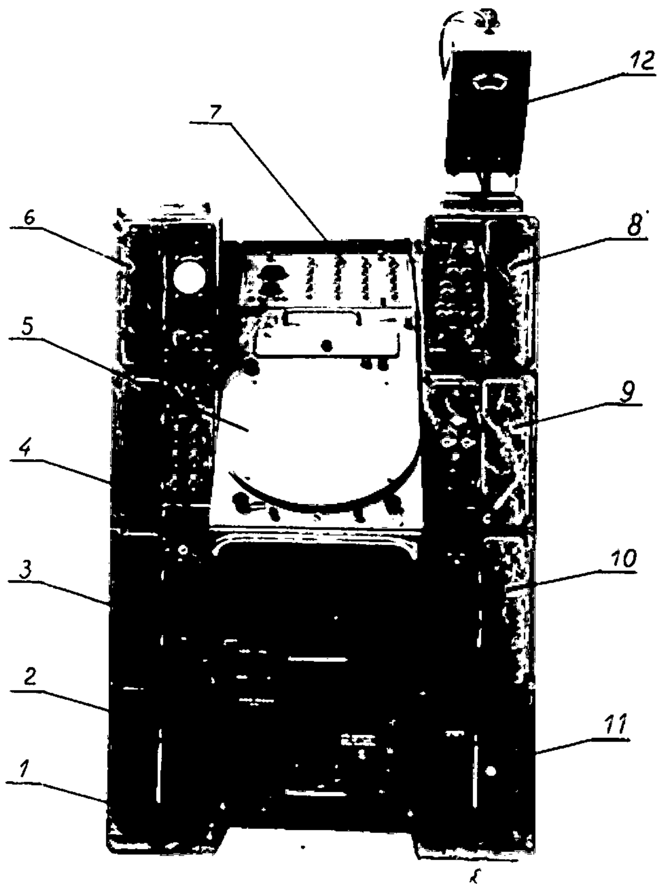

Fig. 71. Cabinet IKO-1.

1 - unit BP-300; 2 - unit UPT-1; 3 - unit BP-200; 4 - unit RD; 5 - unit TI-1; 6 - unit ZR-3; 7 - panel with plugs; 8 - unit VS-3; 9 - unit US; 10 - unit BP-7; 11 - unit BP-150; 12 - unit UN-I.

The IKO-1 is intended for three modes of operations (Figure 72).

1. The circular PPI mode, in which the start of the sweep (a point on the screen which corresponds to the position of the radar on the site) coincides with the center of the screen (Figure 72a).

2. The delayed PPI mode, in which the sweeping of space can be limited to a definite part of the range and the start of the sweep can be delayed up to 350 km. In the delayed PPI mode of operation the targets located in remote parts of the station's zone of action are observed on a magnified scale (Figure 72b).

3. The sector PPI mode (Figure 72c), in which the start of the sweep (p 185) may be shifted to any point of the screen and even beyond its outer edge. The display on the screen in this case will give a more detailed plan position of the targets in the selected sector of radar operation.

Technical data and make-up of the indicator cabinet.

1. Indication of the target is brought about by observing the intensity spot signal on the screen of the cathode-ray tube.

2. Scanning is radial-circular.

3. The range scales: 100, 200 and 370 km.

4. The periods of full (360°) scan along the azimuth are equal to ten seconds (six rpm) and twenty seconds (three rpm).

5. The delay of the start of the range sweep in PPI operation can be varied within 40 to 350 km limits.

6. The coordinates of the target are determined visually by observing the position of the reflected signal relative to the grid of electrical azimuth and range scale markers.

7. Either simultaneous or separate observation of the following are possible on the tube screen: range scale markers (10, 50, and 100 km); azimuth markers (5-degree and 30-degree); two km and 1-degree scale markers; reflected signals coming from both the vertical and slant channels.

Make-up of the IKO-1 cabinet. The PPI is mounted in a standard cabinet and consists of the following units:

-- scope unit TI-1; (p 186)

-- sweep delay unit ZR-3;

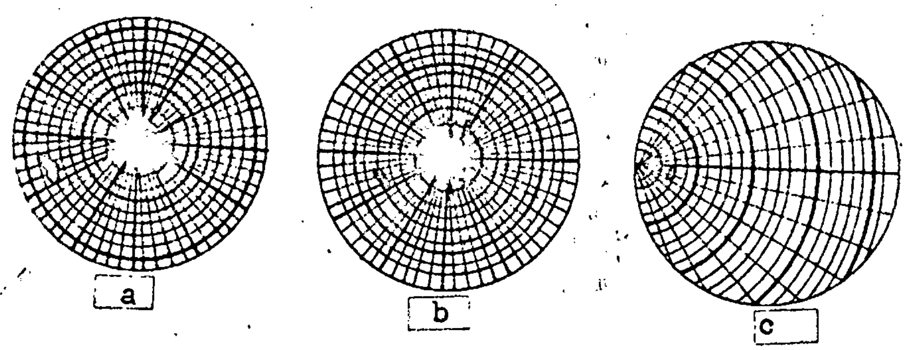

Fig. 72. Displays on the Screen of the Plan Position Indicator in Three Modes of Operation.

a - circular PPI mode; b - delayed PPI mode (20 km delay); c - sector PPI mode.

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-- video signal unit VS-3;

-- servo amplifier US;

-- +300 v power supply unit BP-300;

-- +200 v power supply unit BP-200;

-- -150 v power supply unit BP-150;

-- +7.1 kv power supply unit BP-7;

-- power supply control unit UPT-1.

Circuit diagram and principle of operation of the indicator. A circuit diagram of cabinet IKO-1 is given in Figure 73.

Trigger pulses (ZAP II) from trigger unit BZ of master voltage cabinet ZN-F1 enter sweep delay unit ZR-3 from where the delayed trigger pulse is fed to range sweep unit RD. A sawtooth pulse is formed in RD and supplies the deflection coils in scope unit TI-1. In addition, a negative sawtooth "range gate" pulse is taken from the first stage of unit TD and applied to unit VS-3 where it serves as a trigger pulse for the latter.

The following are applied to unit VS-3 in addition to the gate pulse:

1. Vertical and slant channel video signals from the mixing device.

2. Range scale markers for 2, 10, and 50-100 km.

3. Azimuth scale markers for 1-degree (in combination with 2-km), 5-degrees, and 30 degrees.

All input signals in unit VS-3 are amplified, mixed, and applied to the modulator of the cathode-ray tube in unit TI-1

In the indicator tube unit are stages which supply the center alignment coils and the focusing coils. Here is also mounted the servomotor which works jointly with the servo amplifier (US) and rotates the deflection coils synchronously with the rotation of the antenna. (p 188)

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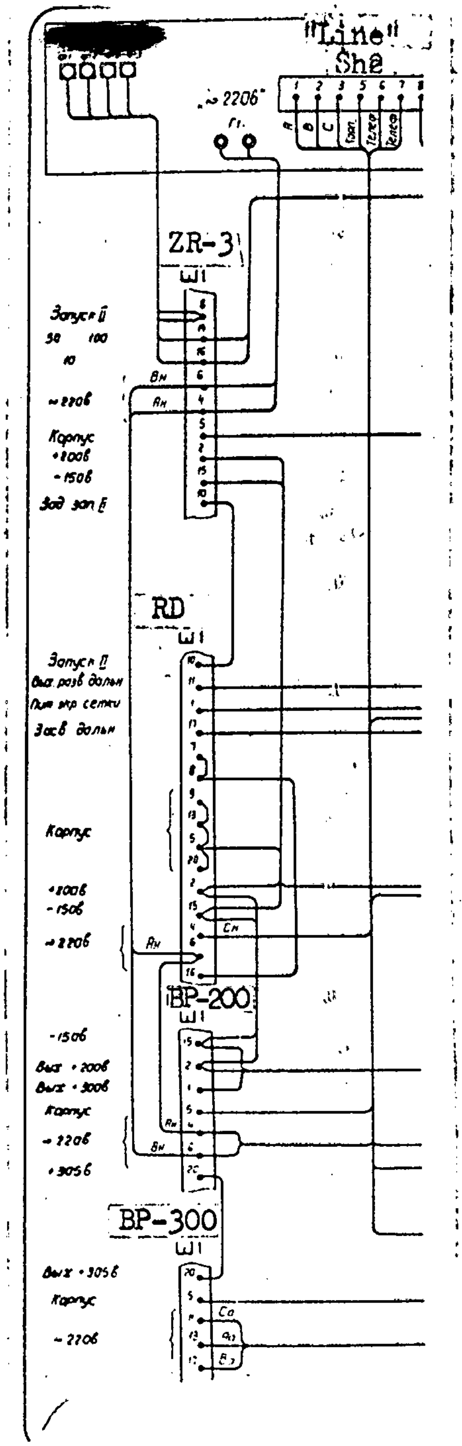

Fig. 73. Diagram of Wiring Connections for Cabinet IKO-1.

All units in the PPI receive voltage from units BP-300, BP-200, BP-150 and BP-7.

The central units are TI-1 and UPT-1. In the left compartments (from top to bottom) are units ZR-3, RD, BP-200 and BP-300; in the right--units VS-3, US, BP-7 and BP-150.

Remote plan position indicator IKO-V1. The remote plan position indicator IKO-V1 is intended for operation at the command guidance post in the radio-relay line system RL-30-1. (p. 189)

In principle, the remote indicator does not differ from the main indicator and fulfills the very same functions.

The IKO-V1 cabinet is furnished with the same units as IKO-1 except for the delay unit. Unit ZR-2 is used in cabinet IKO-V1 in place of unit ZR-3.

A plotter has been added to the remote indicator IKO-V1 to facilitate the recording of the flight altitude of the target.

From the viewpoint of construction, IKO-V1 differs from the main PPI by having additional clamps used in transporting the indicator in a container.

2. The Indicator Scope Unit TI-1.

Function. The TI-1 unit (Figures 74 and 75) is intended for the observation of all detected targets and for the determination of their range and azimuth.

Technical data concerning the unit. 1. Rotation of the sweep line is synchronized with the rotation of the antenna. 2. Displacement of the start of the range sweep is up to two radii. 3. The diameter of the focused spot at the screen center is about 1 mm; in shifting the start of the range sweep by two radii--about 2 mm.

Functional diagram of the unit. Figure 76 gives a functional diagram of unit TI-1. The unit includes:

-- the cathode-ray tube;

-- the deflector system;

-- sweep center shifting stage;

-- the focusing stage;

-- the intensity control circuit;

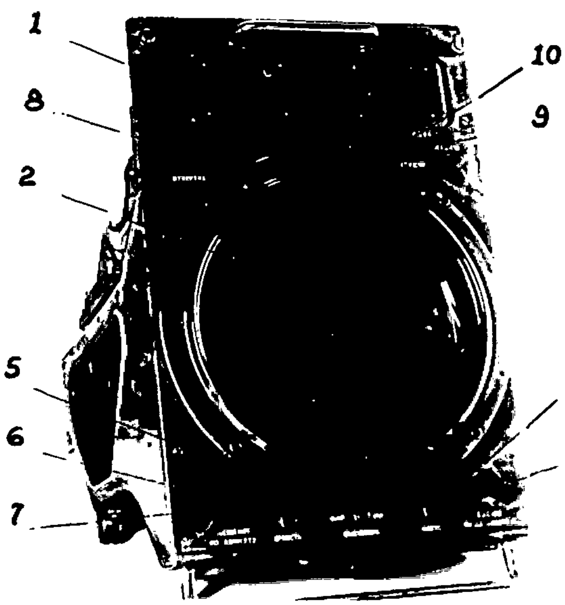

Fig. 74. Unit TI-1 (Right Side).

1 - door of tube compartment; 2 - screen of tube 31LM32; 3 - range shift control; 4 - focus control; 5 - sweep center shift control; 6 - intensity control; 7 - azimuth shift control; 8 - screwdriver; 9 - fuse; 10 - fuse condition indicator.

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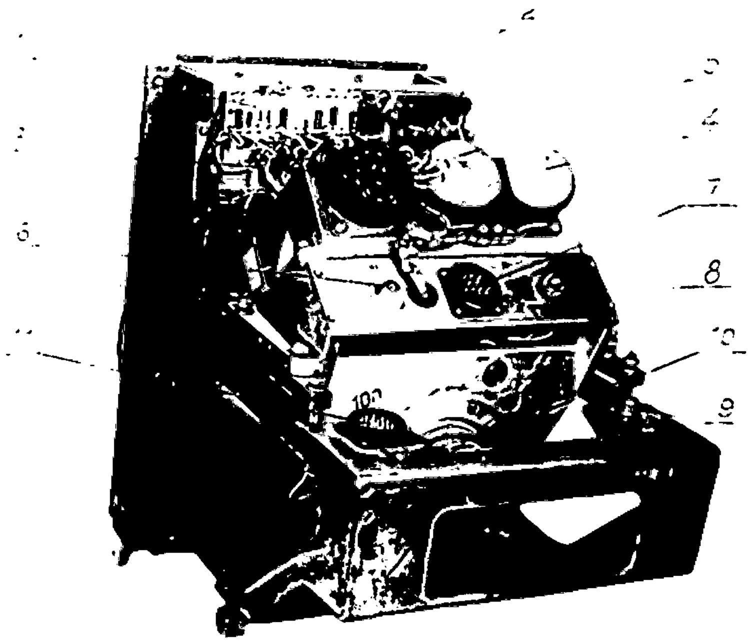

Fig. 75. Unit TI-1 (Rear View).

1 - plate for mounting small parts; 2 - transformer; 3 - motor ADP-262; 4 - fine selsyn; 5 - coarse selsyn; 6 - sweep voltage supply plug; 7 - SSP voltage supply plug; 8 - signal lamp; 9 - plug for applying signals to tube modulator; 10 - focusing coil; 11 - supply voltage plug.

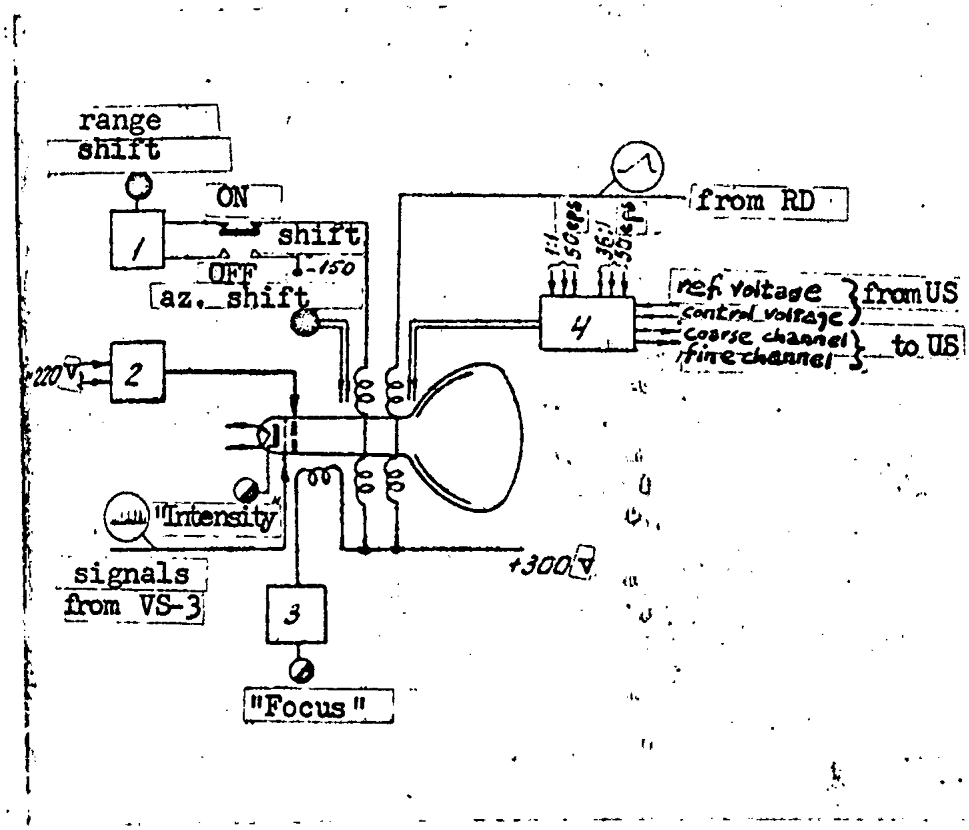

Fig. 76. Functional Diagram of Unit TI-1.

1 - center shifting stage; 2 - +500 volt transformer and rectifier; 3 - focusing stage; 4 - BSM.

-- the servomotor unit;

-- + 500 v transformer and rectifier.

In the unit are four controls: "Intensity", "Focus", "Range Shift", "Azimuth Shift", and the toggle switch "Shift" which turns on the shift of the sweep center. (p 193)

Description of the schematic diagram of the unit. Figure 77 gives a schematic diagram of unit TI-1.

The fundamental element of unit TI-1 is the cathode-ray tube V4, type 31LM32, on the screen of which targets are observed and their coordinates determined.

The indicator tube operates in conjunction with the magnetic deflection system, consisting of the deflecting, shifting, and focusing coils.

Deflecting coil L2 serves to deflect the electron beam of the tube from its electrical axis toward the edge of the screen and serves also to rotate the beam on the screen of the tube synchronously with the rotation of the antenna.

A deflecting coil of the open type (without an iron core) is used in the TI-1 unit. The coil consists of eight sections, divided into two groups, which are placed along the two side of the tube neck.

The placement and connection of the sections in the coil ensures a uniform magnetic field across the tube. The deflecting coil is supplied by a sawtooth current generated in unit RD. The current flowing through the coil forms a magnetic field which deflects the electron beam of the tube. The degree of deflection is directly proportional to the value of the current flowing in the coil.

The deflecting coil rotates synchronously and in phase with the rotation of the station antenna. Coil rotation is brought about with the aid of a special servomotor unit which works in the same fashion as the servomotor of unit VD-1. The difference between them consists in their design and in the fact that motor ADP-362 is used in the VD-1 unit and motor ADP-262 is used in the BSM unit of TI-1. (p 195)

Selsyns of type SS-405 and motor ADP-262 of unit TI-1 are placed in a separate silumin housing. The drive shaft of BSM transmits rotation through a special reduction gear to the deflecting coil.

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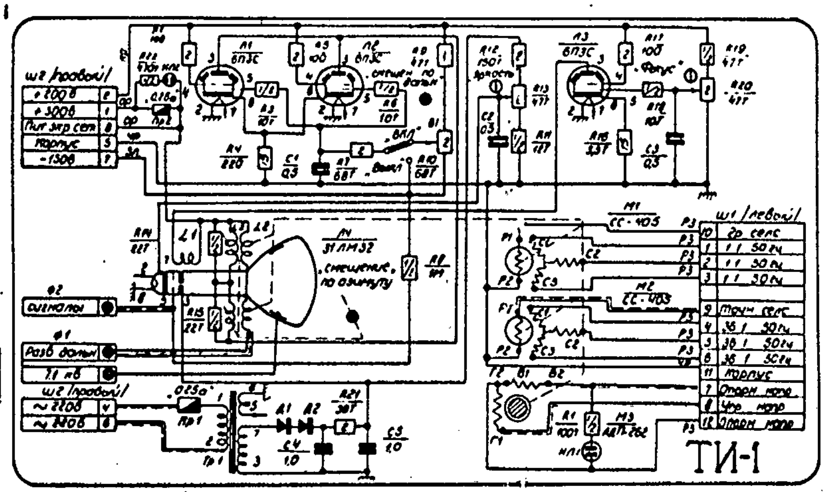

Fig. 77. Schematic Diagram of Unit TI-1.

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The voltage of the deflection coil is fed through the ball bearings of the system (without a special slip ring). Figure 78 shows the bracket with the servomotor unit and the deflecting system. The deflecting coil is shown in Figure 79a. The circuit for the transmission of current to the deflecting coil through the bearing is pictured in Figure 79b.

The shifting coil L3 is made similar to the deflecting coil with the difference that it is enclosed in an external magnetic screen which consists of thin permalloy rings. The shifting coil is connected to the plate circuits of the two parallel-connected tubes V1 and V2, which form the shifting stage of the range-sweep center. With a change in voltage at the control grids of the tubes (resistor R10), their plate current changes as well. The resulting magnetic field which is thus created causes the sweep to move along the radius of the screen. The direction of the magnetic field determines the direction of the sweep shift.

The shifting of the sweep center along the circumference of the screen is brought about by the mechanical rotation of the shifting coil about the tube axis. The rotation knob is located on the front panel of the unit.

The shift circuit may be turned off by switch V1 if the operator wishes. When the circuit is turned off, a -150-v voltage is applied to the grids of the tubes; this turns off the tubes. (p 198)

A wiring diagram for the deflecting and shifting coils is given in Figure 80. For damping of natural parasitic oscillations in the displacement coil, the coil is shunted by resistors R14, R15, which are placed in the frame of the coils themselves. The shunting resistance of the deflecting coils is located in unit RD.

The +300 v circuit which supplies the deflecting and shifting coils in the unit is provided with a fuse. In parallel with the fuse is a neon bulb which signals the blowout of the fuse.

Focusing of the electron beam of the tube in unit TI-1 is accomplished by changing the current in the coil, which is connected to the plate circuit of tube V3. The current from this tube is regulated by means of potentiometer R20, from the sliding contact of which a positive potential is applied to the control grid. The focusing coil (Figure 81) is placed in the iron shield which concentrates the magnetic field. The use of the shield permits one to decrease the necessary ampere-turns of the focusing coil and to reduce the interaction between the focusing and deflecting fields of the system.

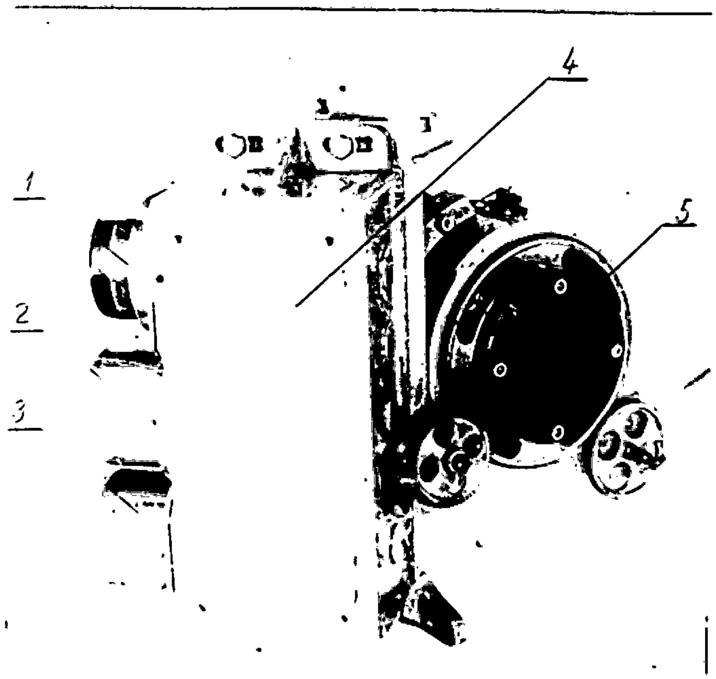

Fig. 78. Bracket With Servomotor Unit and Deflection System.

1 - motor; 2 - fine selsyn; 3 - coarse selsyn; 4 - cover over reduction gearing; 5 - deflection system.

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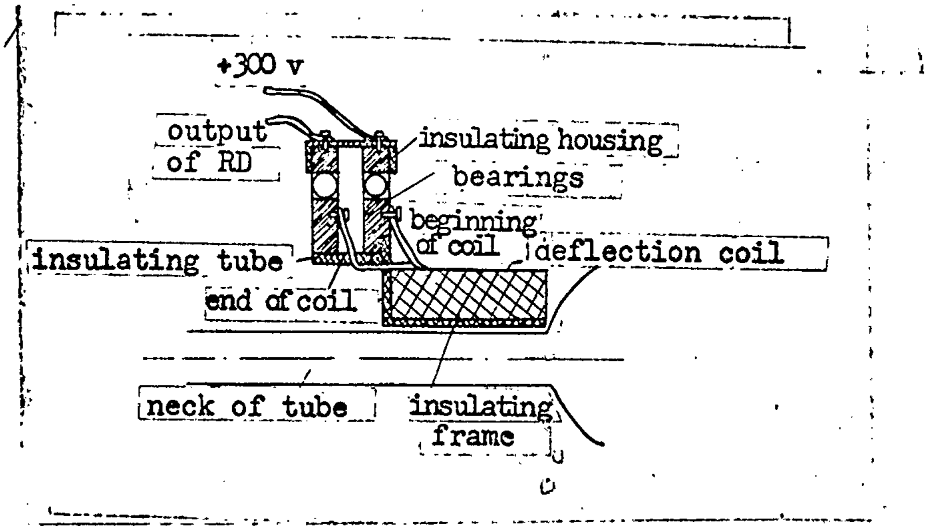

Fig. 79. Deflection System

(Diagram of current flow to deflection coil through bearings).

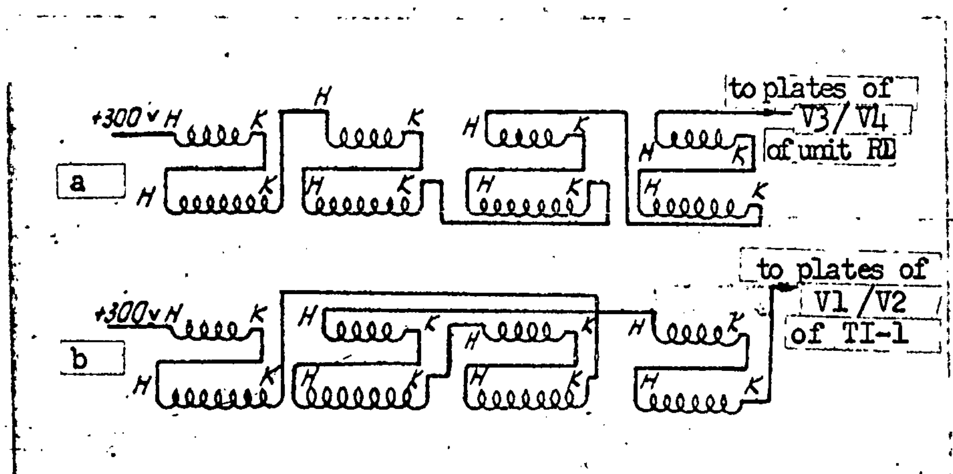

Fig. 80. Diagram of Coil Connections.

a - deflection coil; b - shifting coil.

Optimum focusing requires coincidence of the axes of the tube and focusing coil. This is obtained by proper construction of the system. Optimum position for the coil is found by moving it along the axis of the tube. In addition, in order to receive a sharper focus a d-c voltage of +500v from the special rectifying apparatus in the unit TI-1 is applied to the accelerating electrode of the tube.

Regulation of intensity is brought about by applying a positive potential to the cathode of the tube.

The positive potential is applied to the cathode of the tube from the divider R11, R12, R13. (p 201)

Signals from unit VS-3 are fed to the control electrode of the tube. To prevent flashes and burnouts of the phosphor on the screen of the tube during a break in the circuit which connects the control electrode of the tube with unit VS-3, a negative potential is applied to the control electrode through resistor R8 which blocks the tube in case of a circuit break.

<u>Construction of the unit</u>. Unit TI-1 is situated in the central compartment of the indicator cabinet. The unit is fastened in the cabinet in such a way that it can be turned 90° around the points that fasten the unit.

The unit contains a cathode-ray tube of the type 31LM32, three 6P3S tubes, a rectifier, and the bracket with the deflecting system and the servomotor unit. The tubes are placed on a special removable panel above the indicator. On the bracket is a neon bulb which signals the presence of a reference voltage in the ADP-262 motor.

On the front panel are: the tube screen with the frame and light filter; the control knobs for shifting the start of the range sweep, for intensity, and for focusing; the switch for turning on the circuit displacing the start of the range sweep; a fuse and a neon bulb.

The light filter has a special metalized cover which is connected to the housing of the unit. This permits the light filter to be placed very close to the screen of the tube.

Unit TI-1 is connected with the other units in the cabinet with the help of two 14-pin plug and socket connectors and two high-frequency connectors which connect unit TI-1 with units VS-3 and RD. The 14-pin connector Sh1 is located on the bracket and serves for the transfer of voltage to the servomotor unit.

A 7.1-kv voltage from unit BP-7 is admitted to the anode of the tube (202) through the high-voltage conductor and the cap which is set on the anode of the tube.

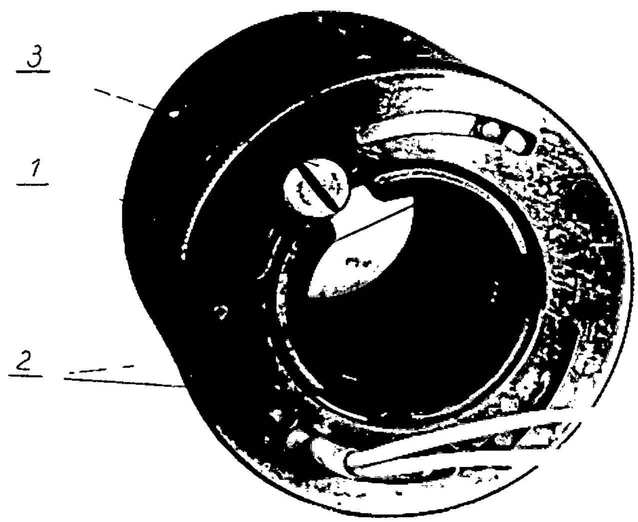

Fig. 81. Focusing Coil.

1 - rotating ring; 2 - clamping lugs; 3 - stop screw.

The connecting cables are of such a length that it is possible to turn the unit without disconnecting the supply voltage source.

The unit is turned to permit regulation of the servomotor unit and access to the plug-and-socket connectors and the tube panel. On a side wall is a schematic diagram of the unit. The weight of the unit is 42.5 kg.

3. The Sweep Delay Unit ZR-3

Function. The sweep delay unit ZR-3 (Figure 82) is designed to generate a trigger pulse, delayed with respect to the main trigger pulse, and for the control of the output voltages of all the receivers and signals of the vertical and slant channels from the signal-mixing unit.

Technical data on the unit. The delay formed by unit ZR-3 changes in 10 km steps from 40 to 350 km. When the delay is switched off, a trigger pulse arrives at the output of the unit without a delay.

The amplitude of the output pulse is not less than 10 v.

For stable operation of unit ZR-3 it is necessary that the 10-km markers which come from unit BZ have a sufficient amplitude.

The value of the delay is read on the screen of the oscilloscope tube when the control selector switch V2 is in the ninth position. The first eight positions of switch V2 are used for monitoring video signals having an amplitude from 1 to 5v. These signals are admitted to unit ZR-3 from the outputs of all the receivers of the station and the outputs of the SS-1 units (EI and EII) as well.

Functional diagram of the unit. Figure 83 gives a functional diagram (p 204) of unit ZR-3. The unit consists of the following elements:

-- sawtooth voltage generator;

-- sawtooth voltage amplifier;

-- electron relay for the signal level;

-- synchronization tubes;

-- blocking oscillator;

-- stabilizing circuit;

-- cathode-ray tube with supply circuit;

-- vertical amplifier;

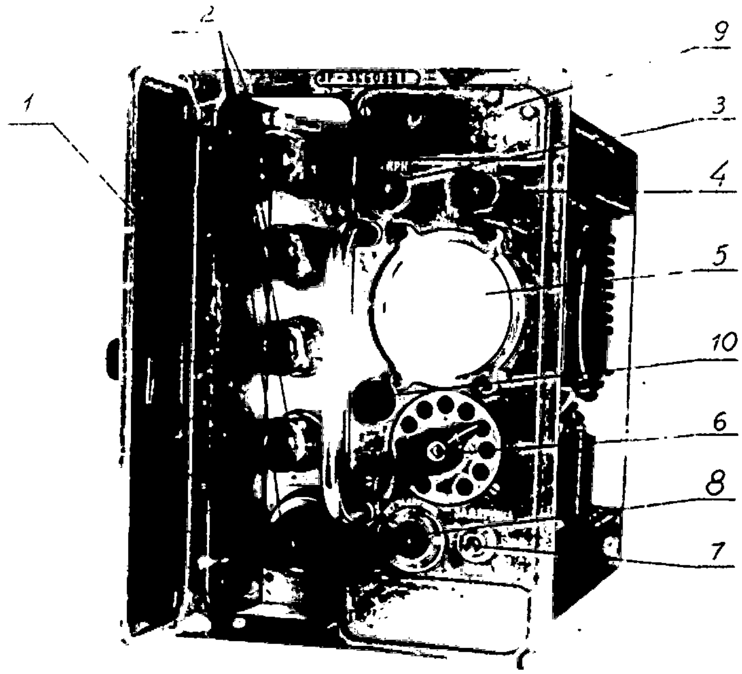

Fig. 82. Unit ZR-3.

1 - label on door; 2 - tubes in tube channel; 3 - intensity control; 4 - focus control; 5 - screen of tube 7L055; 6 - test switch; 7 - trigger pulse delay switch; 8 - trigger delay control; 9 - plug cover; 10 - illuminating bulb holder.

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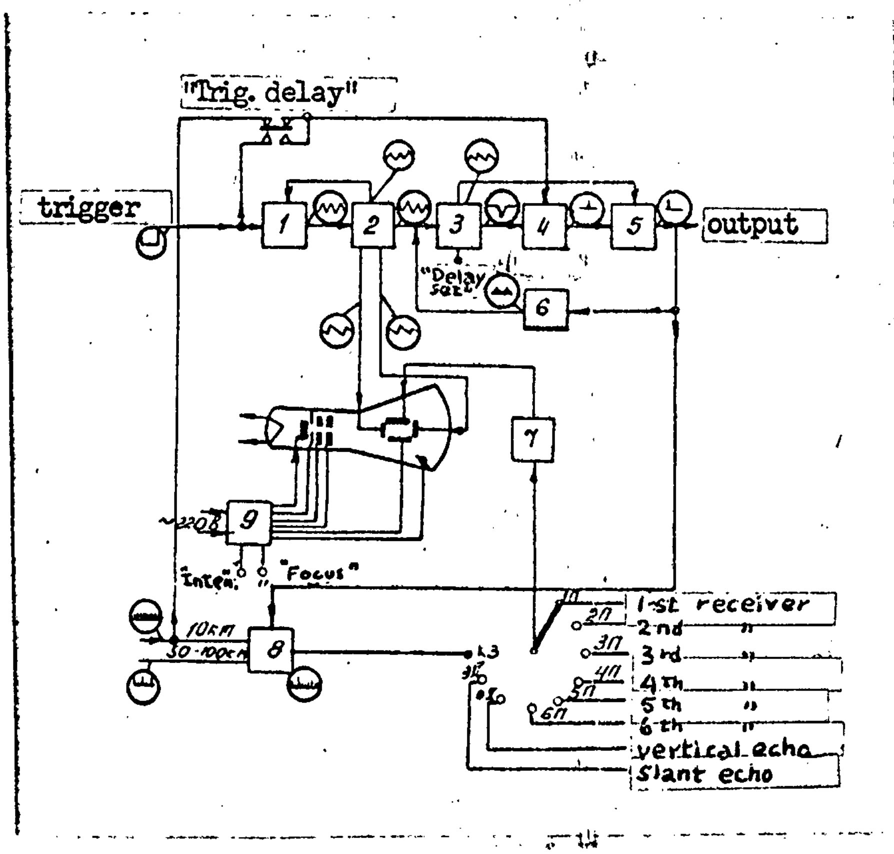

Fig. 83. Functional Diagram of Unit ZR-3.

1 - sawtooth voltage generator; 2 - amplifier; 3 - electronic voltage-level relay; 4 - synchronization tube; 5 - blocking oscillator; 6 - stabilization circuit; 7 - vertical amplifier; 8 - mixing circuit; 9 - tube supply circuit.

-- switchover control circuit;

-- mixing circuit of range-scale markers.

The sawtooth voltage generator produces a periodic sawtooth voltage which is frequency-synchronized by the trigger pulse. The end of this sawtooth voltage corresponds to a 400-km range, the beginning--to approximately 10 km, and different levels of the sawtooth voltage--to various ranges from 10 to 400 km. This voltage is amplified by a paraphase amplifier.

Feedback is supplied from the amplifier to a charging capacitor to increase the linearity of the sawtooth voltage.

The sawtooth voltage is the control voltage for the electronic relay which, depending on the setting of the delay knob, is switched over at different levels of sawtooth voltage; that is, at different ranges. The electronic relay forms a negative square pulse whose leading edge corresponds to the preset range. This pulse is differentiated and the negative part of the differentiated pulse is admitted to the cathode of the synchronization tube. Ten-km range marker pulses are admitted to the grid of this tube. Upon coincidence of the 10-km marker pulse with the differentiated pulse, a pulse appears at the plate of the synchronizing tube which triggers the blocking oscillator. The triggered blocking oscillator thus produces a delayed trigger pulse which corresponds to the preset range and coincides with the 10-km marker. (p 206)

A special stabilizing circuit is used to prevent synchronization alternately from two adjacent 10-km markers.

The blocking oscillator is supplied by a damped sinusoidal voltage from an oscillatory circuit which is connected to the plate circuit of the electronic relay. The oscillations appear in the circuit at the moment of tripping of the electronic relay. These oscillations affect the amplitude of the output pulse of the blocking oscillator. The output pulse of the blocking oscillator is applied to the stabilizing circuit which, depending on the pulse amplitude, changes to a greater or lesser extent the level of change-over of the electronic relay.

When the delay is switched off, a trigger pulse arrives at the output of the unit without delay.

The magnitude of the delay is observed on the screen of the cathode-ray receiver. During this time control switch V2 must be placed in the ninth position. Then, mixed 10-, 50-, and 100-km markers and the output pulse of the blocking oscillator are fed to the vertical amplifier of oscilloscope unit ZR-3.

For the first eight positions of control switch V2, different voltages from all the receivers and units of the signal mixer are admitted to the input of the vertical amplifier.

D-c voltages for supplying the tube of the osillograph unit ZR3 (-880v; +500v) are produced by a special rectifier located in the unit itself.

The unit has three controls--the control "Delay Setting" for selection of the required delay value, and the controls "Intensity" and "Focusing." (p 207)

Unit ZR-3 can be used in the following cabinets: DUS-1, IKO-1, and IAD-1.

Description of the schematic diagram. Figure 84 gives a schematic diagram of unit ZR-3.

The sawtooth voltage generator (tube V1) produces a periodic voltage which triggers the electronic level-relay. The tube is hooked up as a multivibrator with cathode coupling. The sawtooth voltage is taken from charging capacitor C2. The parameters of the circuit are selected in such a fashion that during the operation of the left half of tube V1 a voltage is formed at the cathode which blocks the right half of the tube.

At this time, capacitor C2 is charged from the plate voltage source through resistors R7 and R3. During the charging of the capacitor the voltage on the grid of the right half of tube V1 rises. This continues until the voltage at the grid exceeds the cut-off voltage. Tube V1 begins to conduct, tube V1a stops conducting, after which grid currents appear in tube V1b which quickly discharge the capacitor through the small grid-cathode resistance of V1 and resistors R5 and R6. Voltage at the plate of V1b now rises, making tube V1a conduct and the voltage at the cathode to increase due to the current in tube V1a. Tube V1b stops conducting and capacitor C2 again begins to charge.

For the purpose of synchronization, trigger pulses are fed to the grid of tube V1b through capacitor C2; the arrival of these pulses at the grid causes the appearance of a grid current and prematurely stops the charging of capacitor C2 (Figure 85). This accounts for the fact that the end of charging capacitor C2, i. e., the maximum of the sawtooth voltage, corresponds to the maximum range of 400 km; the minimum, i.e., the beginning of the sawtooth voltage, corresponds to approximately 10 km, and the different levels of sawtooth voltage correspond to ranges from 10 to 400 km. (p 210)

The sawtooth voltage is applied to the grid of the cathode-coupled paraphase amplifier (V2). By proper selection of the value of resistor R11 in the cathode coupling, sawtooth voltages are formed at the plates of both halves of V2 which are opposite in phase and equal in magnitude.

The grid bias voltage for tube V2 is taken from part of cathode resistance R15 and R16 through resistor R17.

Compensating capacitor C3 is connected between the cathodes of the amplifier.

To improve the linearity of the sawtooth voltage, the charging of capacitor C2 is not carried out directly from the d-c voltage source, but from divider R13, R14, located at the right plate of the amplifier (V2b).

The sawtooth voltage is also used as the control voltage for the electronic level relay. Divider R18, R19, R20 is connected between the plate of tube V2b and the d-c voltage source (-150 v). Sawtooth voltage from the cursor of potentiometer R19 is applied to the electronic level relay; the d-c voltage varies (Figure 86) at the different points of the potentiometer from +30 v at the upper point of the potentiometer to -30 v at the lower. The electronic relay flips over when voltage at its input (the grid of tube V3a) becomes equal to approximately +30 v. Therefore, when the cursor of the potentiometer is in the extreme upper position the electronic relay flips over at the very beginning, i.e., when the sawtooth voltage is equal to zero, which approximately corresponds to a 10 km range.

When the cursor of potentiometer R19 is moved downward the d-c voltage drops and the switchover of the electronic relay will take place only at a certain level of the sawtooth voltage. This level will correspond to a definite range. Capacitor C5 is inserted for better transmission of the sawtooth voltage between the plate of tube V2b and the cursor of potentiometer R19. (P 212)

<u>Description of the stepped-delay electronic relay circuit with a stabilization circuit</u>. The electronic voltage-level relay works as follows: normally, tube V3b is conducting and there is a positive voltage at its cathode.

This voltage is applied to the cathode of V3a through crystal diodes D2 and D3, conducting in the given direction; thus, tube V3a is cut off. When the sawtooth voltage at the grid of V3a reaches the operating level of the electronic relay, the current which appears causes a decrease of the voltage at the plate of V3a and an increase of voltage at its cathode.

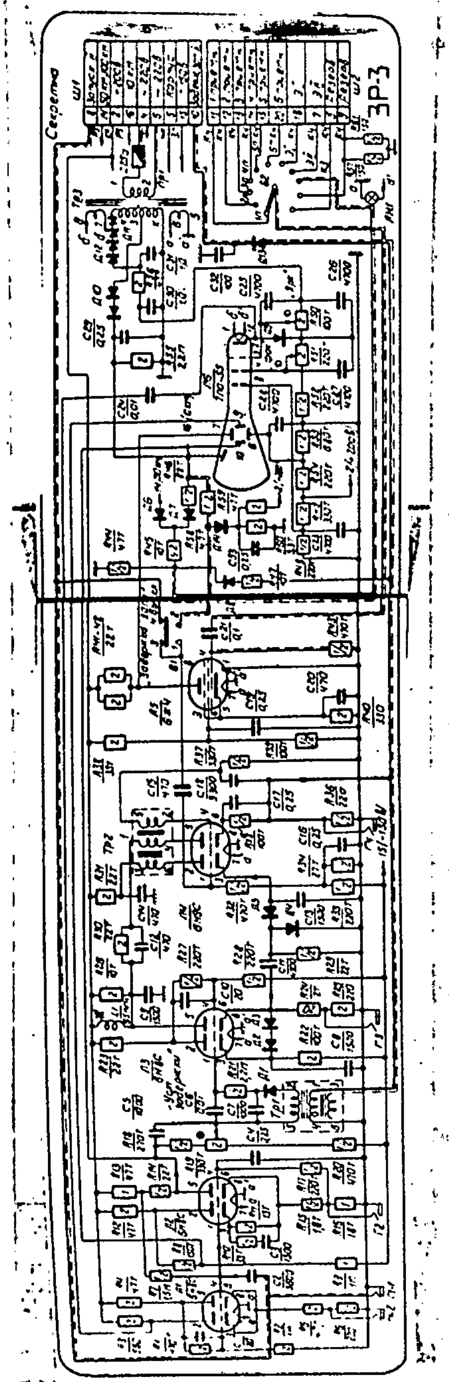

Fig. 84. Schematic Diagram of Unit ZR-3.

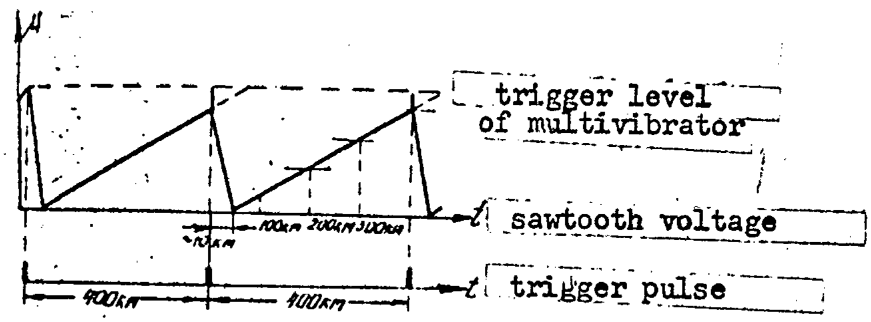

Fig. 85. Synchronization of the Sawtooth Voltage by the Trigger Pulse.

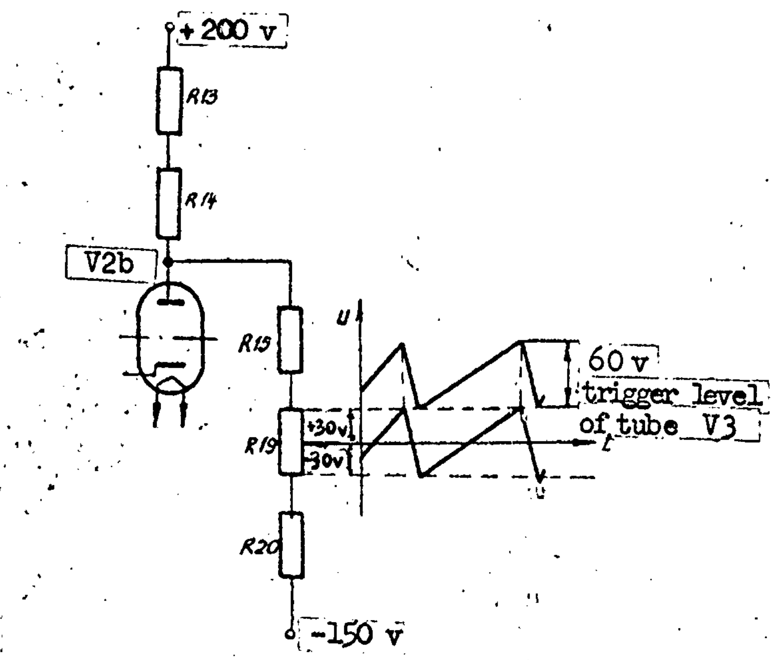

Fig. 86. Diagram of Sawtooth Voltage Transmission From Amplifier to Electronic Voltage-Level Relay.

As a consequence of the increase in voltage at the cathode of V3a and the decrease in voltage at the cathode of V3b, crystal diodes D2 and D3 cease to conduct; but the cathodes of the left and right halves of electronic relay tube V3 became disconnected from each other (Figure 87).

The voltage at the cathode of V3a rises in proportion to the rise of the sawtooth voltage to a maximum at the grid of V3a. V3a continues to conduct, whereas V3b is cut off. After this, the sawtooth voltage begins to fall.

A return to the initial position of the relay occurs at a lower level than the initial switchover. Therefore, when the sawtooth voltage is lowered, conditions are created for a return of the circuit to the initial state. However, with samll delays, the switchover takes place at low levels of sawtooth voltage so that return to the initial state becomes impossible and normal operation of the electronic relay is upset (Figure 88). In order to ensure normal operation of the electronic relay for the starting ranges, capacitor C8 is connected to the cathode of V3a. While the sawtooth voltage is rising capacitor C8 charges; but during a quick drop in the sawtooth voltage C8 is not able to discharge completely, so that some voltage remains in it and, consequently, at the cathode of V3a which will bring about the cutoff of V3a at a higher voltage level than normally is needed to make it conduct.

While the electronic relay is operating, a negative square pulse is formed at the cathode of V3b whose start corresponds to the selected range value. This pulse is differentiated by circuit C11 and R29. The positive part of the differentiated pulse is clipped by crystal diode D4. The negative part, which corresponds to the start of the pulse of the electronic relay, is applied through crystal diode D5 (in order to lower the resistance of the transmission circuit) to the cathode of synchronization tube V4a. Capacitor C13 is used to smooth the differentiated pulse.

Synchronization tube V4a is normally cut off by a large negative bias. When "Delay" Switch V1 is in the position "On", a negative differentiatiated pulse from the electronic relay is applied to the cathode of V4a and 10-km range markers are applied through capacitor C15 to the grid. The tube conducts only during coincidence of these two pulses. Moreover, a pulse is produced at the plate load of the tube (the winding (p 216) of blocking transformer Tr2) which triggers blocking oscillator V4b. The blocking oscillator is normally in an operating mode close to a blocked state due to the self-bias formed by the circuit R35 and C17. The blocking oscillator forms a delayed output pulse which corresponds to the selected range and coincides with the 10-km marker (Figure 89). The output pulse is taken from cathode load R36.

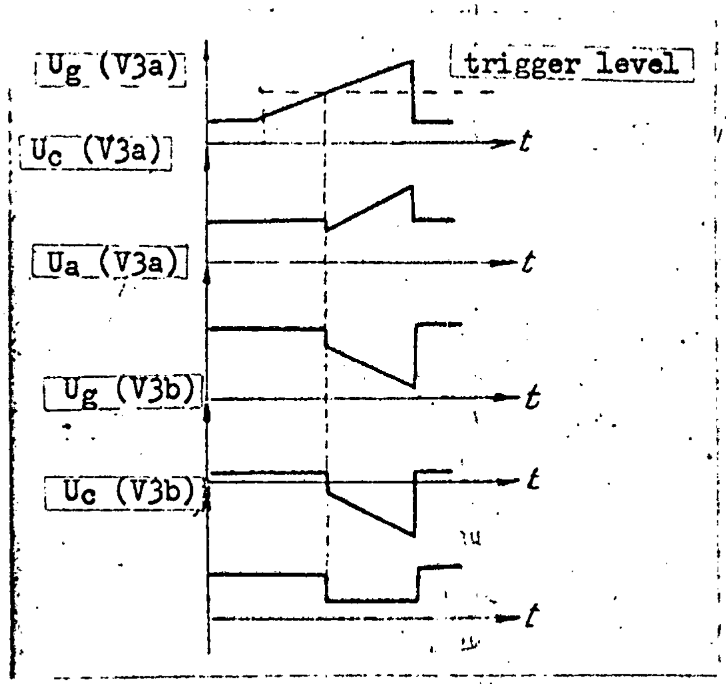

Fig. 87. Voltage Forms in the Circuit of the Electronic Voltage-Level Relay.

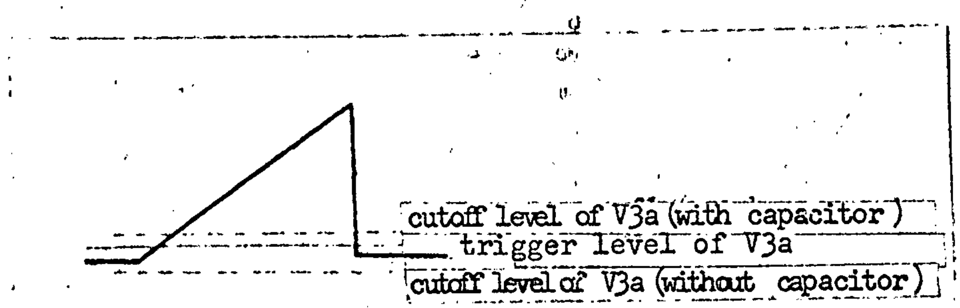

Fig. 88. Trigger Level of Electronic Voltage-Level Relay at Small Delays.

When the "Delay" switch V1 is in the "Off" position, a main trigger pulse is applied to the synchronization tube grid from unit BZ which actuates blocking oscillator V4b at the instant corresponding to zero range. The trigger pulse is admitted without delay to the output of the unit.

The blocking oscillator pulse is fed to the output of the unit through stretcher circuit D13, C32.

A special stabilization circuit is used for stable operation of the delay circuit. Oscillatory circuit V1 and C9 is connected to the plate of tube V3b. During switchover of the electronic voltage-level relay (cutoff of V3b), damped sinusoidal oscillations are formed in the oscillatory circuit whose first period is used in the stabilization circuit.

Damping of the circuit is determined by resistor R26 which shunts the circuit. The period of oscillations is equal to approximately 70 microseconds, that is, about 10 km. These oscillations are fed through circuit R30 and C12 to the plate winding of blocking transformer Tr2.

The voltage at the plate of the blocking oscillator appears as the sum of the d-c and sinusoidal voltages. Consequently, the amplitude of the pulses of the blocking oscillator will vary in accordance with the sinusoidal voltage.

As was mentioned before, the blocking oscillator operates when the (p 218) 10-km marker coincides with the differentiated pulse at the cathode of tube V4a. The sinusoidal voltage and differentiated pulse are range-shifted in accordance with the instant of trigger operation.

The 10-km marker pulses do not change their position with respect to time. Thus, the amplitude of the output pulse depends on the relative position of the 10-km marker and the sinusoidal voltage. The amplitude is medium when the 10-km marker coincides with zero sinusoidal voltage; greater than medium when the marker coincides with the positive half-wave of the sinusoidal voltage; or smaller than medium when the marker coincides with the negative half-wave of the sinusoidal voltage.

Figure 90 shows the amplitude of the output pulse of the blocking oscillator changes during various points of relay tripping. If the relay trips at instant 1, then the 10-km marker (Figure 90) will coincide with the zero of the plate sinusoidal voltage of the blocking oscillator (Figure 90b) and the amplitude of the output pulse will be of a medium vlaue (Figure 90a).

This is the most stable position, since now the 10-km marker coincides with the maximum of the differentiated pulse at the cathode of the synchronizing tube (Figure 90c) so that synchronization of the blocking oscillator now becomes more precise.

If the electronic relay trips over at instant 2 (Figure 90a), then the 10-km marker coincides with a higher plate voltage (Figure 90b) and the output pulse amplitude will be greater (Figure 90e). If the electronic relay trips at instant 3 (Figure 90a), then the 10-km marker will coincide with a lower plate voltage of the blocking oscillator (Figure 90b) and the amplitude of the output voltage will become smaller (Figure 90e). (p 220)

The output pulse is admitted through blocking transformer Tr1 and crystal diode D1 to capacitor C7 of the stabilizing circuit and charges it. The crystal diode ensures rapid charging of the capacitor and slow discharging. If the output pulse has a high amplitude (position 2, Figure 90e), then capacitor C7 will be charged to a higher voltage, and across capacitor C6, which is connected through a large resistor R21 to C7, as well as at the grid of the electronic relay there will be impressed a higher voltage; now the electronic relay will trip at a lower level of the sawtooth voltage, i.e., will shift closer to position 1, which is the most stable. If the output pulse has a lower amplitude (Figure 90e, position 3), voltage at the grid of electronic relay P3a will decrease and it will be capable of tripping at a higher level of sawtooth voltage, i.e., it will again move closer to position 1.

Thus, for any small departures of the instant of operation of the electronic relay from that of the most stable, the stabilizing circuit will force it to return to the most stable position.

Control oscillograph and power supply circuit. The unit has a control oscillograph which measures the magnitude of delay or the external voltages.

Transformer Tr3 has special windings which provide voltages for the cathode-ray tube of the oscillograph. These voltages are rectified by selenium rectifiers D10, D11 and D12 and are applied to the third plate of the tube (+800 v) and to a voltage divider consisting of resistors R50, R51 and R52 (-500 v). From the divider the control voltages are fed to the tube modulator (intensity) and to the first plate of the tube (focus), as well as to the tube cathode. Also supplied to the tube cathode is the gating pulse of sawtooth flyback taken from the plate of V1a. Crystal diode D9 serves to restore the d-c component of the gating pulse after capacitor C24. (p 221)

Positive voltage for adjusting the focus is supplied from divider R48, R49 to the second plate of the tube.

The sawtooth voltage from the plates of tube V2 of the paraphase amplifier is used to actuate the sweep.

To one of the vertical deflection plates is supplied voltage from the plate of tube V5 of the vertical amplifier; to the other vertical deflection plate is supplied vertical-shift voltage for the sweep from voltage divider R53, R54. The vertical amplifier incorporates tube V5. The amplifier has a self-shifting circuit consisting of resistor R40 and capacitor C20. With the control switch V2 in the ninth position, the oscillograph is used for the control of delay. Range marker pulses are fed to the control grid of tube V5 through crystal diodes D6 and D7, and the output trigger pulse is fed through crystal diode D8. The range scale markers and the delayed trigger pulse are now seen on the oscillograph screen (figure 91).

The oscillograph is used for testing the receiver output circuits (p 223) and signal-mixing units when the test selector switch is in any of the first eight positions. In these positions, the output voltage of the 1st, 2nd, 3rd, 4th, 5th and 6th centimeter-wave receivers, the mixed slant channel E II and mixed vertical channel E I are fed to the control grid of tube V5.

Testing of the unit. Testing of unit ZR-3 is carried out with the aid of five test jacks:

G 1-1 -- for testing the trigger pulse at the input of the unit;

G 1-2 -- for testing the square pulse at the cathode of tube V1;

G-2 -- for testing the sawtooth voltage at the cathode of tube V2;

G-3 -- for testing the square pulse at the cathode of tube V3b;

G-4 -- for testing the blocking oscillator output pulse (delayed trigger pulse) at the cathode of tube V4b.

Design of the unit. Unit ZR-3 is built as a separate instrument on a standard chassis. In the tube channel are five tubes (three 6N8S, one 6N9S, one 6Zh4), five test jacks and a switch. The screen of the cathode-ray tube, type 7LO55, shafts of the three potentiometers "Intensity", "Focus", and "Delay Setting", trigger-pulse delay switch, test switch knob, and switch-inscription illuminating bulb are located on the front panel.

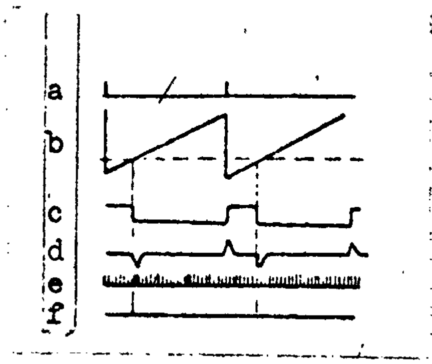

Fig. 89. Voltage Forms in the Synchronization Circuit.

a - trigger pulses; b - sawtooth voltage at grid of intensity electronic relay; c - square pulses at cathode of intensity electronic relay; d - differentiated pulse; e - 10-km marker; f - output pulse of blocking oscillator.

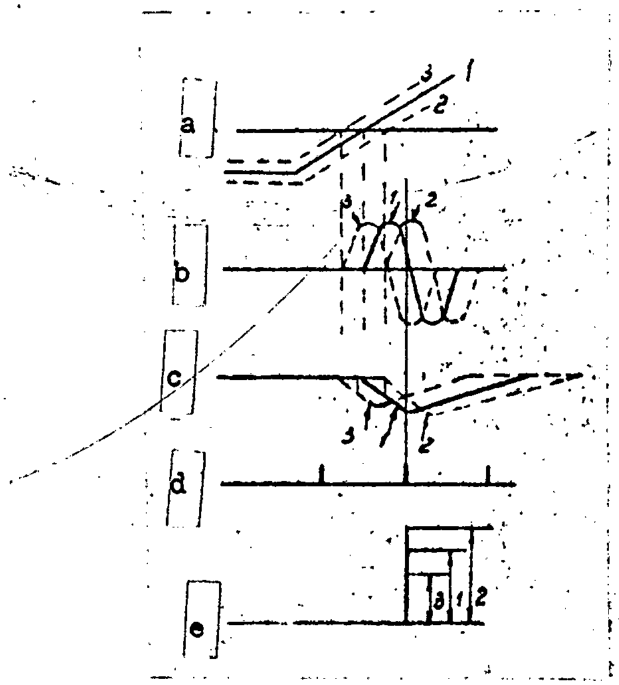

Fig. 90. Voltage Forms in the Stabilization Circuit.

a - operating level of electronic intensity relay; b - sinusoidal voltage at plate of relay and at plate of blocking oscillator; c - differentiated pulse at cathode of synchronizing tube; d - 10-km marker at grid of synchronizing tube; e - output pulse of blocking oscillator

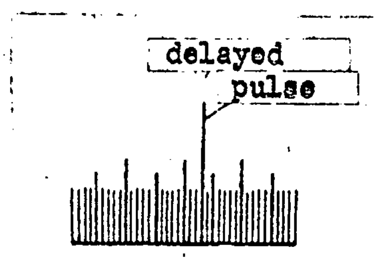

Fig. 91. Image of Delayed Pulse on Oscillograph Screen.

The delay-setting knob has a stop which limits the position of the knob in such a manner that a maximum delay cannot exceed 350 km. The cathode-ray tube is mounted on a special support in the upper part of the unit. Potentiometers "Intensity" and "Focus"are insulated from the frame of the unit. The unit has two connectors. Weight of the unit is 7.6 kg.

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The sawtooth voltage generator consists of a multivibrator with a charging capacitor. It is started by a trigger pulse. This stage determines the duration of sawtooth voltage. The sawtooth voltage is amplified by a three-stage amplifier with feedback. The last stage acts as a power amplifier. In this stage the sawtooth voltage is transformed into a sawtooth current which can be adjusted to a desired value. Feedback from this stage is applied to the charging capacitor for linearization of the sawtooth voltage and to the first amplifier for compensation of sawtooth voltage distortion, From the specifications of the range sweep unit (RD) it is seen that the unit generates sweep signals which vary in duration and range scale depending on the type of indicator used. (p 227)

Thus, in the PPI (IKO-1) cabinet are generated three sawtooth current pulses with durations of 300 km - I, 370 km - II and III. The current amplitude is set in such a manner that on the first range scale the sweep length is three radii of the tube, on the second range scale -- two radii, and on the third range scale -- one radius (Figure 94a).

In the cabinet of the range sweep unit (IAD-1) are generated three sawtooth current pulses of 30, 50 and 100-km duration. The current for all three range scales is set such that the sweep length will be 1.4 radii of the tube.

In cabinet IIV-1 is generated one sawtooth current pulse having a duration of 300 km. The sweep length should be 2.1 radii of the tube.

Therefore, each cabinet has its own circuit commutation which determines the duration and length of sweep in accordance with the function of the cabinet. (p 229)

The unit has a three-position switch and six controls. The switch is used for selection of the sweep range. Each range has controls for continuous change of the duration ("Duration I", "Duration II - III") and of the scale ("Scale I", "Scale II" and "Scale III") within the limits indicated in the technical data for

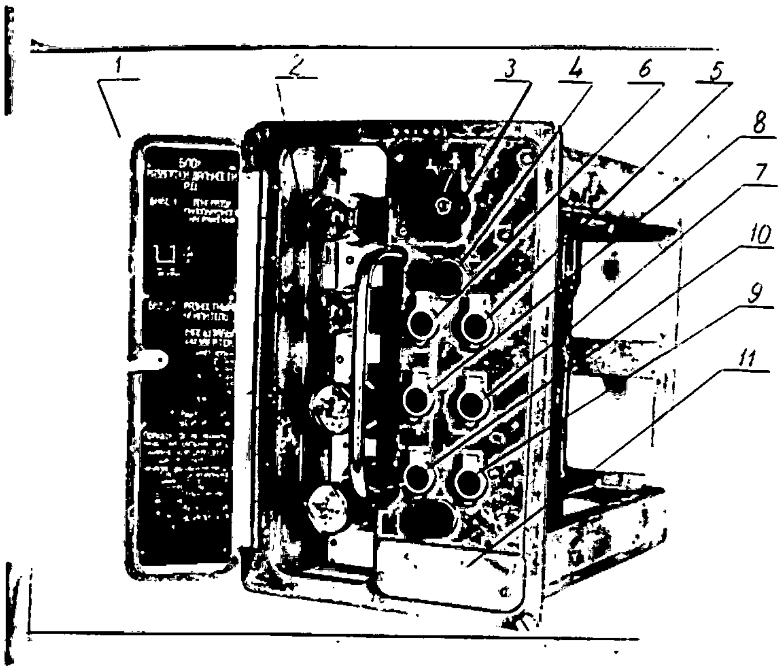

Fig. 92. Range Sweep Unit RD.

1 - label on door; 2 - tubes in tube channel; 3 - range-scale selector switch; 4 - holder for illuminating bulb; 5 - adjustment of duration I; 6 - range-scale I adjustment; 7 - adjustment of duration II-III; 8 - range-scale II adjustment; 9 - adjustment for sweep start of IKO-1; 10 - range-scale III adjustment; 11 - cover for plug connectors.

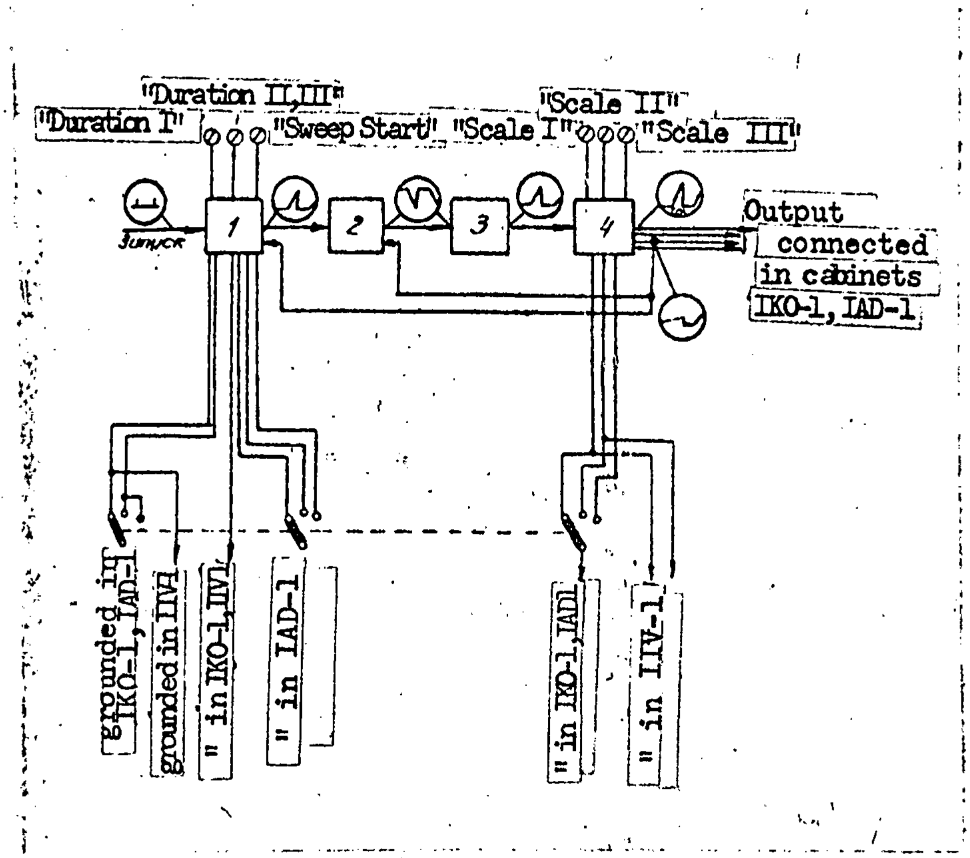

Fig. 93. Functional Diagram of Range Sweep Unit RD.

1 - sawtooth voltage generator; 2 - first amplifier; 3 - second amplifier; 4 - power amplifier.

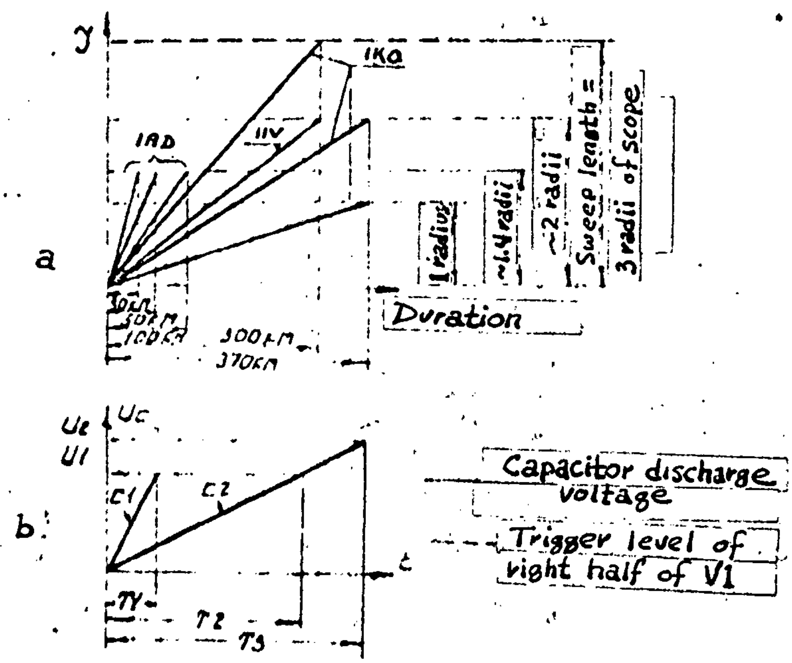

Fig. 94. Sweep Range Scales Generator by Range Sweep Unit RD.

a - duration and sweep length for various indicators; b - dependence of sawtooth voltage duration on parameters of the circuit.

the unit. The adjustment "Correction for Start of PPI (IKO-1)" serves to compensate for the non-linearity of the initial sector of the sweep in the PPI (IKO-1) and the height measurement indicator (IIV-1).

The switch in cabinet IIV-1 should not be used.

Description of the schematic diagram of the unit. Figure 95 shows a schematic diagram of range sweep unit RD.

A multivibrator with cathode coupling incorporating tube V1 is used as a sawtooth voltage generator. The sawtooth voltage is generated during charging of capacitors C4, C5, C6, or C7, depending on the desired duration. Switching of the capacitors is carried out with switch V1 and commutation to various cabinets by grounding corresponding circuits in the appropriate cabinet. Thus, in cabinet PPI (IKO-1) capacitor C4 (used to obtain I, II and III duration) is grounded, in the azimuth-range indicator (IAD-1) cabinet capacitors C5 ("Duration I"), C6 ("Duration II") C7 ("Duration III") are grounded through switch V1, and in the height measurement indicator (IIV-1) capacitor C4 is grounded.

Prior to the arrival of the trigger pulse at the multivibrator circuit the left half of tube V1 is blocked by negative bias while the right hall of V1 is conducting and the tube grid has a positive voltage close to zero. The capacitor connected to the grid is not charged. (p 231)

A positive polarity trigger pulse is applied to the cathode of tube V1 which reduces the current in the conducting right half of the tube. Now the voltage at the plate of the right half of the tube rises and makes the left half of the tube conduct. The current in the left half of the tube (being considerably greater than the current in the conducting right half of the tube, because the plate resistance of the left half is considerable smaller than the plate resistance of the right half) increases the voltage at the common cathode resistance of tube V1. This increased voltage now blocks the right half of tube V1.

Charging of the capacitor connected to the right grid of tube V1 through crystal diodes D1, D2 and D3 and resistors R11 and R12 now begins. Voltage at the right grid of tube V1 rises during the charging of the capacitor. This rise continues until the grid voltage exceeds the conduction potential of the right half of tube V1; then the tube begins to conduct, voltage at the plate falls, and the voltage at the grid of the left half of tube V1 also drops. The left half of tube

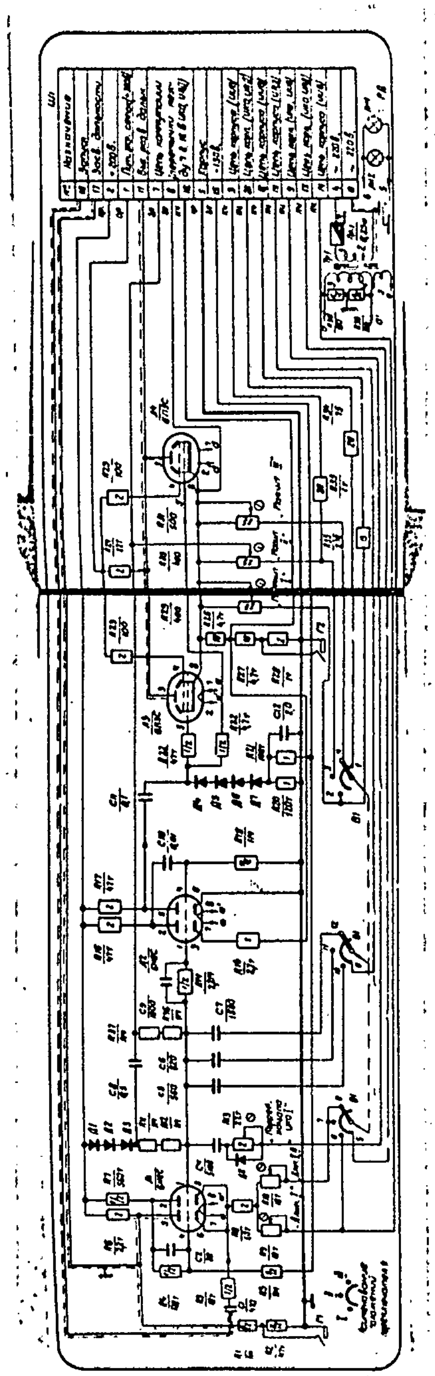

Fig. 95. Schematic Diagram of Range Sweep Unit RD.

V1 is now blocked and its current ceases to flow through the common cathode resistance; voltage at the cathode of tube V1 now drops, which results in increased conduction in the right half of tube V1 and the appearance of grid currents in this tube.

After this, the capacitor is rather rapidly discharged by the grid currents through the small grid-cathode resistance of the conducting right half of tube V1 and resistor R8, R9 and R10.

As a result of this, a sawtooth voltage is formed at the grid of the right half of tube V1. The duration of this voltage pulse (p 232) depends on the rate of capacitor charging and on the amplitude to which the capacitor has been charged prior to conduction of the tube. The rate of capacitor charging depends on the parameters of the charging circuit, i.e., capacitance of the capacitor and the size of resistors R11 and R12. The amplitude depends on the value of positive voltage at the cathode of tube V1 which blocks tube V1b. This voltage is formed as a result of current flowing from conducting tube V1a through resistors R8 and R9 or R10 (depending on the position of the switch and commutation in the cabinet). As is seen from Figure 94b, an increase in the capacitance of the charging capacitor, as well as an increase in voltage at the cathode of V1, i.e., conduction level of the right side of V1, will result in an increased duration of the sawtooth voltage ($C1 < C2$; $U1 < U2$; $T1 < T2 < T3$). Selection of the sweep range is effected therefore by selection of an appropriate value of the charging capacitor (C4, C5, C6 or C7) and resistance in the cathode circuit of V1 (R9 and R10). Continuous adjustment of the duration is carried out by varying the value of the cathode resistance (variable resistors R9 and R10).

The sawtooth voltage from the charging capacitor is applied to the first amplifier incorporating tube V2a. Voltage from the plate of this amplifier is fed through capacitor C10 to the second amplifier.

Voltage from the plate of V2b is applied through C11 to the power amplifier incorporating tubes V3 and V4, which are connected in parallel. Feedback voltage for the charging capacitor is taken either from the cathode of output tubes V3 and V4 (in cabinets IKO-1 or IAD-1) or from potentiometer R30 (in cabinet IIV-1). This voltage is fed through capacitor C8 to the cathode of crystal (p 233) diode D3 which blocks the diode. With the rise of sawtooth voltage at the charging capacitor, a corresponding rise of voltage occurs at the right plate of capacitor C8. Capacitor C8 now begins to feed current to the charging capacitor circuit through resistors R11 and R12. Since the voltage at the right plate of capacitor C8 rises according to a sawtooth rule, i.e., uniformly, the value of current fed to the charging circuit remains constant, which ensures a rather linear charge of the capacitor. Since the capacitance of

C8 is considerably larger (about 100 times) than the capacitance of the charging capacitor, the discharge of capacitor C8 during the forward stroke of the sawtooth voltage will be insignificant. During the flyback stroke, capacitor C8 will be recharged to a voltage of + 300 v through diodes D1, D2, and D3.

The performance of cabinet IIV-1 does not require great linearity, but it requires ease of adjustment of the sawtooth voltage form so that the range sweep can be matched with the optical scale. In cabinet IIV-1 the sawtooth voltage form can be varied by regulating the linearity. For this purpose the voltage supplied to capacitor C8 is taken not directly from the cathodes of V3-V4, but from potentiometer R30 in the cathode circuit. Also, an additional feedback is suppled from the same points as the fundamental; the latter passes through C8 to the charging capacitor. The additional feedback is coupled directly to the charging capacitor through resistors R36 and R37.

Depending on the position of the sliding contact of potentiometer R30, the sawtooth voltage in the upper end of resistor R37 can be either larger or smaller than the sawtooth voltage at the charged capacitor. If the voltage across R37 is greater than at the capacitor, then an additional current will pass through R37 and R36, increasing the charge current of the capacitor. The sweep now will be stretched at the end. If the voltage across R37 is smaller than at the capacitor, then a current will travel through R37 and R36 in a reverse direction, decreasing the charging current of the capacitor. The sweep now will be compressed at the end. (p 234)

In cabinets IKO-1 and IAD-1 the sliding contact of potentiometer R30 is connected to the cathodes of V3 - V4 so that feedback is taken directly from the cathodes.

Both halves of tube V2 and tubes V3 - V4 form a three-stage amplifier with negative feedback. On the left side of the first tube (V2) of the stage the following voltages are impressed:

-- on the grid, a linear sawtooth voltage of positive polarity from master oscillator V1;

-- on the cathode, a positive polarity sawtooth voltage from the cathode of the last tube of stage V3-V4 which has been distorted by tubes V3 - V4, type 6P3S.

When voltages of identical polarity are fed to the grid and cathode of the left half of tube V2, the tube will amplify the difference between these two voltages. This difference is further amplified by the right half of the second amplifier V2 and is then admitted to the grids of the third amplification stage V3 - V4, which also serves as the output stage for the range sweep unit RD. Let us assume that, due to the distortions caused by the output tubes, the voltage at the cathodes of these tubes has decreased. This voltage drop will be reflected in the left-half cathode of tube V2 through the feedback circuit.

Then the voltage difference amplified by the left half of tube V2 will become larger and the voltage on the grids of the output stage will also become greater, thus compensating for the decrease introduced by the output stage. (p 235)

During operation of the unit in cabinet IIV-1 the degree of feedback is lowered. Voltage applied to the cathode of tube V2a is taken from divider R26 and R27 (resistor R28 is used for monitoring). Resistor R26 is shorted in cabinets IKO-1 and IAD-1.

Tubes V3 and V4 are connected in parallel to increase the current fed to the deflection coils. For the same purpose the plates of tubes V3 and V4 are supplied with + 300-v power. The circuit of crystal diodes D4, D5, D6 and D7 is intended for restoration of the d-c component of the sawtooth voltage after capacitor C11. The deflection coil of the indicator serves as a plate load for tubes V3 and V4.

Continuous adjustment of the range scale is achieved by regulating the tube current of the power output amplifier. This is achieved by varying the cathode resistance of these tubes (R29, R30 or R31).

When removing the scope unit TI-1, TI-2 or TI-3 from the cabinet, the deflection coil is disconnected from the output tubes, which results in an increase of the plate load resistance of tubes V4 - V3. This in turn causes a drop in the plate current and an increase of current through the screen grids. This might overheat resistors R23 and R25. To avoid the possibility of such overheating, the supply voltage to tubes V3 and V4 should be disconnected during the removal of scope units TI-1, TI-2 or TI-3 from the cabinet.

A negative pi-shaped pulse is fed to video signal units VS-3 and VS-4 from the plate of tube V1a.

When range sweep unit RD is used in IKO-1 or indicator IIV-1, resistor R13 is provided which forms a controlling pedestal for correction of the non-linearity of the sweep start. During the discharge of capacitor C4, which is connected to the same circuit, current travels through crystal diode D8 which helps to reduce the discharge time. Matching of the range sweep with the optical scale is necessary when unit RD operates in cabinet IIV-1. This matching is carried out in the following manner: the beginning of the range sweep, up to 50 km, is regulated by potentiometer "Correction of Start of IKO-1" with a scale angle of 40°; the middle part, approximately from 50 to 200 km, is regulated by potentiometer "Scale I", also with a scale angle of 40°; and, finally, regulation for over 200 km is done with potentiometer "Scale II" with a scale angle of 20°. (p 236)

Since range sweep unit RD is used to obtain various sweeps in cabinets IKO-1, IAD-1, and IIV-1, appropriate jumpers are provided at the connectors in these cabinets.

Testing the unit. Testing of range sweep unit RD is carried out with the aid of two test jacks:

G1 -- used to test the intensifier pulse at the plate of V1a;

G2 -- used to test the sawtooth voltage at the cathodes of the tubes of the power amplifier (V3 and V4).

Design of the Unit. Range sweep unit RD is in the form of a self-contained unit mounted on a standard chassis. The tube channel has four tubes (two 6N8S and two 6P3S) and two test jacks.

On the front panel are the shaft of the range sweep selector switch and the shafts of six potentiometers: two duration-adjustment potentiometers, three range scale adjustment potentiometers, and a potentiometer for adjustment of the sweep start. The front panel (p 237) has two illuminating bulbs. The unit has one plug connector. The unit weights 6.5 kg.

5. Unit VS-3 for Mixing and Amplifying Video Signals

Function. Video signal unit VS-3 (Figure 96) mixes into a single channel the range marker pulse, echo signals, and identification signals; it also amplifies them and controls the cathode-ray tube.

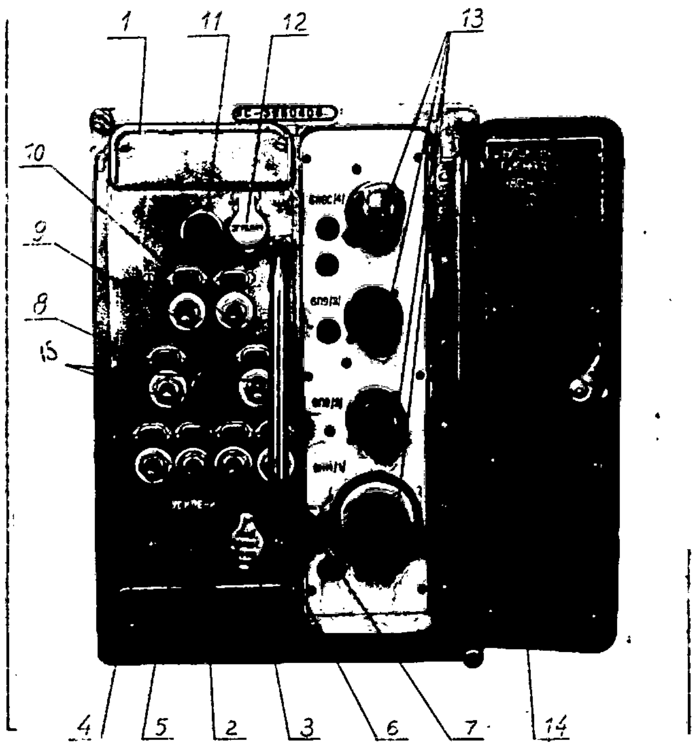

Fig. 96. Unit VS-3.

1 - cover for socket; 2 - common amplification control; 3 - amplification control for range-scale markers; 4 - 2-km marker toggle switch; 5 - 10-km marker toggle switch; 6 - 50-km and 100-km marker toggle switch; 7 - azimuth marker toggle switch; 8 - socket for illuminating bulb; 9 - toggle switch for channel I signals; 10 - toggle switch for channel II signals; 11 - socket for illuminating bulb; 12 - limit control; 13 - tubes in tube channel; 14 - label on door; 15 - reserve toggle switches.

Technical Data on the Unit. The unit output signal can be regulated from 0 to 70 v. The bandpass of the unit is 1.5 Mc.

Functional Diagram of the Unit. A functional diagram of unit VS-3 is given in Figure 97. The unit consists of the following components:

-- input dividers;

-- wideband amplifier;

-- output stage;

-- control tube.

Reflected signals, identification signals, and range and azimuth scale markers are admitted to the input of the unit. At the input of each channel is a toggle switch (except for the IFF channel). (p 240)

When these toggle switches are on, all the signals are admitted to input dividers, are mixed, and then admitted to a wideband amplifier through a common channel.

The wideband amplifier consists of two stages. Common amplification is adjusted in the first stage. Control of scale marker amplification permits varying the amplitude of the scale marker relative to the video signals. Limiting control carried out in the second stage of the amplifier prevents defocusing of signals on the indicator when signals with large amplitude are admitted to the input of unit VS-3.

A cathode follower serves as the output stage of the unit.

Range-gating pulses of indicator IKO-1 and range- and azimuth-gating pulses of indicator IAD-1 are fed to VS-3 and make the circuit at the input of the amplifier conduct.

In the absence of gating pulses, the signals will not arrive at the input of the amplifier.

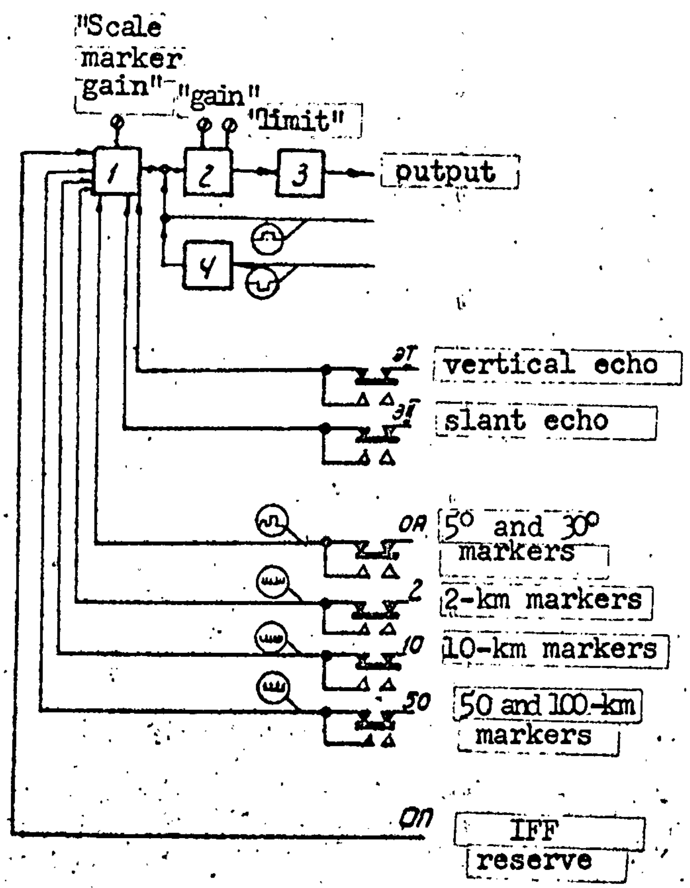

Fig. 97. Functional Diagram of Unit VS-3.

1 - input dividers; 2 - wideband amplifier; 3 - output stage; 4 - control tube.

Description of the schematic diagram of the unit. Figure 98 shows a schematic diagram of unit VS-3. The following signals are fed to the circuit:

-- signals of the vertical channel;

-- signals of the slant channel;

-- identification signals;

-- 2-km range markers and 1-degree azimuth markers; (p 242)

-- 10-km range markers;

-- 50-km and 100-km range markers;

-- 5^{o} and 30^{o} azimuth markers.

All of these signals are admitted to input dividers R1 to R23 where the amplitude of the signal is reduced from 3 to 40 times. The input dividers are connected in a star pattern. Mixed signals are admitted to the grid of the first amplifier tube from the common point of the dividers.

Because the sweep speed in IAD-1 is greater than in IKO-1, auxiliary shunting resistors R1, R2, R9 and R10, located in cabinet IAD-1 and connected in parallel with the main dividers of these circuits, are connected to the dividers of the 2-km range markers and azimuth marker circuits.

The first amplifier stage incorporates tube V1 (6Zh4) and ensures amplification on the order of 15. Amplified signals from the plate load R31 and R32 of the first amplifier tube are fed through capacitor C3 to the grid of the second amplifier stage.

The second amplifier stage incorporates tube V2 (6P9) and ensures amplification on the order of 10. From plate load R37 to R40 of the second tube the signals are admitted through capacitor C6 to the grid of the cathode follower. The cathode follower incorporates tube V3 (6P9).

The signals are applied to the grid of the cathode-ray tube from cathode load R51 of the output stage.

To eliminate the flyback trace on the cathode-ray tube, the circuit has a provision for blanking the signal during the flyback sweep. (p 243)

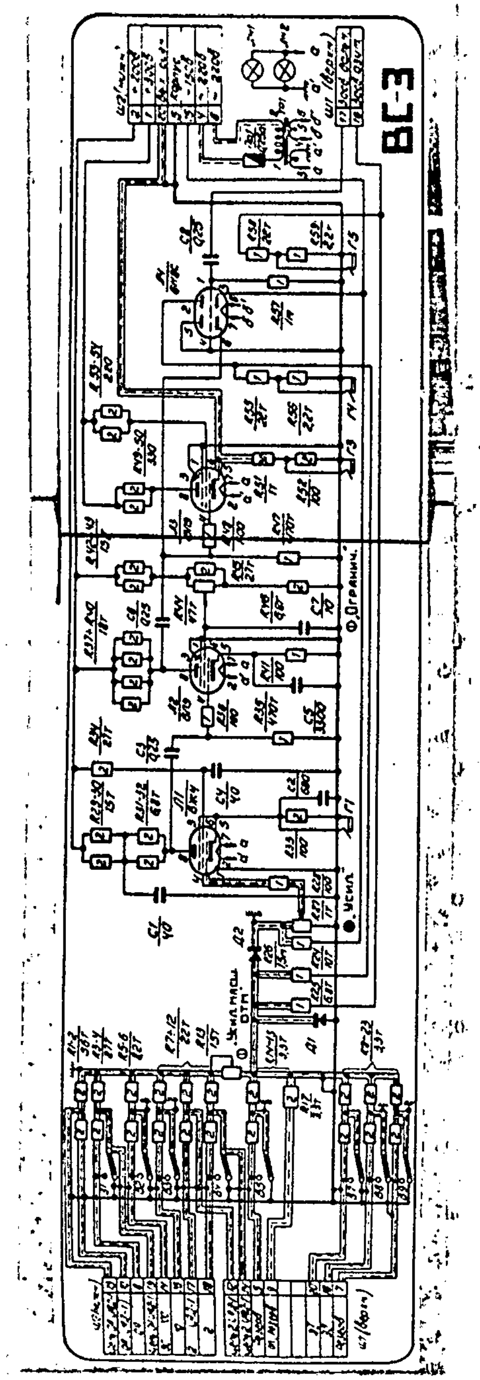

Fig. 98. Schematic Diagram of Unit VS-3.

A negative potential from the plate of the right half of conducting tube V4 (6N8S) is fed through resistor R24 to the anode of crystal diode D2 where it blocks the pulse-transmission circuit to the grid of tube V1. A negative pi-shaped pulse from range sweep unit RD is fed to the unit during the forward sweep. During the appearance of a negative pi-shaped pulse, the right half of tube V4 does not conduct and the voltage at its plate becomes zero. This voltage is applied to the crystal diode, causing the signal-transmission circuit to conduct. Azimuth blanking is carried out in a similar manner. The left half of tube V4 is used as a diode and serves to restore the d-c component of the voltage after capacitor C6.

The circuit of the unit has the following control elements:

a) 8 toggle switches which permit any of the channels to be switched on or off;

b) common amplification control of the unit;

c) amplification control of the range-scale markers;

d) limiting control.

Testing the Unit. Testing of unit VS-3 is carried out with the aid of four test jacks:

G1 -- for testing signals at the cathode of tube V1; (p 244)

G3 -- for testing signals at the cathode of tube V3;

G4 -- for testing range blanking pulse at the plate of V4;

G5 -- for testing azimuth blanking pulses.

Design of the Unit. Unit VS-3 is a self-contained instrument mounted on a standard chassis. The tube channel has four tubes (one 6Zh4, two 6P9, one 6N8S) and four test jacks. All the control elements are accessible on the front panel. Two illuminating bulbs are mounted on the panel.

The unit weighs 6.8 kg.

6. Sweep Delay Unit ZR-2 (p 245)

Function. Sweep delay unit ZR-2 (Figure 99) generates trigger pulses delayed with respect to the main trigger pulse produced by trigger unit BZ.

Unit ZR-2 is intended for use with indicator IKO-1 and also may be used with indicators IKO-V1 and IAD-1 in place of unit ZR-3.

Technical data on the unit. The delay is continuously regulated from 10 to 350 km. With the delay unit disconnected, the trigger pulse arrives at the output of the unit without delay.

The output pulse amplitude is not less than 15 v. Delay setting error on the unit's scale does not exceed ± 10 km.

Functional diagram of the unit. A functional diagram of unit ZR-2 is shown in Figure 100.

The unit consists of the following components:

-- trigger pulse tube;

-- clamping diode;

-- phantastron;

-- synchronizing tube;

-- blocking oscillator.

The trigger pulse is admitted to the circuit through the trigger tube. From here it is admitted through a clamping diode to the phantastron and triggers it. At this instant the phantastron generates a square pulse. The phantastron pulse duration is variable and is controlled by varying the voltage at the phantastron plate which is set by the clamping diode with the aid of potentiometer R7 "Delay Setting."

The trailing edge of the phantastron pulse triggers the driven blocking oscillator through the synchronizing tube and generates the delayed trigger pulse. The value of the delay is read on the dial. Switching-on of the delay is carried out by placing switch "Delay" in position "On". When this switch is in position "Off", a main trigger pulse is applied to the blocking oscillator and a trigger pulse without delay is applied to the unit input. (p 248)

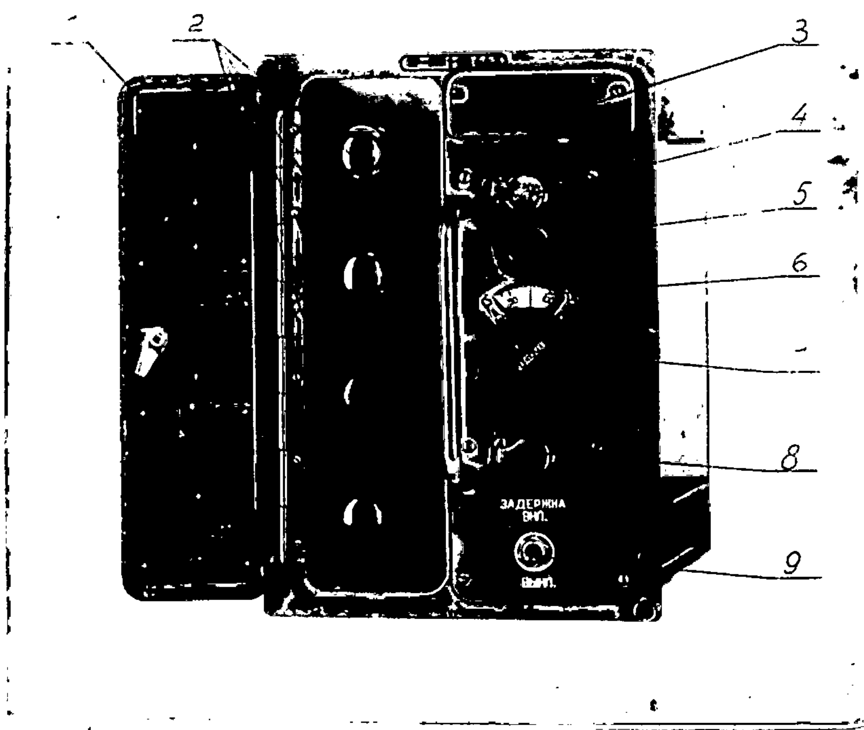

Fig. 99. Unit ZR-2.

1 - label on door; 2 - tubes in tube channel; 3 - cover over connector; 4 - end correction; 5 - socket for dial-illuminating light; 6 - delay dial; 7 - delay control knob; 8 - start correction; 9 - delay toggle switch.

The unit has three controls. The control "Delay Setting" serves for setting the desired value of the delay. Control "Correction of Start" and "Correction of End" serve for setting the highest and lowest value of the delay (matching with the scale).

Description of the functional diagram of the unit. A functional diagram of Unit ZR-2 is shown in Figure 101.

The positive trigger pulse is admitted through trigger tube V1 to the cathode of clamping diode V2a. Then the trigger pulse is admitted through the clamping diode and the phantastron cathode follower (V2b) to the control grid of the main phantastron tube V3.

Description of the phantastron circuit. Prior to the arrival of the trigger pulse, voltage at the control grid of tube V3 is high, and the cathode current is strong and forms a voltage drop at the cathode of this tube which is sufficiently high to blank tube V3 at the auxiliary control grid. At this time there is no plate current in tube V3. Capacitor C5 charges through the cathode follower (tube V2b), grid-cathode resistance of tube V3, and resistors R13, R14. (p 250) Charging is rapid due to the low resistance of the charging circuit.

With the arrival of a negative trigger pulse at the control grid of tube V3, the cathode current of this tube decreases and voltage at the cathode drops, thus making tube V3 conduct through the auxiliary control grid. A plate current now appears in tube V3 and the plate voltage drops. This voltage drop is transmitted through cathode follower V2b and capacitor C5 to the control grid of tube V3, resulting in a further drop of potential and a decrease in cathode current. This process occurs in an avalanche fashion. Now the circuit is in an unstable state. Capacitor C5 recharges through resistors R11 and R10. Voltage at the control grid of V3 now begins gradually to rise and attains a level where the unstable state is disturbed and favorable conditions are created for a new sawtooth process.

As the cathode current of tube V3 increases, so does the voltage at the cathode of this tube. This blocks tube V3 at the auxiliary control grid, decreases the plate current, and increases the plate voltage of tube V3. The increased plate voltage is admitted through cathode follower V2b and capacitor C5 to the control grid of tube V3, thus further increasing tube conductivity. The process occurs in an avalanche fashion and ends by the return of the circuits to the initial state. After this, capacitor C5 is charged through cathode follower V2b, grid-cathode gap of tube V3 and resistors R13 and R14.

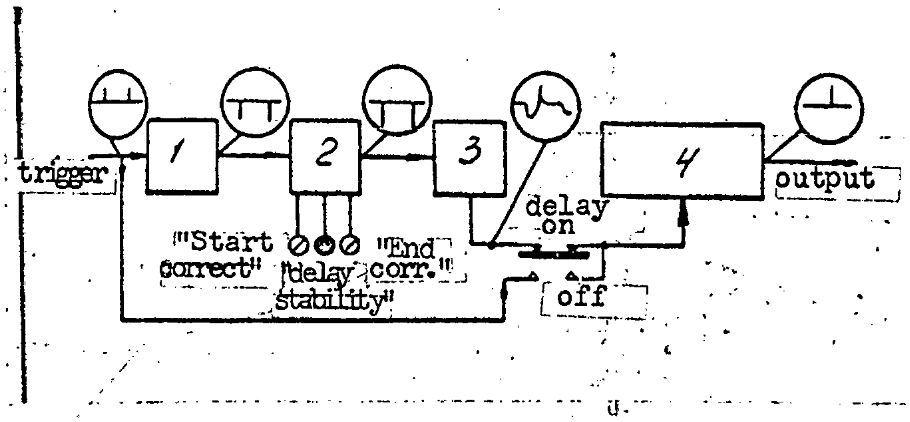

Fig. 100. Functional Diagram of Unit ZR-2.

1 - trigger pulse tube; 2 - clamping diode and cathode follower; 3 - phantastron; 4 - synchronizing tube and blocking oscillator.

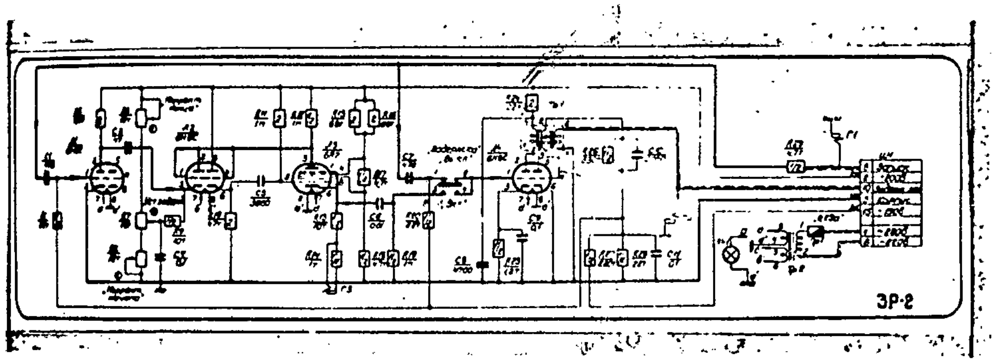

Fig. 101. Schematic Diagram of Unit ZR-2.

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During the operation of the circuit a square pulse of negative polarity is formed at the cathode of tube V3 (Figure 102). (p 251)

When the toggle switch is in the position "Delay On" this pulse is fed to the grid of synchronizing tube V4a and is differentiated in its plate circuit. The differentiated pulse, corresponding to the trailing edge of the phantastron pulse, passes through the grid winding of the blocking transformer to the grid of blocking oscillator V4b.

The blocking oscillator is normally cut off by a negative bias. With the arrival of the differentiated pulse the blocking oscillator operates and generates a delayed trigger pulse which is taken from the third winding of the blocking transformer.

The value of the delay depends on the duration of the phantastron pulse, which in turn depends on the magnitude of voltage at the plate of phantastron V3 when the plate voltage is absent. This voltage can be controlled by potentiometer R7 through clipping diode V2a.

The control limits are set by potentiometer R8 ("Correction of Start") and R6 ("Correction of End").

The magnitude of the delay is read from a visible dial.

Negative bias to the grids of tubes V1a, V4a and V4b is supplied from a common divider consisting of resistors R27 and R28. (p 253)

Testing the Unit. Testing of unit ZR-2 is carried out with the aid of three test jacks:

G1 -- for testing the main trigger pulse at the input of the unit;

G3 -- for testing the phantastron pulse at the cathode of tube V2;

G4 -- for testing the output trigger pulse.

Design of the Unit. Unit ZR-2 is mounted on an individual standard chassis. In the tube channel are four tubes (three 6N8S, one 6A7) and three test jacks.

On the front panel of the unit are the delay turn-on switch, a potentiometer shaft for setting the delay with the dial, and two potentiometer shafts for adjustment of the start and end of the delay. Over the delay setting knob is the dial window and an illuminating bulb for the dial.

The unit has one plug-and-socket connector.

The unit weighs 6.3 kg.

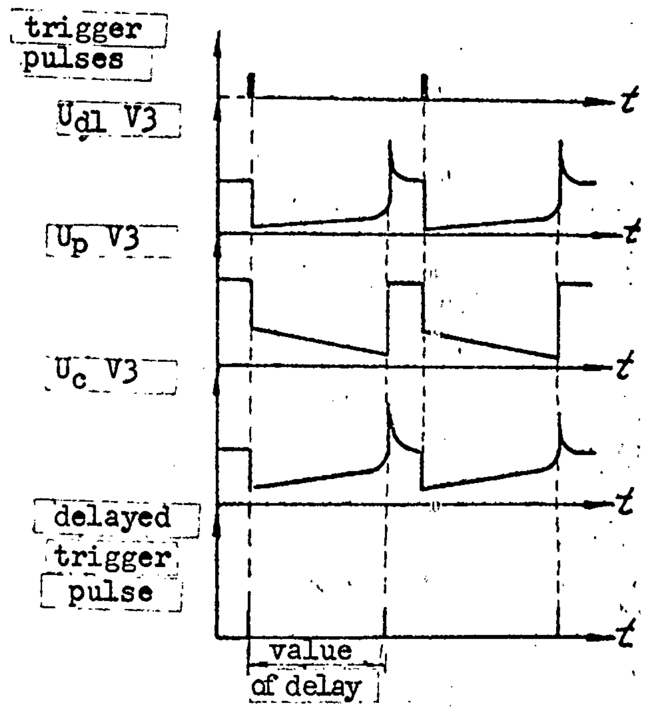

Fig. 102. Voltage Forms in the Delay Circuit.

CHAPTER FOUR

STATION REMOTE CONTROL CABINET DUS-1

1. General Information on Operation of the Cabinet Equipment

The station remote control cabinet DUS-1 (Figure 103) serves for controlling and monitoring the transceiver equipment of the station. Because the DUS-1 cabinet contains its own plan position indicator, it is possible to select the mode of operation for the entire station as well as its individual units and mechanisms.

Presence of the indicator also makes it possible to effectively combat active and passive interferences by switching on protective circuits or switching off the affected channel or the antenna slant.

Signal communications with the electric power unit is carried out from the DUS-1 cabinet.

The cabinet provides for monitoring the output voltages of each of the centimeter-wave receivers and the identification system receiver and the mixed outputs of the vertical and slant channels.

The operation of the units for protection against nonsynchronous pulse interference, located in cabinet ZN-F1, is monitored from the DUS-1 cabinet (on the display screen).

Cabinet DUS-1 consists of the plan position indicator, the mixer system units, and the remote control panel.

The mixer system consists of two identical units -- signal mixers, in one of which are mixed the output voltages of the vertical channel centimeter-wave receivers, and in the other -- the slant channel centimeter-wave receivers. (p 256)

Either of the centimeter-wave channels may be disconnected from the station in these units while retaining the possibility of monitoring the output of each of the receivers on the screen of the cabinet display.

The combined unit for blanking the start and for tuning the interference protection circuits are also part of the cabinet equipment; pulses for blocking the input circuits of the mixers and pulses for tuning the instruments for protection against nonsynchronous interference are generated in this unit.

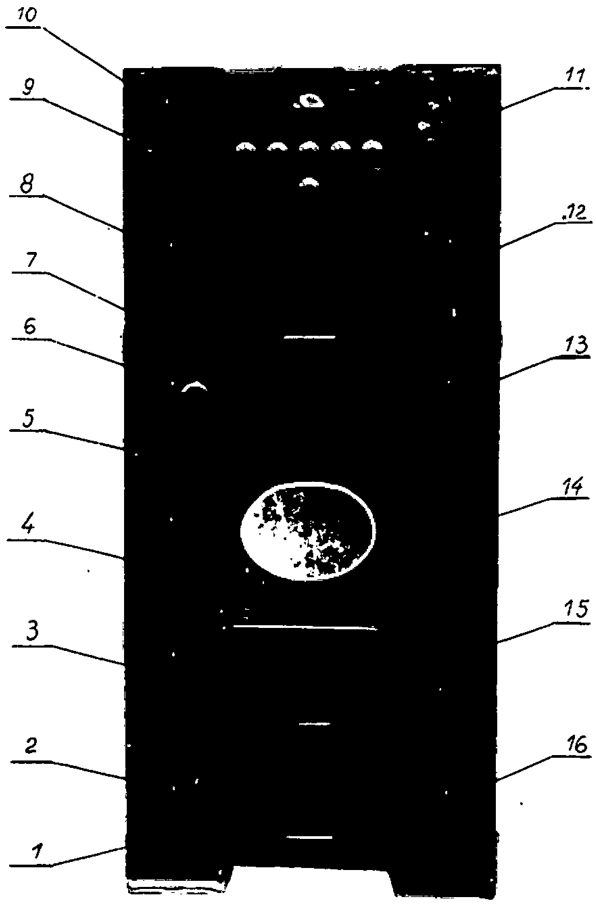

Fig. 103. Cabinet DUS-1.

1 - unit UPT-1; 2 - unit BP-300; 3 - unit BP-200; 4 - unit RD; 5 - unit TI-1; 6 - unit ZR-3; 7 - panel with plugs; 8 - unit BNF; 9 - unit PDU-1; 10 - false panel; 11 - unit US; 12 - unit SS-1; 13 - unit VS-3; 14 - unit SS-1; 15 - unit BP-7; 16 - unit BP-150.

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Technical data. The following units may be switched on and off remotely from the DUS-1 cabinet:

-- receiving-transmitting apparatus of the station;

-- each of the receivers together with the corresponding transmitter;

-- MARU and DIF noise protection circuits in the receivers;

-- circuits for controlling the slant of the antenna reflector system.

2. The cabinet panel provides for the following:

-- monitoring the magnetron current of each of the transmitters;

-- signaling of trouble in the transmitting apparatus and switching on the plate voltage of the magnetrons.

3. The 200 v, 50 cps and the 200 v, 400 cps voltages are monitored in this cabinet. (p 257)

4. Remote switching on of cabin rotation and initiation of the warning signal are provided for in this unit.

5. Adjustment of the output voltage of the VPL-30 unit and the gain circuits of all receivers are possible.

6. Mixing of the output voltages of the three vertical beam receivers into a common vertical channel and of the three slant beam receivers into a common slant channel is performed in the units of the DUS-1 cabinet.

7. The DUS-1 cabinet provides for monitoring the output voltage of each of the receivers and output voltages of the vertical and slant channels on the screen of the oscilloscope.

In addition, the output voltage of each of the centimeter-wave receivers, the output voltage of the vertical and slant channels, and the identification signals may be monitored individually on the screen of the test indicator.

8. Over-all adjustment of the units for protection against non-synchronous pulse interference can be made from the screen of the test indicator.

9. The plan position indicator included in the DUS-1 cabinet has the same technical specifications as the main operating indicator.

Make-up of the DUS-1 cabinet. The station remote control cabinet is a standard plan position indicator combined in a single cabinet with the mixer units and the remote control panel.

The DUS-1 cabinet consists of: (p 258)

-- the plan position indicator with all its units;

-- two signal mixer units SS-1;

-- blanking and filter adjusting unit BNF;

-- remote control panel PDU-1.

For the convenience of the operator, unit US of the indicator has been removed from the main cabinet to an upper attached section and one of the SS-1 units of the slant channel is located in its place.

Thus, in the attached section of DUS-1 are: PDU-1 -- central; the upper left section is a spare, the lower is unit BNF; on the right side (from top to bottom) are units US and SS-1 of the vertical channel. Control panel B-12 of the NRZ-1 system is located on cabinet DUS-1.

Circuit diagram and operating principle of the cabinet equipment. The circuit diagram of cabinet DUS-1 is given in Figure 104. The plan position indicator performs the same functions in the cabinet as the main plan position indicator.

The output voltages of the centimeter-wave receivers are led to the switch of unit ZR-3 from where they are applied to the mixers of the vertical and slant channels -- units SS-1. The two SS-1 units are identical. Each has three input circuits for the centimeter-wave channels. In unit SS-1 the output voltages of the receivers are correspondingly mixed in the vertical and slant channels and pass to the switch of unit ZR-3 for monitoring on the screen of its tube. (p 260) From unit ZR-3 the vertical and slant channel voltages are fed to the cabinet junction box from where they are fed to other indicators. Unit SS-1 has switches from which voltages are applied to the indicator of unit VS-3. With these switches, the output voltages of the receivers and the voltages of vertical and slant channels after mixing may be fed separately to the inputs of the vertical and slant channels of unit VS-3. The IFF voltage from unit B-15 goes to unit VS-3 of cabinet DUS-1.

Remote control panel PDU-1 is part of the control, monitoring, and protection system of the station. Remote switching on, control, and monitoring of the transceiver equipment is performed from unit PDU-1.

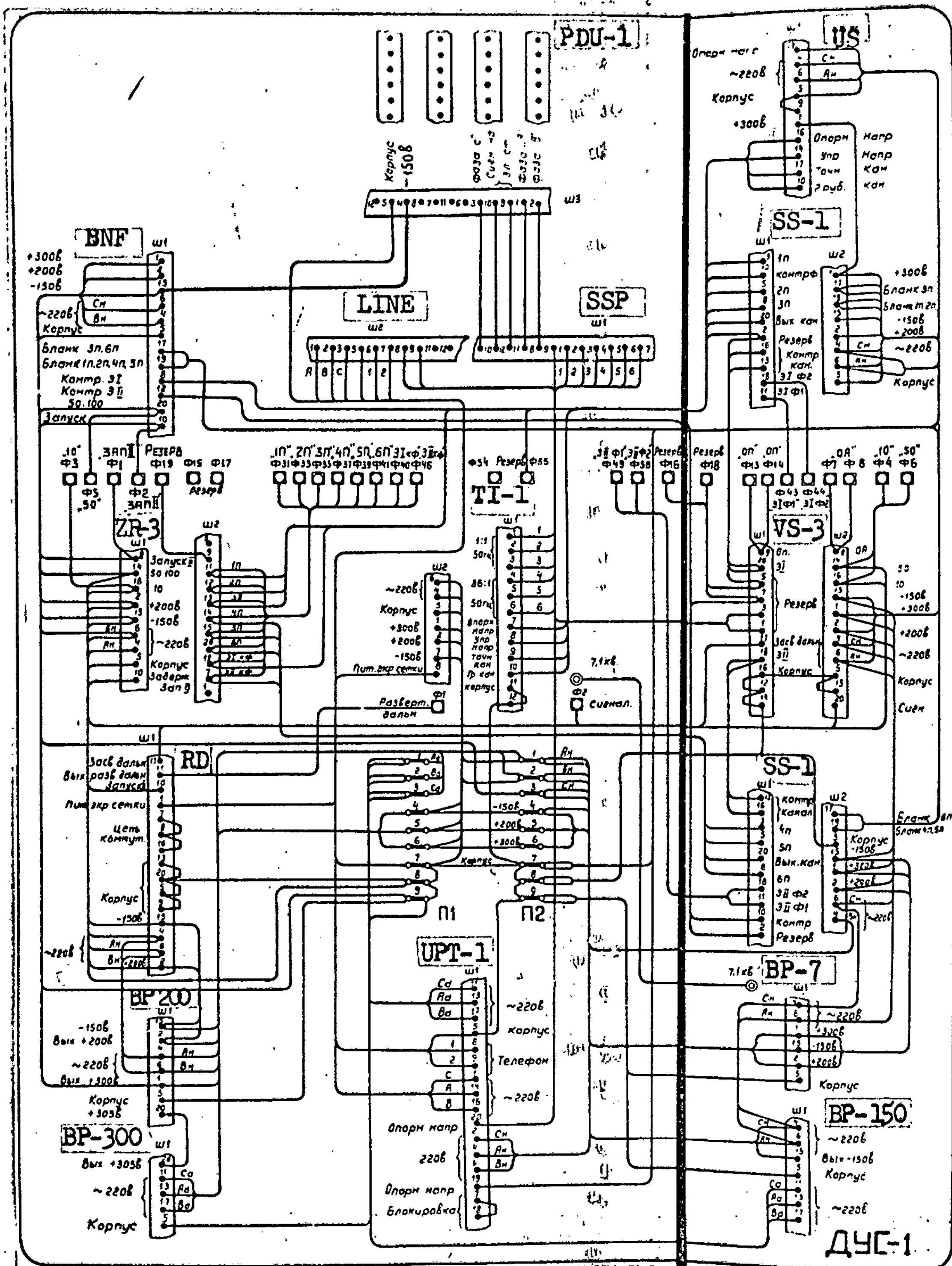

Fig. 104. Circuit Diagram of Cabinet DUS-1.

A complete description of unit PDU-1 is given in Part One, Chapter Four.

Voltage supply for all units of cabinet DUS-1 is taken from the plan position indicator supply units.

2. Signal Mixer Unit SS-1

Function. The signal mixer unit SS-1 (Figure 105) is designed for mixing the output voltages of the three centimeter-wave receivers into a common channel. The station uses two completely identical SS-1 units. One of the SS-1 units mixes the output voltages from the three vertical beam receivers, forming the vertical channel; the other SS-1 unit mixes (p 262) the voltages from the three slant beam receivers, forming the slant channel.

Technical data. The output voltage of the mixed signals of each channel is equal to the voltage at the output of the corresponding receiver, i.e. the amplification factor of the video amplifier is equal to one.

The pass band of the video amplifier is on the order of 2Mc.

Functional diagram of the unit. A functional diagram of unit SS-1 is given in Figure 106. The diagram includes:

-- input circuits;

-- mixed video signal amplifier I;

-- amplifier II;

-- output cathode follower;

-- blocking circuit;

-- test circuit.

The output voltages of the vertical or slant beam receivers enter through the monitoring switch to the input crystal diodes of unit SS-1; the diodes have a common load in which these voltages are mixed.

The simulated signals from unit BNF pass directly through the crystal diode to the common load and are mixed with the echo signals. The load is a potentiometer, from the cursor of which mixed voltages are (p 264) fed to the video signal amplification channel.

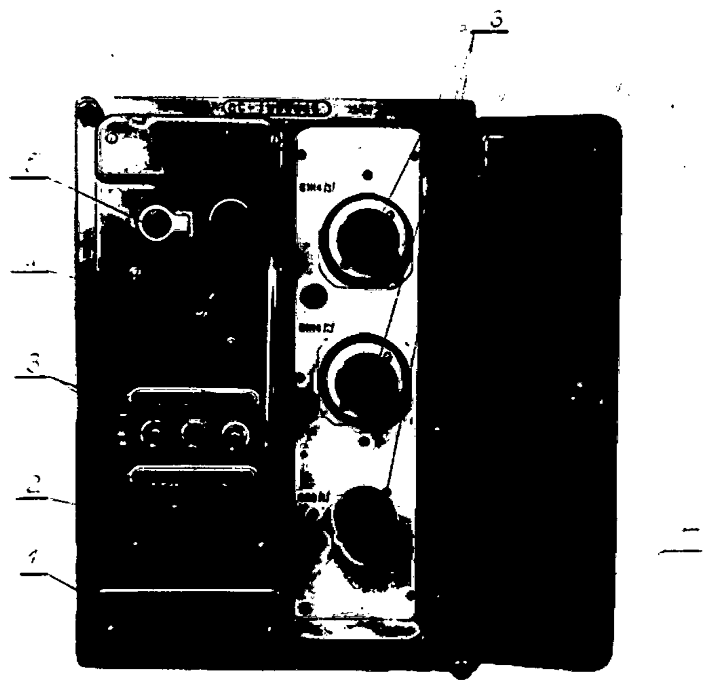

Fig. 105. Unit SS-1.

1 - plug cover; 2 - illuminating bulb holder; 3 - toggle switches for blocking (blanking) and switching off receivers; 4 - monitoring selector switch; 5 - gain control; 6 - tubes in tube channel; 7 - nameplate on door.

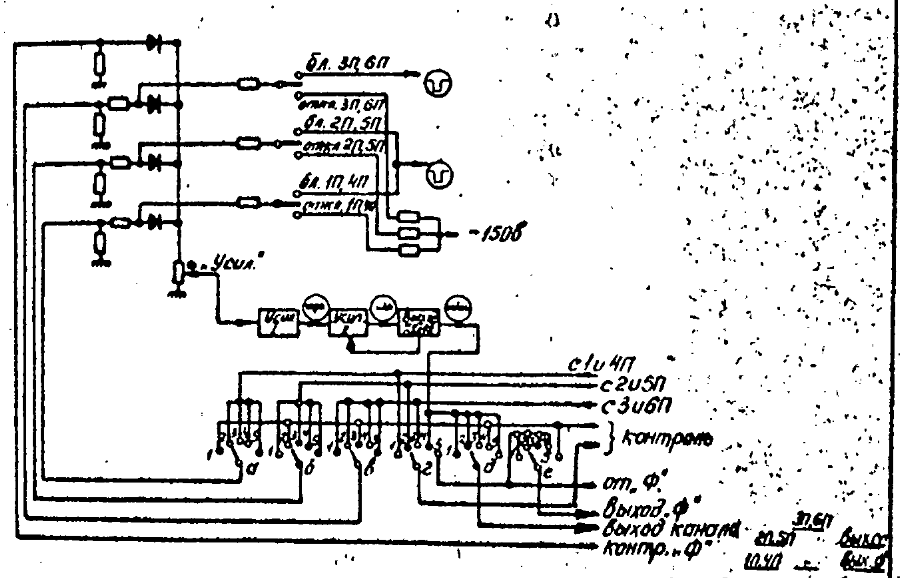

Fig. 106. Functional Diagram of Unit SS-1.

Blocking pulses from unit BNF or a negative voltage for cutting-off the receivers (blocking the input of unit SS-1) are applied to the crystal diodes in the vertical or slant channel receiver circuits.

The mixed video signal amplification channel represents a three-stage amplifier, the last two stages of which have feedback. The "Gain" potentiometer can change (within small limits) the amplitude of the mixed video signals applied to the video amplifier input.

With the aid of the selector switch in units SS-1 it is possible to observe signals coming from the outputs of any of the receivers, mixed signals from the outputs of the vertical or slant channels to all indicators, and also, the same signals after they have passed the interference-protection units.

Description of the schematic diagram. Figure 107 gives a schematic diagram of unit SS-1.

Input and blocking circuits of the unit. Unit SS-1 has 4 input circuits. Three circuits are for the corresponding number of receivers of the vertical and slant channels and are loaded with an impedance equal to the cable characteristic impedance of 75 ohms. The fourth circuit is for simulated signals used for tuning the noise-protecting units. (p 266)

A basic component of the input circuits are diodes D6 and D8 through D10, to which the output voltages of the three receivers are fed through switch V2.

Switches V3, V4 and V5, in this case, must be in the middle position. The crystal diodes have a common load -- resistor R22, through which the input voltages from the receivers are fed.

To eliminate the appearance of blocking pulses or a negative voltage at the outputs of the receivers, dividers consisting of resistors R27 to R29, R32 to R34, R37 to R39, and crystal diodes D11 to D16 are placed in the input circuits of unit SS-1 to reduce these voltages at the input of the unit to approximately 20-25 millivolts.

Mixed video signal amplification channel. The channel consists of tubes V1 (6P9), V2 and V3 (6Zh4). The mixed receiver voltage goes from potentiometer R22 to the grid of video amplifier tube V3.

The signal passes from the plate of the tube V3 (resistors R17 to R19) through coupling capacitor C7 to the control grid of tube V2. In parallel with the grid circuit of V2 are two crystal diodes D3 and D4 for restoration of the d-c component of capacitor C7, and also a correcting network consisting of resistors R12, R13, R14 and capacitors C5 and C6 for creating the necessary video amplifier frequency and amplitude characteristic. From the plate load (resistors R10 and R11),

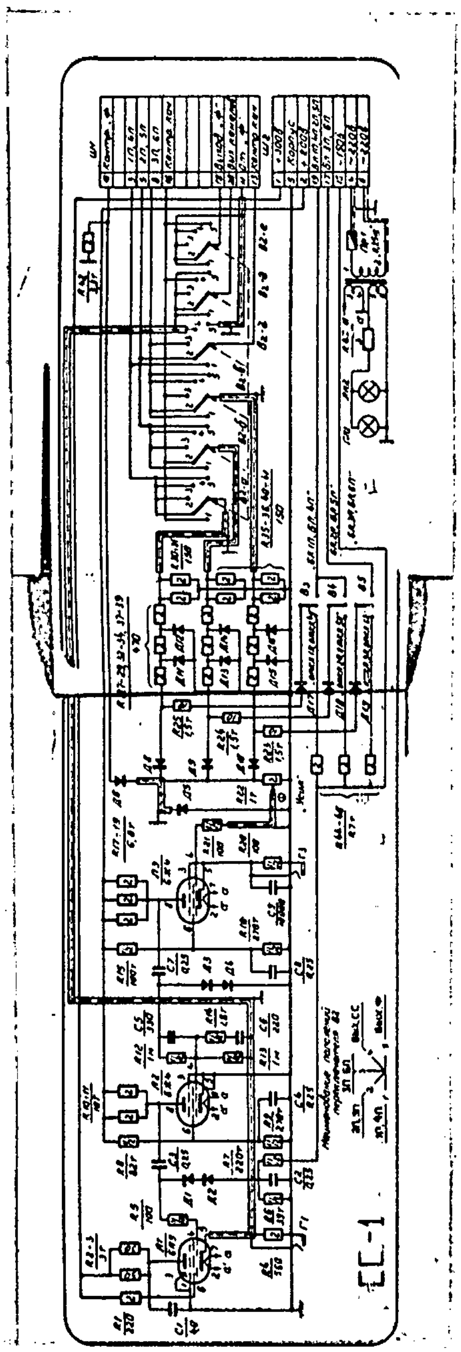

Fig. 107. Schematic Diagram of Unit SS-1.

the signal passes through coupling capacitor C3 to the control grid of tube V1 which operates as a cathode follower.

At the plate of the tube are limiting resistors R2 and R3 which are connected in parallel and blocked by capacitor C1. In the grid circuit of tube V1 are two series-connected diodes D1 and D2 for restoration of the d-c component of the capacitor C3.

A negative voltage of about 19 v, applied to the control grid of tube V1, shifts the characteristic of the tube to the left, thus providing at the output of the unit a d-c component of the tube current no larger than 0.2 v.

Tubes V1 and V2 are provided with feedback. Total amplification factor of the video amplifier is equal to one with a pass band on the order of 2 Mc.

Blocking (blanking) circuits. The unit has three selector switches V3, V4, and V5, which correspond to the number of receivers in each channel. Blocking pulses produced in unit BNF are sent to the input crystal diodes D8, D9, D10 when the switches are in "BL.1P.", "BL.2P.", and "BL.3P." positions. With the switches in the position "OTKL-1P.", "OTKL-2P.", and "OTKL-3P.", a negative d-c voltage is applied. In the first case the input of unit SS-1 will be blocked only during the time of action of the blocking pulse; in the second case the input is (p 268) blocked as long as the switch is in position "OTKL". Resistors R23, R24 and R25 are part of the 150-v voltage divider circuit and form the plate load of the BNF unit output tubes, depending on the position of switches V3, V4, and V5.

Crystal diodes D17, D18 and D19 block the passage of output signals from one output circuit to the other.

Monitoring circuits. Signals from the receiver's output enter switch V2 through which they may be fed to input crystal diodes D8, D9 and D10, or they may first pass to unit VS-3 of the monitoring indicator in cabinet DUS-1 and then to the SS-1 input diodes.

When monitoring the receiver's output on the indicator screen in cabinet DUS-1, the voltage from the output passes to unit VS-3 of cabinet DUS-1 through selector switch V2 and proceeds to the TI-1 indicator tube. From unit VS-3 the voltage goes again through switch V2 of unit SS-1 to the corresponding crystal diode.

Thus, the output voltage is monitored on the indicator screen before entering the signal mixer.

For example, with switch V2 in the first position the voltage from the output of the first receiver goes to switch plate V2g. From the arm of this plate the voltage goes to plug connector Sh1, contact 13, and then to unit VS-3. From unit VS-3 this voltage goes through plug connector Sh1, contact 16, to switch plate V2a, and through its arm and the input circuits to diode D8.

The mixed output of the video channel (position "VYKh.SS") and the mixed output of the video channel after the noise-protection apparatus (position "VYKh. F") are monitored in the same way. Such switching makes it possible to monitor the output of each receiver directly on the screen of the plan position indicator in cabinet DUS-1. Operation of unit SS-1 may be monitored through test jacks G1 and G3.

Design of the unit. Unit SS-1 is assembled on a standard chassis. In the tube channel are two tubes of the type 6Zh4, one 6P9 tube, and two test jacks.

On the front panel of the unit are: monitoring selector switch, potentiometer for control of amplification "USIL.", three switches for blocking the receivers, and two dial - illuminating bulbs.

Unit SS-1 is connected to other units of cabinet DUS-1 by two plug connectors.

Inside the unit are components and small parts.

Weight of the unit is 7.5 kg.

3. Unit BNF for Blanking and Tuning the Filter Units.

Function. During operation of the station the receivers receive signals reflected from the target as well as those reflected from objects located in the immediate vicinity of the station (local objects) which create images on the indicator screen at the beginning of the range sweep. In order to eliminate the images created by these signals on the screen, blanking pulses are applied to the inputs of units SS-1 which temporarily disconnect the receiver circuits.

The blanking stages in unit BNF form these blanking pulses; the pulses have a controlled duration. (p 270)

In unit BNF (Figure 108), in addition to the blanking stages, is a circuit for tuning and controlling the apparatus used for protection against nonsynchronous noises (in the filter units); the apparatus is located in cabinet ZN-F1.

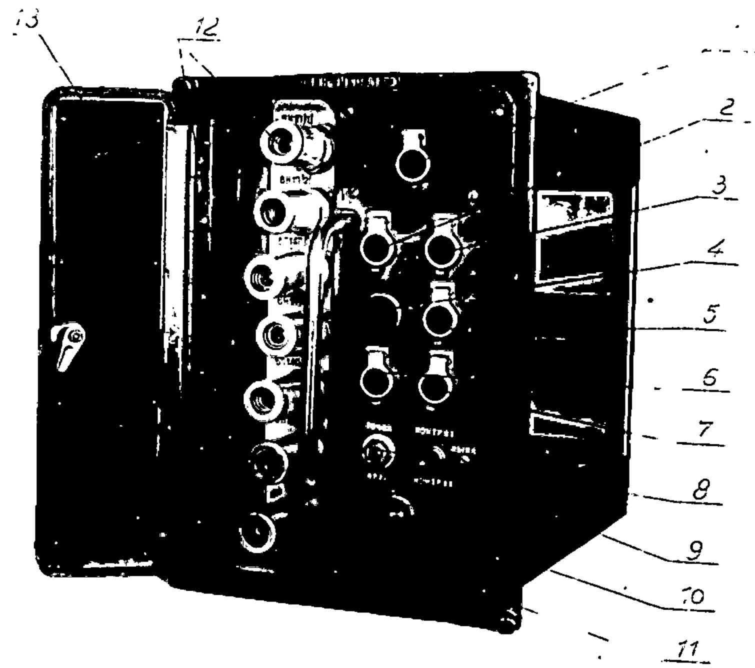

Fig. 108. Unit BNF.

1 - blanking start control; 2 - duration control for blanking pulse of lower receivers; 3 - duration control for blanking pulse of upper receivers; 4 - illuminating bulb holder; 5 - repetition rate control for simulating pulses; 6 - pulse train duration control; 7 - simulating pulse cutoff control; 8 - "Circle-Dot" mode switch; 9 - tube MN-3; 11 - plug cover; 12 - tubes in tube channel; 13 - label on door.

Technical data. The blanking stages produce blanking pulses having regulated duration within the limits of 20 to 110 km for the lower receivers (1st, 2nd, 4th, and 5th) and 20 to 60 km for the upper receivers (3rd and 6th).

The blanking pulse amplitude at the output of the unit under load, during simultaneous blanking of all the receivers and with maximum duration of the blocking pulses, constitutes approximately 60 v.

The circuit stages for tuning and testing the noise-protection apparatus form trains of video pulses which simulate the signals reflected from the targets.

The circuit of the apparatus ensures continuous control of the number of pulses in a train (from three to five), continuous variation of the amplitude within limits up to three volts, and continuous control of the repetition rate of the simulating pulses within limits of 1 cps ±50%.

Functional diagram of the unit. Figure 109 gives a functional diagram of unit BNF.

It includes the following elements:

-- trigger pulse delay stage;

-- lower blanking oscillator;

-- upper blanking oscillator;

-- blanking pulse amplifier; (p 273)

-- control pulse oscillator;

-- kipp relay;

-- gating stage.

The blanking pulse delay stage delays the trigger pulse for a time equal to the duration of the sweep. The stage produces a special delay pulse for this purpose. By means of this pulse, two pulse blanking oscillators of the upper and lower channels are triggered; these pulses are admitted through the amplifiers to the SS-1 units.

Cutoff of the input circuits of the SS-1 units is accomplished by means of corresponding channel switches located in the SS-1 units.

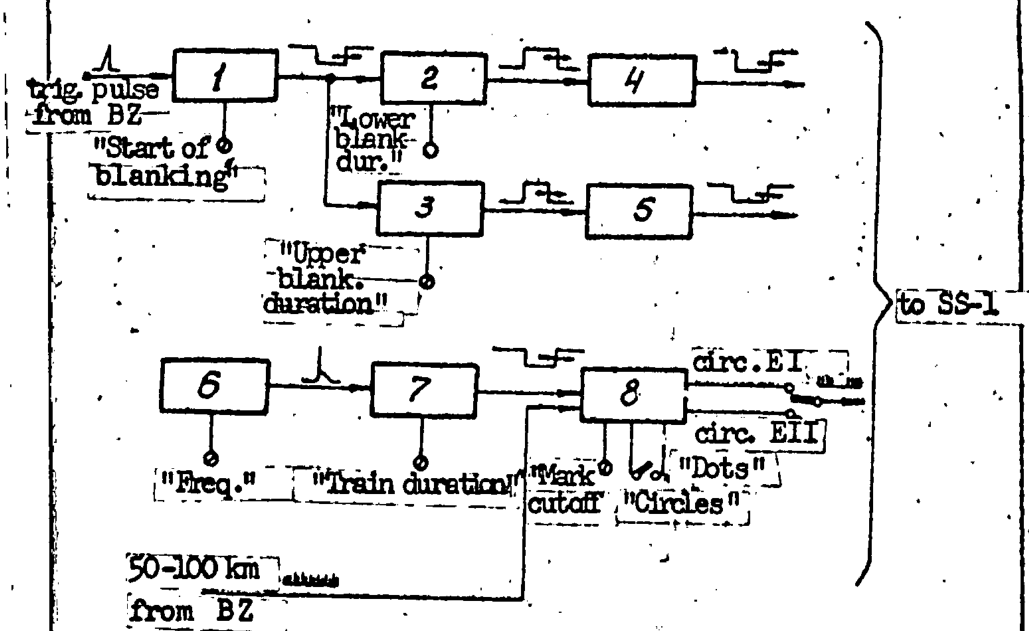

Fig. 109. Functional Diagram of Unit BNF.

1 - trigger pulse delay stage; 2 - lower blanking pulse oscillator;
3 - upper blanking pulse oscillator; 4, 5 - blanking pulse amplifiers;
6 - trigger pulse oscillator; 7 - kipp relay; 8 - gating stage.

The second assembly of the unit is the BNF apparatus for tuning the nonsynchronous noise protection apparatus. The master pulse oscillator generates video pulses with a regulated repetition rate within the limits of one cps ±50%; these pulses trigger the kipp relay, which forms a negative square pulse that is admitted to the gating stage. The pulse duration of the kipp relay is regulated within limits of 9 to 12 microsec.

The gating stage also receives 50 and 100-km range markers from unit BZ; their amplitude is continuously regulated at the input of the unit.

As a result of the effect of the pulses of the kipp relay and of the 50 to 100-km range markers upon the gating stage, a train of video pulses of the simulating marks will appear at the output of the circuit; these marks can be fed with the aid of a switch to the SS-1 units of the vertical (EI) or slant (EII) channels.

The circuit provides for two modes of tuning: "Circle", and "Dots". (p 274) In the "Circle" mode, video pulses of the simulated marks are taken continusouly from the output of the circuit; these pulses form concentric circles on the screen of the monitoring indicator. In the "Dots" mode, trains of pulses are taken from the output of the circuit; these pulses form marks on the indicator screen in a dot form similar to the markers from the circuits and located along the radius of the sweep. Switching from one mode to another is done by means of a toggle switch.

<u>Description of the schematic diagram</u>. Figure 110 shows a schematic diagram of unit BNF.

The trigger pulse delay stage is a kipp relay-type circuit. The stage incorporates tube V1 of the 6N1P type. The trigger pulse is fed through capacitor C4 and crystal diode D1 to the cathode of tube V1 (Figure 111). Prior to the trigger pulse arrival, tube V1b is cut off (by a negative voltage through damping resistance R8) from the -150 v circuit. Tube V1a, prior to the arrival of the trigger pulse, is conducting.

When a trigger pulse arrives at the V1a cathode, the tube ceases to conduct and the plate voltage rises sharply. This causes the voltage at the V1b control grid to rise. V1b conducts and the voltage at its plate falls.

Since resistor R4 is considerably smaller than resistor R3, tube V1b forms (at the common cathode resistance) a voltage which cuts off tube V1a. Capacitors C1 and C2 now begin to charge through resistors R1 and R2.

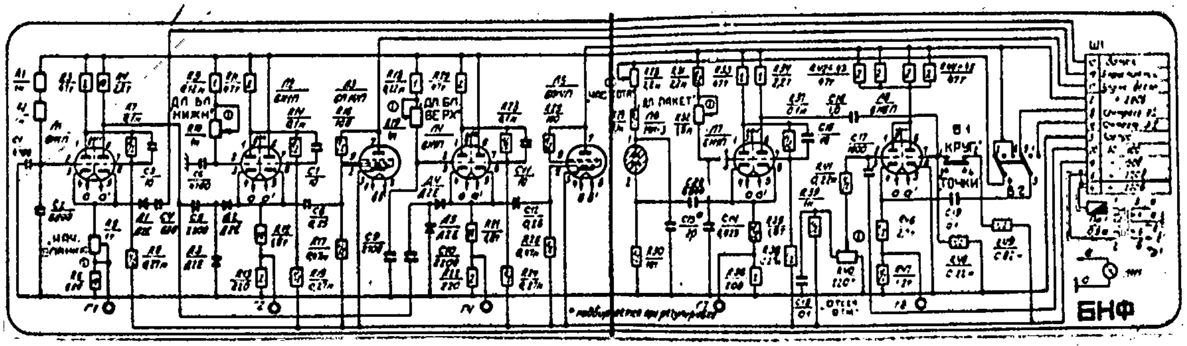

Fig. 110. Schematic Diagram of Unit BNF.

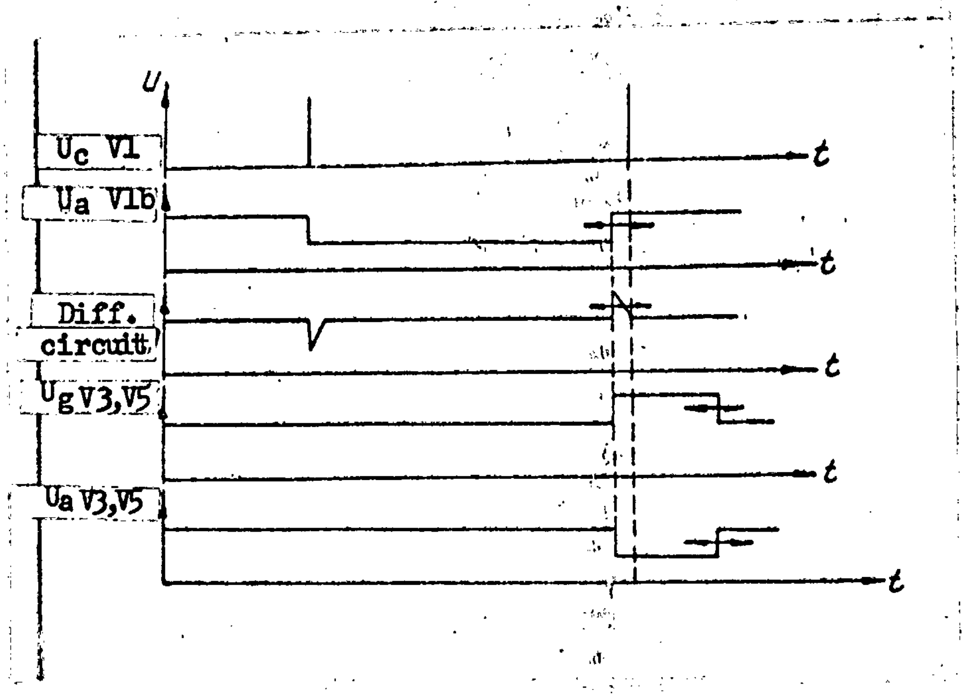

Fig. 111. Voltage Forms in Blanking Stages of Unit BNF.

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The voltage at the control grid of tube V1a grows in proportion to the charge at capacitors C1 and C2; when it reaches the conduction level, tube V1a begins to conduct. When this occurs, the voltage at the plate falls. This cuts off tube V1b. Capacitors C1 and C2 are discharged by the grid currents of tube V1a. The circuit returns to its initial state. As a result of this process, a negative square pulse is formed at the plate of V1b. The duration of this pulse depends on the position of potentiometer R5, which determines the value of the cutoff voltage at the cathode of tube V1. (p 277)

The negative pulse from the plate of tube V1b is admitted to the differentiating circuits C5, R12, and C10, R21.

As a result of the differentiation of the trailing edge of the negative square pulse, there is formed a voltage pulse which triggers the upper and lower channels of the blanking pulse oscillators. Since the duration of the negative square pulse is regulated, the instant at which the positive differentiated pulse is formed also varies relative to the trigger pulse.

The blanking pulse oscillators of the upper and lower channels have similar kipp relay circuits and incorporate tubes V2 and V4 of type 6N1P.

The stages generate positive square pulses which are taken from cathode load R12 and R21.

The duration of the square pulses is regulated by potentiometers R10 and R19, which are connected to the capacitor charging circuits C6 and C9. From the cathode loads of the blanking pulse oscillators, through capacitors C8 and C12, positive square pulses are admitted to the control grids of the upper and lower channel (V3 and V5) of the blanking pulse amplifiers. (p 278)

The blanking pulse amplifiers incorporate tubes V3 and V5 of type 6P14P. The tube grids are blocked in the initial position. With the arrival of positive square pulses to the grids, the tubes begin to conduct and negative pulses appear at their plate load resistances, located in the SS-1 units.

The amplifiers ensure the required amplitude of the blocking pulse. When the switches in the SS-1 units are turned on, the plate circuits of tubes V3 and V5 start to conduct and negative pulses appear at the plate loads which cut off the corresponding input diodes of the SS-1 unit.

The supply of tubes V3 and V5 comes from the -150 v power source.

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The trigger-pulse generator operates on the principle of a relaxation oscillator. The stage incorporates tube V6 of type MN3.

Capacitor C13 is charged through resistors R28, R29; the capacitor is connected in parallel with tube V6. (p 279)

When the voltage necessary to fire the tube has been obtained at the capacitor plate (connected to V6), the tube begins to conduct, and a rapid discharge of C13 takes place through it.

At resistor R30 a positive voltage pulse is formed (Figure 112) which, through capacitor C20, is applied to the cathode of the kipp relay stage V7. The charging time of capacitor C13 and, consequently, the triggering frequency of the oscillator, is regulated by potentiometer R28.

The kipp relay circuit is analogous to the circuit examined in the blanking stages. The stage incorporates tube V7 of the 6N1P type. From the plate load resistance R34 of tube V7b a negative square pulse is admitted through capacitor C16 to the control grid of tube V8b. The duration of the generated pulse is varied by means of potentiometer R32.

The gating stage incorporates tube V8 of type 6N6P. Fifty-and 100-km range markers pass through the plug connector Sh1 and contact 20 to the unit and through potentiometer R40 and capacitor C17 to the control grid of tube V8b.

Tube V8b conducts in the initial stage. The voltage at its plate and at the plate of tube V8a is low. The operating mode of V8a is such that when V8b conducts, tube V8a is cut off. With the arrival of the kipp relay negative pulse at its control grid, tube V8b stops conducting and the voltage at the plates of V8a and V8b rises. Now tube V8a starts to conduct and pulse trains appear at its cathode load R46, R47. The duration of the kipp relay blanking pulse lies within the limits of 9 to 12 microsec, which corresponds to the time for 3 and 5 sweeps on the indicator. During this time, from 3 to 5 range marker pulses will be formed at the resistances R46, R47. (p 281)

By means of switch V2, the pulse trains from resistors R46, R47 pass through capacitor C19 to the SS-1 units of the upper and lower channels. By means of toggle switch V1, the gating stage is switched over to either of the two modes of operation:

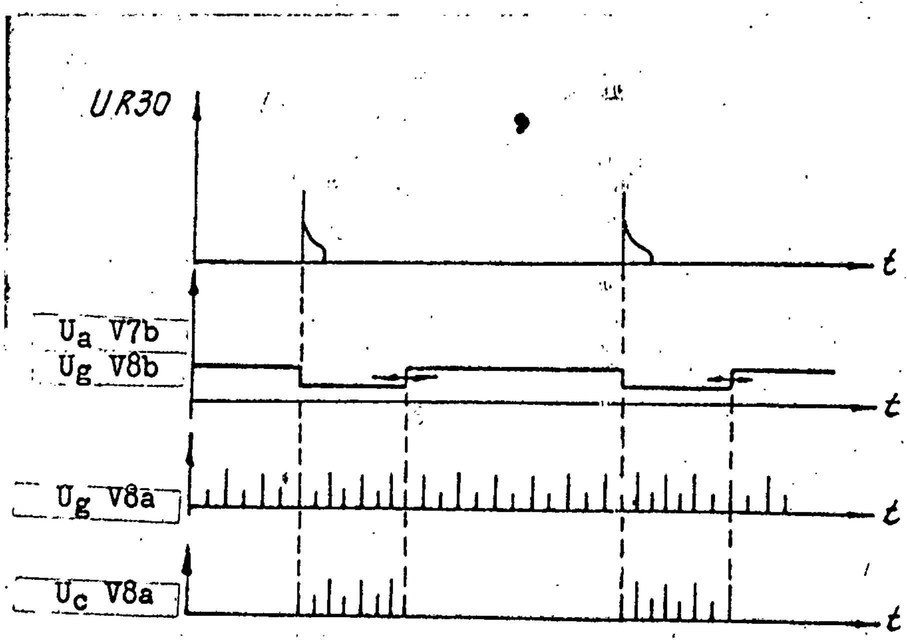

Fig. 112. Voltage Forms in Stages of Device for Tuning Noise-Protection Apparatus of Unit BNF.

-- "Dots" - when the kipp relay negative pulse is admitted to the control grid of tube V8b;

-- "Circle" - when a negative voltage is applied to the same grid through resistor R49 from the -150 v source.

In the "Dots" mode, pulse trains appear at resistors R46, R47, as was stated above, which form marks in the form of dots located along the sweep radii on the indicator screen.

In the "Circle" mode, the range markers are repeated at resistor R46, R47 so that concentric circles will be visible on the indicator screen.

The intensity of the markers is regulated by potentiometer R40.

Testing of the unit. The unit is tested with the help of five test jacks:

G1 -- for testing the blanking pulse start delay;

G2 -- for testing the lower blanking 1P, 2P, 4P, 5P;

G4 -- for testing the upper blanking 3P, 6P;

G7 -- for testing the kipp relay pulse;

G8 -- for testing the gate stage output pulses.

Construction of the unit. Unit BNF is assembled on a standard chassis. In the tube channel are located seven tubes (four 6N1P, two 6N14P, one 6N6P).

On the forward panel are all the potentiometers and two toggle switches, tube MN-3 with a cap, and the illuminating bulb.

Unit BNF is connected with other units in cabinet DUS-1 by means of one plug-and-socket connector. Within the unit are located other components and small parts.

The weight of the unit is 7.8 kg.

CHAPTER FIVE

HEIGHT MEASUREMENT INDICATOR IIV-1

1. General Information on the Operation of the Indicator

Height measurement indicator IIV-1 (Figure 113) is designed for measuring the height of detected targets. Measurement of the height of targets takes place through the arrival at the indicator of the signals from the vertical and slant channels. On the indicator screen appear points from which, with the aid of the scale projected onto the screen of the tube, it is possible to determine the heights of the detected targets.

The height measurement indicator is an oscillographic one with horizontal and vertical sweeps and an intensity spot signal.

Sweep across the horizontal axis of the tube is linear and proportional to the uniform range scale. Sweep on the vertical axis is also linear and is proportional to the angle of rotation of the antenna system relative to any fixed initial position. (p 284

The range sweep voltage controls the current in the coils which deflect the beam in the horizontal direction, and, as a result, the beam moves to the left or right across the horizontal axis of the tube.

The sweep voltage for the angle of rotation of the antenna controls the current in the coils which deflect the beam of the cathode-ray tube in the vertical direction, and the beam therefore moves upward along the vertical axis of the tube.

The reflected signal voltages of the vertical and slant channels which pass to the display from the signal-mixer units (SS-1) are fixed on the screen in the form of two vertical lines extending along the vertical axis of the screen.

The mutual position of these lines on the screen determines the value of the angle of rotation of the antenna system between successive interceptions of the target by the vertical and slant beams.

Hence, the range and angle of rotation of the antenna system may be read directly from the screen of the display tube on the electrical grid scale.

Having determined the angle of rotation of the antenna and the range, the flight altitude of the target may be computed from known formulas.

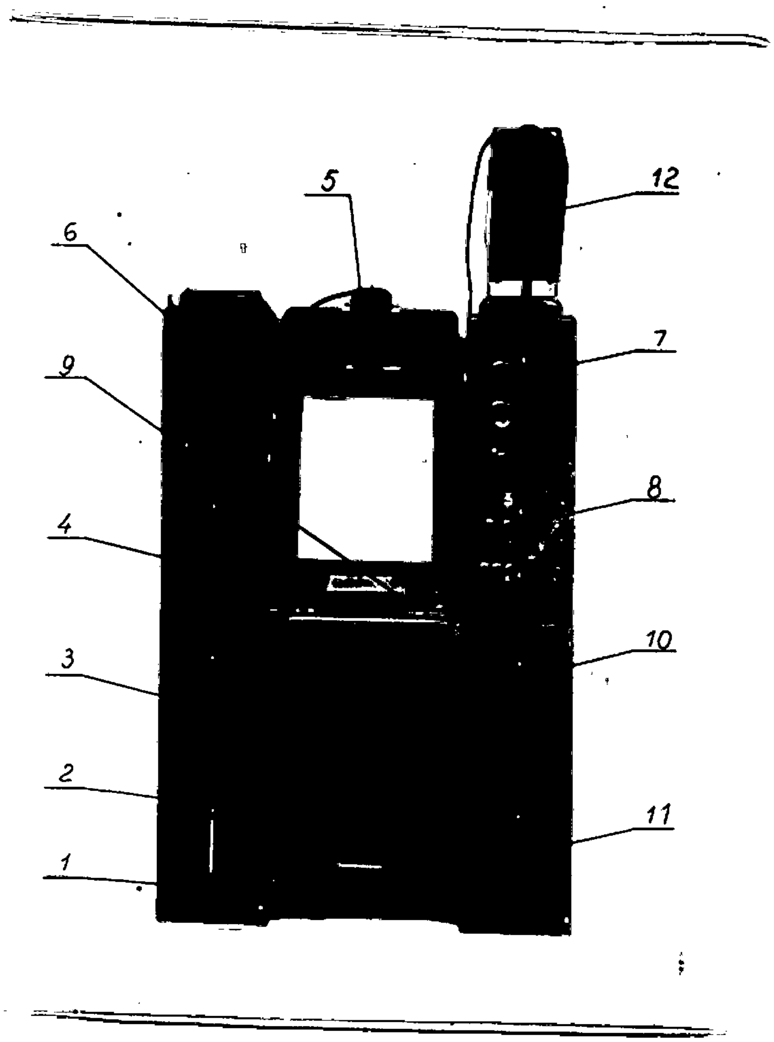

Fig. 113. Cabinet IIV-1.

1 - unit BP-300; 2 - unit UPT-1; 3 - unit BP-200; 4 - unit RD; 5 - unit PN-12; 6 - unit RU-2; 7 - unit RU-1; 8 - unit VS-4; 9 - unit TI-2; 10 - unit BP-7; 11 - unit BP-150; 12 - unit UN-II.

In order to increase operability, computations are first made for altitudes from 0 to 30 km at every 2 km for all values of range from 20 to 300 km. Lines of equal altitude computed in this manner and scale lines for range and angle of rotation of the antenna are transfered to a diapositive and are projected on the screen of the display with the aid of a special optical device (unit PN-12).

The height of the target is determined by visually interpolating (p 285) the position of the center of the marker from the slant channel reflected signal with respect to the lines of equal altitude which lie closest to it.

In order to read the altitude correctly it is necessary to align the electrical scale markers with the scale markers projected on the screen of the tube. Height of the target is determined once the zero line of the projected scale coincides with the center of the reflected signal markers of the vertical channel.

When the vertical and then the slant beams intercept two targets with the same azimuth located at different altitudes but at different ranges, the targets will be visible at different elevations.

When the target is near, two successive interceptions of the target by the vertical and slant beams will be made with large values for the angle of rotation of the antenna. For the same scale of angles of rotation of the antenna, the accuracy in determining altitude would drop as the range increases. Therefore, two vertical sweep scales -- 20° and 40° -- are used.

The use of two vertical sweep scales makes it possible to read the altitude with minimum error at all ranges. An optical image presented on the screen of the height-measurement indicator is given in Figure 114.

Technical data. 1. Target display is by a brightness marker on (p 287) the screen of the cathode-ray tube.

2. Range is indicated by the horizontal sweep and angle of rotation of the antenna by the vertical sweep.

3. Antenna angle of rotation scales are 20° and 40°.

4. Range scale on the screen of the display is from 20 to 200 km for an angle of rotation scale of 40° and from 120 to 300 km for an angle of rotation scale of 20°.

5. Height is determined by the vertical and slant antenna method.

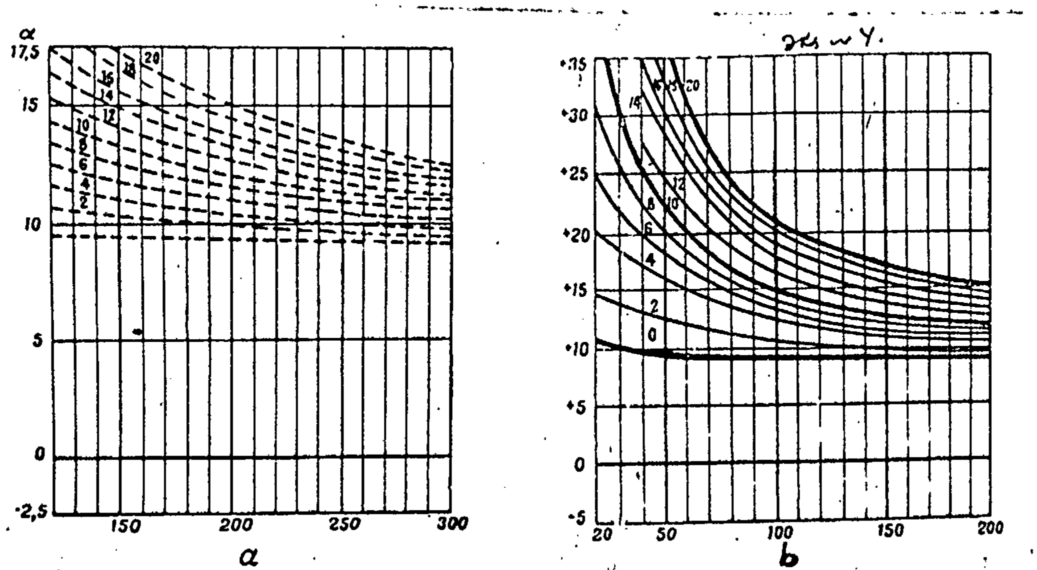

Fig. 114. Optical Image on the Screen of the Height Measurement Indicator.

a) scale for antenna angle of rotation of 20°; range from 120 to 300 km;

b) scale for antenna angle of rotation of 40°; range from 20 to 200 km.

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The height of the target on the screen of the tube is determined visually from the position of reflected signals of the mixed vertical and mixed slant channels relative to the lines of equal altitudes projected on the screen of the display by an optical method.

6. The height-measurement indicator provides for the successive illumination of reflected signals from the vertical channel on the lower part of the screen and illumination of signals from the slant channel on the top part of the screen. This makes it possible to simultaneously observe the reflected signals of both channels on the screen.

Make-up of the IIV-1 cabinet. The height-measurement indicator is built in a standard cabinet and consists of the following units:

TI-2 -- display tube;

RD -- range sweep;

RU-1 -- elevation sweep input unit;

RU-2 -- elevation sweep output unit; (p 288)

VS-4 -- video signal unit;

PN-12 -- projection adapter;

BP-300 -- +300 v power supply;

BP-200 -- +200 v power supply;

BP-150 -- -150 v power supply;

BP-7 -- +7.1 kv power supply;

UPT-1 -- power supply control unit.

Units TI-2 and UPT-1 are centralized. In compartments on the left side (from top to bottom) are units RU-2, RD, BP-200, and BP-300, and on the right side are units RU-1, VS-4, BP-7, and BP-150. The projection adapter unit is located on the front panel of unit TI-2 (in place of the light filter).

A diagram showing the wiring connections for the IIV-1 display is given in Figure 115. Trigger pulses from unit BZ pass to unit RD. Unit RD is the same as that in the IKO-1 cabinet. Unit RD shapes a sawtooth current which supplies the horizontal deflection coils in unit TI-2.

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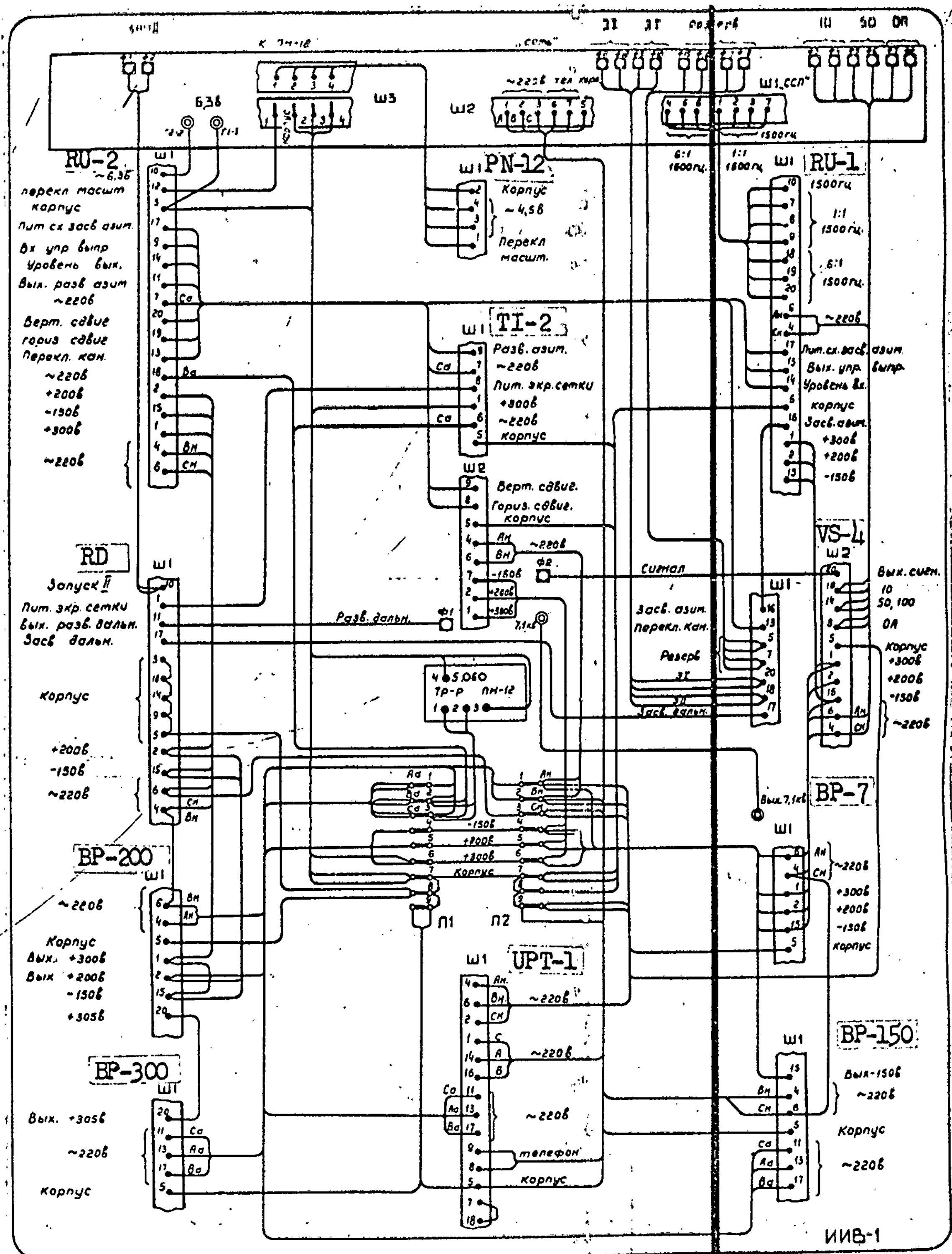

Fig. 115. Diagram of Wiring Connections for Cabinet IIV-1.

A description of unit RD is given in Chapter Three, section 4.

Note: The scale switch in unit RD of cabinet IIV-1 must be placed in the first position. The switch is not used.

The SSP (selsyn) voltages are applied to unit RU-1 from unit VD-1. (p 290) Units RU-1 and RU-2 shape a voltage proportional to the angle of rotation of the antenna which is used to supply the vertical deflection coils, to shape the square pulses which trigger the elevation sweep, and to switch channels in unit VS-4.

Unit VS-4 receives voltages from the outputs of the vertical and slant channel signal-mixer units, range and azimuth scale marker pulses, range gating pulses from unit RD, and an elevation sweep gating voltage from unit RU-1. Incoming video signals and scale marker signals may be turned on and off individually at the input of the unit.

The signals entering unit VS-4 are mixed, amplified, and sent to the modulator of the cathode-ray tube in unit TI-2. Switching of the vertical and slant channels is also provided for in unit VS-4. (p 291)

Unit TI-2 contains the stages which supply the alignment coils and focusing coil.

An electrical scale grid is illuminated on the screen of the tube and, in addition, a scale grid and equal-height lines are optically projected on the screen from which the height of the target is read. The electrical and optical scale grids are first aligned on the screen. A description of the method of aligning the grids is given in the description of unit RD.

Unit PN-12 is used to project the scale grid on the screen.

All units in cabinet IIV-1 are supplied from standard power supply units BP-300, BP-200, BP-150, and BP-7.

2. Indicator Tube Unit TI-2.

Function. Unit TI-2 (Figures 116 and 117) is used to determine the flight altitude of detected targets on the screen of the tube using a scale which is optically projected on the screen.

Technical data. 1. The accuracy of aligning the electrical and optical scales for an antenna angle of rotation from 5° to 30° and a range from 20 to 250 km is ±1 mm.

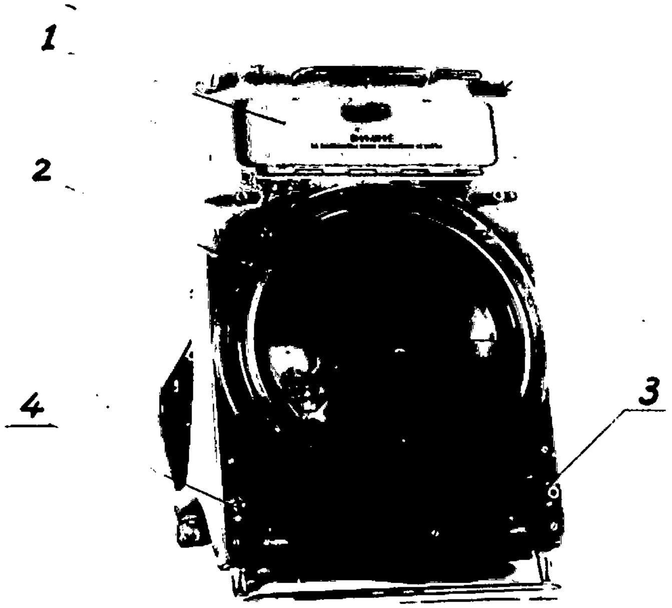

Fig. 116. Unit TI-2 (Front View).

1 - door of tube compartment; 2 - screen of tube 31LM32; 3 - focus control; 4 - brightness control.

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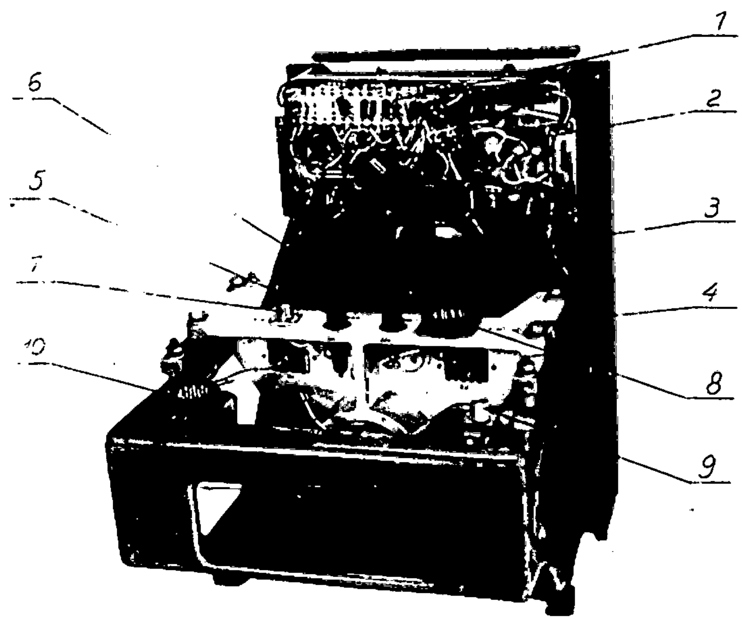

Fig. 117. Unit TI-2 (Rear View)

1 - plate for mounting small parts; 2 - transformer; 3 - tube housing; 4 - bracket for attaching deflection system; 5 - fuse; 6 - fuse condition indicator; 7 - plug for sweep voltage supply; 8 - plug for SSP voltage supply; 9 - plug for feeding signals to tube modulator; 10 - plug for power supply voltage.

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2. A point focused in the center of the screen changes its dimensions at the edges of the screen by a factor of not more than 1.5.

A functional diagram of unit TI-2 is given in Figure 118.

The unit includes:

-- cathode-ray tube;

-- deflection system;

-- vertical and horizontal alignment stages; (p 295)

-- focusing stage;

-- brightness control circuit;

-- +500 v rectifier.

Description of the schematic diagram of the unit. Figure 119 gives a schematic diagram of unit TI-2.

The main element of the unit is the cathode-ray tube V5, type 31LM32, whose screen is used to determine the height of the target.

The tube operates in conjunction with a magnetic system which includes the deflection and focusing coils.

Unit TI-2 uses closed-type deflection coils (on a closed iron core).

The deflection coils are used to deflect the electron beam of the tube away from its axis in response to a predetermined rule.

Four coils, located two each on the vertical rods of the core, deflect the beam in a horizontal direction. Each coil has two sections 1 and 2. The series-connected coils of section 1 deflect the beam in a horizontal direction and are supplied by a sawtooth voltage from unit RD. Deflection of the beam is proportional to the current through the coils. In order that the horizontal sweep begin from the edge of the tube rather than the center, the series-connected coils of section 2 are introduced and connected against the coils of section 1.

These coils are supplied by a d-c voltage through tubes V1 and V2. The value of this d-c current and, consequently, the deflection of the beginning of the sweep can be changed by means of a potentiometer in unit RU-2. (p 297)

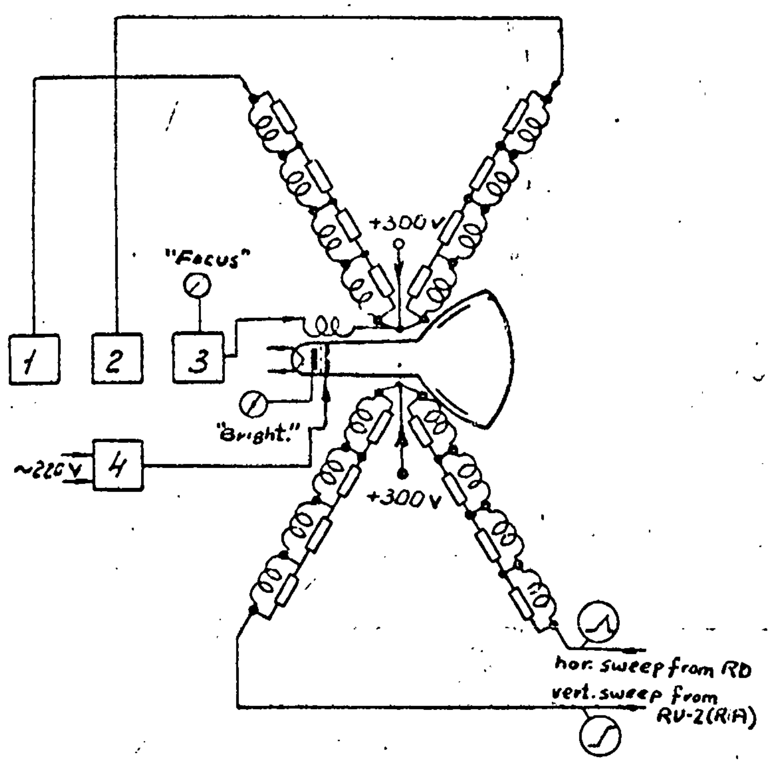

Fig. 118. Functional Diagram of Unit TI-2 (TI-3).

1 - horizontal alignment circuit; 2 - vertical alignment circuit; 3 - focusing circuit; 4 - transformer and +500 v rectifier.

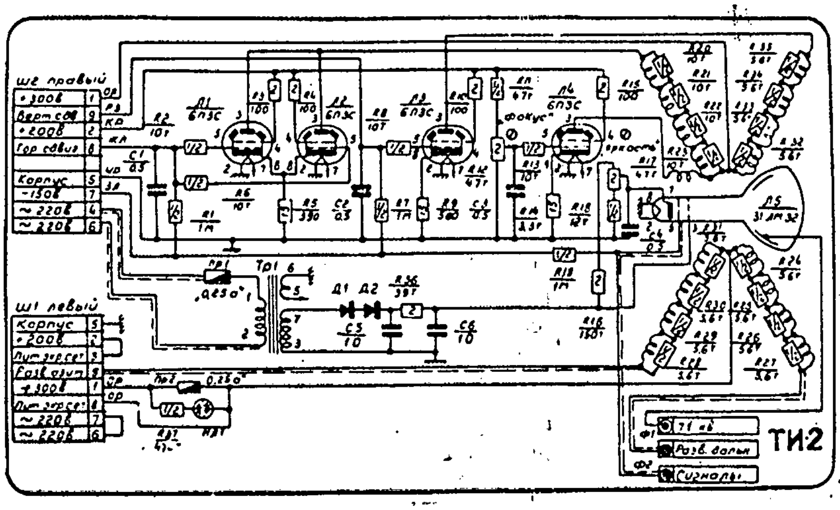

Fig. 119. Schematic Diagram of Unit TI-2 (TI-3).

Four coils, located two each on the horizontal rods of the core, deflect the beam in a vertical direction. The coils of section 1 are connected in parallel and deflect the beam vertically. These coils are supplied by a voltage proportional to the angle of rotation of the antenna which originates in unit RU-2.

In order that the vertical sweep begin at the bottom of the screen and not at the center, the series-connected coils of section 2 are introduced and connected against the coils of section 1. These coils are supplied by a d-c voltage through tube V3. The value of this current and, consequently, the deflection of the start of the vertical sweep can be changed by means of a potentiometer located in unit RU-2.

Each section of the coils is shunted by a resistor for the purpose of quenching natural parasitic oscillations (the shunting resistors are placed in the coils).

The focusing system and the brightness control circuit in unit TI-2 are identical to those in unit TI-1 (Chapter Three, section 2). An over-all view of the deflection system of unit TI-2 is given in Figure 120.

Design of the unit. The unit is located in the central compartment of the indicator cabinet. The unit contains: cathode-ray tube 31LM32 with deflection and focusing systems, four 6P3S tubes, and a +500 v rectifier transformer.

The deflection system is designed to provide for shifting of the coils around their bases when aligning the electrical scale markers with the optical lines of the scale.

Above the tube is a panel on which all tubes and small components are mounted.

On the front panel are the screen of the cathode-ray tube with a frame and the knobs of the brightness and focus controls. Means for securing the optical attachment are also provided.

The unit is held in the cabinet in such a manner that it may be (p 299) turned 45° around the point of attachment in its compartment.

The unit is linked to the other units in the cabinet by two 14-pin plug connectors, a high-voltage plug, and two high-frequency plugs.

One of the 14-pin plugs is attached to the chassis of the unit and the other to a bracket on the deflection system.

The unit weighs 13.8 kg.

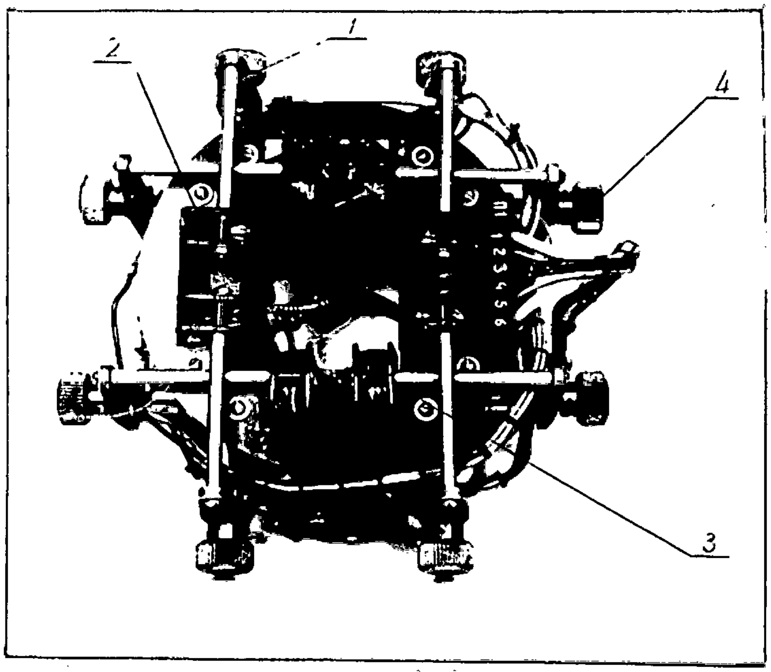

Fig. 120. Deflection System of Unit TI-2.

1 - adjustment screws of horizontal deflection coils; 2 - horizontal deflection coils; 3 - vertical deflection coils; 4 - adjustment screws of vertical deflection coils.

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3. Projection Adapter Unit PN-12 for Cabinet IIV-1

Function. The PN-12 projection adapter unit is designed for projecting a family of equal-altitude curves and a scale grid on the phosphor of the tube screen in unit TI-2.

Technical data on unit PN-12. 1. When projecting a square (20 x 20 cm^2) on a surface, the projection unit gives a barrel-shaped distortion (with a positive distortion of 4.2%).

2. When looking at the screen of unit TI-2 through the semi-transparent glass of the optical attachment, the brightness of the yellow afterglow is reduced by not more than 40%.

3. The thickness of the focused optical lines is 0.3 to 0.5 mm.

4. The vertical alignment control for the diapositives permits adjustment of both images on the screen of the tube in unit TI-2 by at least ±50 mm and fixing them in position with an accuracy of ±0.2 mm.

Optical diagram of the unit. An optical diagram of the unit is given in Figure 123.

The light source passes through a condenser and illuminates two diapositives of complementary colors (red and green). On the red diapositive are transparent equal-altitude curves and a scale grid for the following scales: a 20° azimuth representing 160 mm on the screen, and a 180 km range representing 200 mm on the screen (from 120 to 300 km). On the green diapositive are transparent equal-altitude curves and a scale grid for the following scales: a 40° azimuth representing 200 mm (p 303) on the screen, and a 180 km range representing 200 mm on the screen (from 20 to 200 km). Light passing through the transparent curves of one of the diapositives and through the second diapositive assumes the color of the second diapositive.

The light rays then pass through a light filter, through an objective lens, are reflected first by a mirror and then by a semi-transparent glass, and finally are projected on the phosphor of the screen of the tube in unit TI-2. A red or a green image appears on the screen depending on the color of the filter selected (by means of a knob).

Design and electrical diagram of the unit. Unit PN-12 is attached to the front panel of unit TI-2 by four screws. Unit PN-12 may be tilted away from the front panel of unit TI-2 to provide access to the tubes of the latter and the front panel of the unit.

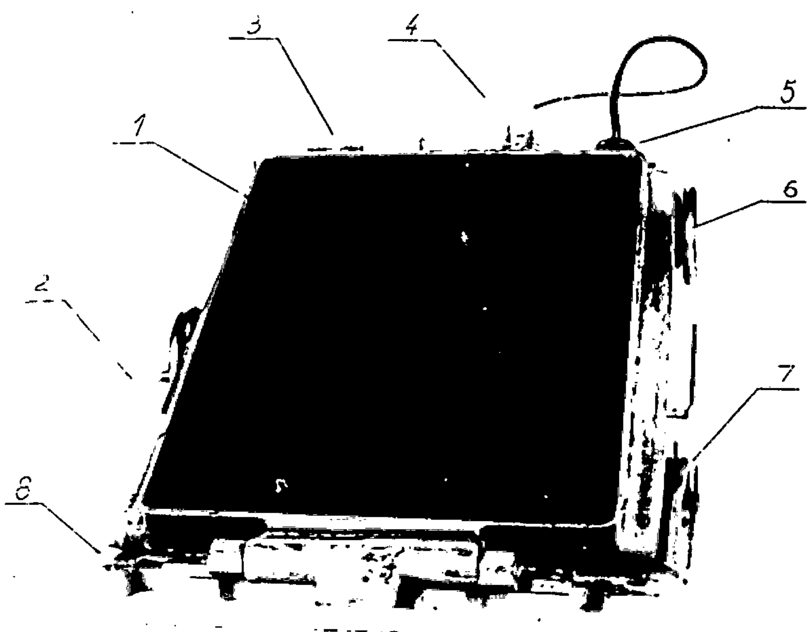


Fig. 121. Unit PN-12 (Front View).

1 - semitransparent glass; 2 - handle for shifting optical scales in vertical direction; 3 - desicant holder; 4 - removable illuminating light; 5 - plug; 6 - knob for switching 20 and 40° scales; 7 - catch; 8 - seating holes.

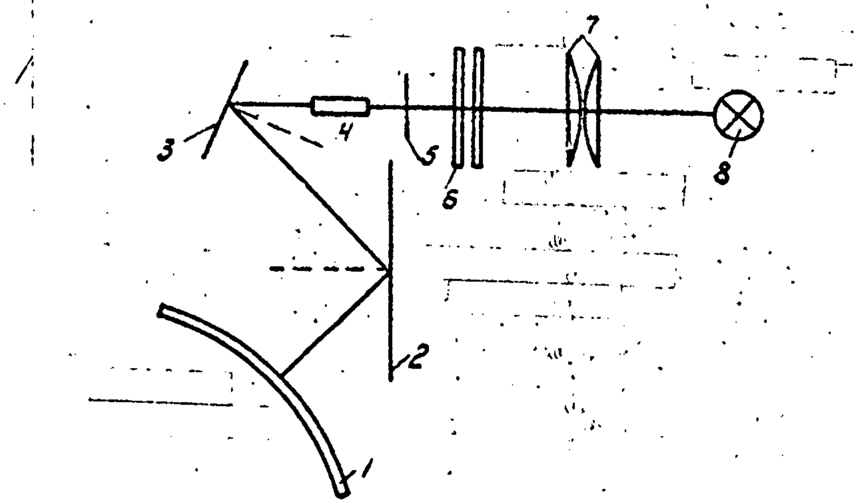
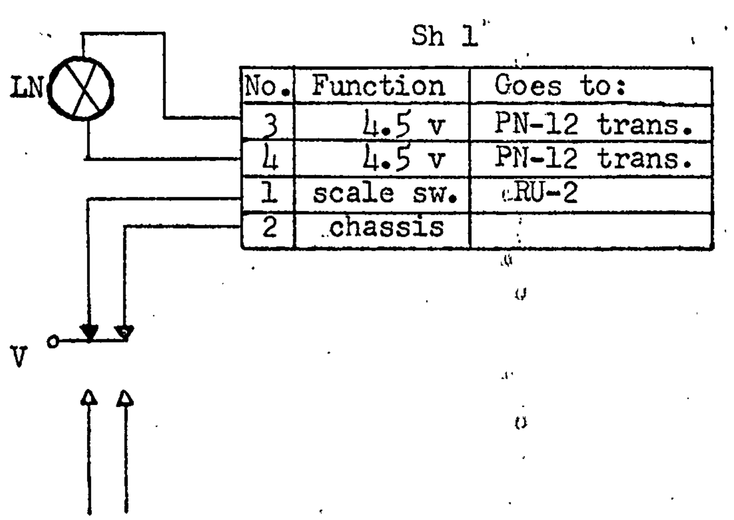


Fig. 123. Optical Diagram of Unit PN-12.

1 - screen of unit TI-2; 2 - semitransparent glass; 3 - mirror; 4 - objective lens; 5 - filter; 6 - diapositives; 7 - condensor; 8 - light source.



No.	Function	Goes to:
3	4.5 v	PN-12 trans.
4	4.5 v	PN-12 trans.
1	scale sw.	RU-2
2	chassis	

Fig. 124. Schematic Electrical Diagram of Unit PN-12.

On the front panel of the unit are a removable illuminating bulb holder and a holder for a desicant.

The optical image on the screen of the cathode-ray tube in unit TI-2 may be adjusted in a vertical direction by a handle on the left panel of unit PN-12.

The filters are switched by means of a lever on the right panel of the unit. Switching of the filters simultaneously switches a microswitch in unit LN-12 which closes a relay circuit for the elevation sweep scale in unit RU-2.

On the top part of the front panel of the unit is mounted a 4-contact box to which are applied the power for the light source and the voltage for the microswitch in the relay circuit.

A schematic electrical diagram of the unit is given in Figure 124.

4. Elevation Sweep Input Unit RU-1 (p 305)

Function. The elevation sweep input unit RU-1 (Figure 125) is designed to produce a voltage proportional to the angle of rotation of the antenna in a 40-degree sector and to produce a gate pulse voltage for the tube during the direct trace of the vertical sweep.

Technical data on the unit. 1. The linearity error of the output voltage does not exceed 0.5%.

2. During the increase in output voltage, the unit generates a voltage which triggers signal amplifier VS-4.

Functional diagram of unit RU-1. Figure 126 gives a functional diagram of unit RU-1. The unit includes the following elements:

-- 1:1 selsyn transformer SS-405;

-- reduction gearing;

-- 6:1 selsyn transformer SS-405;

-- voltage summing stage;

-- cathode follower;

-- controlled voltage rectifier of the selsyn transformer;

-- differential amplifier; cathode follower for 1,500-cps voltage;

-- amplifier.

Fig. 125. Unit RU-1.

1 - elevation sweep linearity control; 2 - sector selector crank; 3 - fine reading dial; 4 - illuminating bulb holder; 5 - coarse reading dial; 6 - plug cover; 7 - tubes in tube channel; 8 - label on door.

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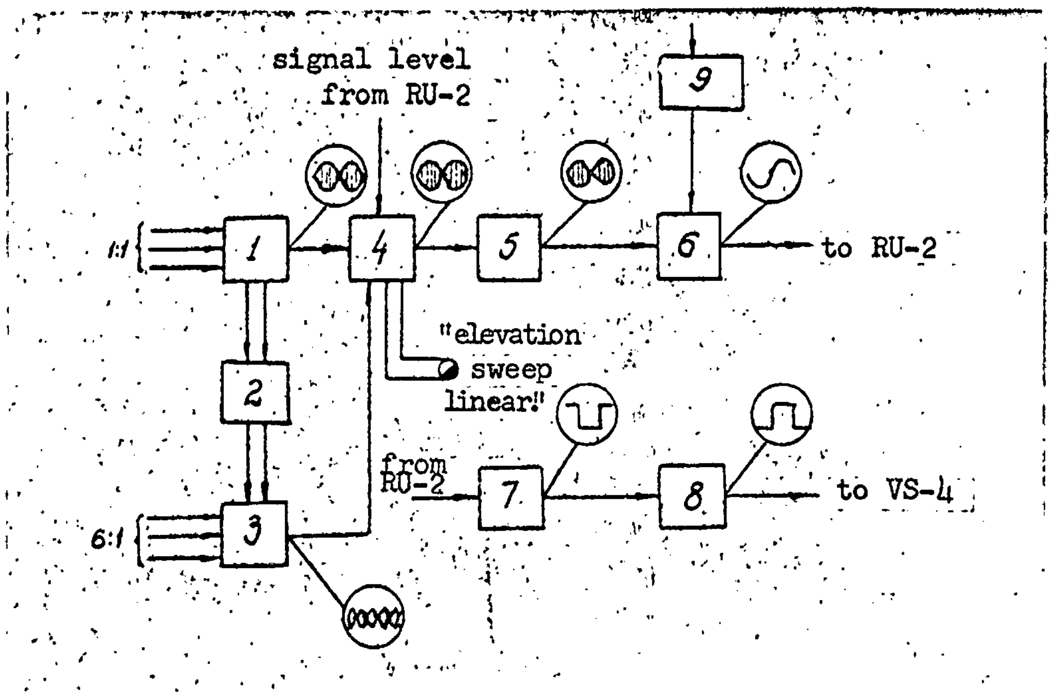

Fig. 126. Functional Diagram of Unit RU-1.

1 - SS-405 selsyn transformer; 2 - reduction gearing; 3 - SS-405 selsyn transformer; 4 - voltage summing stage; 5 - cathode follower; 6 - controlled rectifier; 7 - differentiating amplifier; 8 - amplifier; 9 - cathode follower.

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The voltage from the 1:1 and 6:1 selsyn transformers of the secondary selsyn unit is fed to the selsyn transformers located in unit RU-1. The voltage from the 6:1 selsyn transformer is used in the unit to linearize the voltage envelope of the 1:1 selsyn transformer in an interval of angles from -30° to $+30^{\circ}$, which is necessary to achieve the desired accuracy.

The voltage of the 1:1 selsyn transformer with the added (approximately 1%) voltage of the 6:1 selsyn transformer is fed through the cathode follower to the controlled rectifier. The 1,500-cps control voltage is also sent to this rectifier through the cathode follower. (p 308)

The output voltage of the controlled rectifier is approximately equal to the amplitude of the input voltage and is linear in the interval of angles from -30 to $+30^{\circ}$.

Voltage from the controlled rectifier is applied to the differential amplifier of unit RU-2.

The sweep gating voltage is taken from output tube 6P3S of unit RU-2 and is differentiated, amplified, and fed to video signal unit VS-4.

<u>Description of the schematic diagram of the unit.</u> Figure 127 gives a schematic diagram of unit RU-1.

The three-phase 1,500-cps voltages of the 1:1 and 6:1 selsyns from secondary selsyn unit VD-1 are taken from the plug connector of unit RU-1 (pins 7, 8, 9, 18, 19, and 20) and applied to the three-phase windings of the selsyn transformers.

The voltage from the single-phase winding of the 1:1 selsyn transformer is added in opposition to a small part (approximately 1%) of the voltage of the 6:1 selsyn transformer and fed through resistor R7 to the grid of the cathode follower, which uses tube V1.

The cathode load of the cathode follower is connected to the -150 v bus. Choke Dr1 and capacitor C2 are included in the screen grid circuit of tube V1 to maintain the voltage at the screen grid relative to the cathode, which is necessary for linear voltage transmission. Voltage from the cathode load of tube V1 (resistors R10, R11, R12, and R13) is applied to the controlled rectifier -- tube V3. A voltage at a frequency of 1,500 cps from the higher-frequency generator unit GCh is sent to unit RU-1 to control this rectifier. This voltage is applied to the grid of cathode follower V2b. The cathode load of this cathode follower is transformer Tr1, from which a voltage is fed to the grids of the controlled rectifier. (p 310)

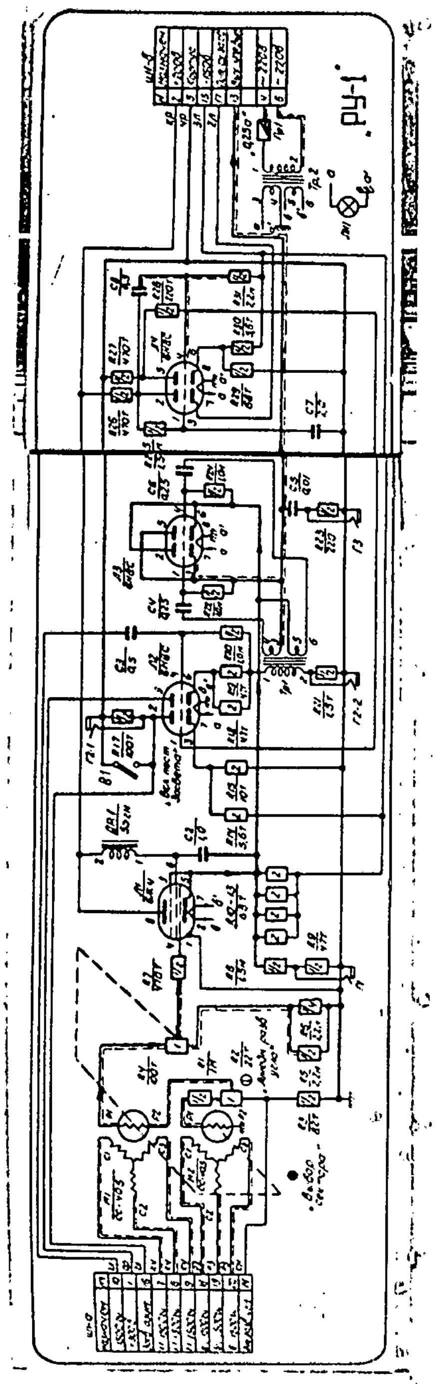

Fig. 127. Schematic Diagram of Unit RU-1.

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The rectified voltage taken from the output (capacitor C5) of the rectifier, equal to the voltage envelope of the 1:1 selsyn transformer and linearized in an interval of angles from -30^{o} to $+30^{o}$ by the voltage of the 6:1 selsyn transformer, is applied to the grid of the differential amplifier in unit RU-2.

Voltage for the gating pulse is taken from the cathode of V3 in unit RU-2 and applied to the gating circuit of the tube in unit RU-1 (to the cathode of the left triode of V4). When the voltage at the cathode of V4a increases, the voltage at the grid also increases with a certain lag as a result of the time constant of the grid circuit (R25 and C7). An amplified voltage having the same sign as that at the cathode is produced at the plate.

After differentiation of this voltage, a positive pulse is produced in the grid circuit of V4b which triggers this triode (the cathode of the tube is blocked). The plate of V4b is connected to ground through resistor R27.

A negative voltage appears at the plate load of V4b as the voltage at the cathode of V4a builds up.

Tube V2a serves as the output tube of the gating circuit. The main plate load of this tube is a resistor in unit VS-4 to which the gating pulse is sent. The potential at the cathode of V2a is on the order of 80 - 100 v. The grid of this triode is connected through resistor R28 to the plate of tube V4b. When tube V2a is conducting, a current on the order of 5 ma flows through it.

As the voltage at the cathode of V4a builds up, a negative pulse arrives at the grid of tube V2a and blocks it. The current flowing through the plate load of tube V2a, located in unit VS-4, is blocked, (p 311)
and the input diode of unit VS-4 is unblocked.

When the voltage at the cathode of V4a decreases, the voltage at the grid also decreases, since capacitor C7 discharges through the grid-cathode circuit of V4a. The voltage at the plate of V4a also decreases. After differentiation of this voltage, a negative pulse appears in the grid circuit of tube V4b and blocks the tube. As a result, there will be a positive voltage at the grid of tube V2a and this tube will conduct.

Constant gating of the tube, which is necessary when aligning the display, may be turned on by means of switch V1 in unit RU-1; the switch shorts the conductor coming from units VS-4 to ground.

<u>Monitoring the operation of the unit.</u> Unit RU-1 is monitored with the aid of four test jacks:

G1 -- for monitoring the voltage of the 1:1 selsyn transformer at the cathode of tube V1;

G2-1 --/for monitoring the azimuth gating voltage at the plate of triode V2a;

G2-2 -- for monitoring the 1,500-cps voltage at the cathode of triode V2b;

G3 -- for monitoring the operation of the controlled rectifier at its output.

Design of the unit. Unit RU-1 is built in the form of a self-contained instrument mounted on a standard chassis. In the tube channel are four tubes (one 6Zh4 and three 6N8S), four test jacks, and the gating switch.

The selsyn transformers are mounted on a common frame representing a complete unit and are enclosed in a silumin housing.

The selsyn transformer unit is attached to the inside of the front panel. It contains two SS-405 selsyns whose shafts turn through a reduction gear with a ratio of 6:1. Dials are fixed to the shafts of both selsyns to denote the scanning sector which has been chosen in the display. (p 312)

The shaft of the 6:1 selsyn extends through the front panel and serves as the "Sector Selection" knob.

A corrective device is attached to the chassis of unit RU-1 behind the selsyn transformer unit. This device consists of a variable-profile template connected by a coupling to the shaft of the 1:1 selsyn transformer. The desired profile of the template is selected and fixed in position by means of 24 screws.

When the selsyn transformer rotates, the template also rotates and transmits motion to the shaft of potentiometer R4, which is connected to the template by two levers. Thus, the arms of the variable voltage divider (R4, R5, R6) move in accordance with the profile of the template. The profile is fixed so that the elevation sweep scale does not change with respect to the setting of the "Sector Selection" knob.

A light on the front panel of the unit serves to illuminate the dials.

The controlled rectifier and filament transformers are attached to the chassis of the unit. Resistors and capacitors are attached to a mounting plate.

The unit weighs 10.35 kg.

5. Elevation Sweep Output Unit RU-2.

Function. The RU-2 elevation sweep output unit (Figure 128) is used to supply the deflection coils of unit TI-2 in cabinet IIV-1 with a current which changes in proportion to the output voltage received from unit RU-1.

The unit provides for the presentation of two vertical sweep scales (20° and 40°) on the screen of the tube in unit TI-2.

In addition, the unit is used to change the control voltages in the horizontal and vertical alignment tubes of unit TI-2 and to generate a current which supplies the switching relay for the vertical and slant channels in unit VS-4. (p 314)

Technical data on the unit. 1. Linearity error of the output voltage at an angle of 35° does not exceed 0.5%.

2. Scale adjustment makes it possible to control the current which supplies the deflection system of unit TI-2 so that one scale on the screen of the tube represents a 20° angle of rotation of the antenna and the other scale represents a 40° angle.

3. The unit is used to change the control voltages of the horizontal sweep alignment tube in unit TI-2 within limits of 0 to 50 v and the vertical sweep alignment tube within 30 to 70 v.

4. The "channel switching" control permits setting the angle at which the channels are switched within limits of 0 to 10° according to the optical scale of the display.

Functional diagram of the unit. Figure 129 gives a functional diagram of unit RU-2.

The following elements are included in unit RU-2:

- -- amplifier;
- -- screen grid voltage rectifier;
- -- channel switch;
- -- output stage;
- -- vertical alignment circuit;
- -- horizontal alignment circuit;
- -- circuit for changing the degree of linearization in unit RU-1.

The voltage from the controlled rectifier in unit RU-1 is amplified in the differential amplifier of unit RU-2 and is applied to the grid of output V3. This tube generates a current which supplies the vertical (p 316)

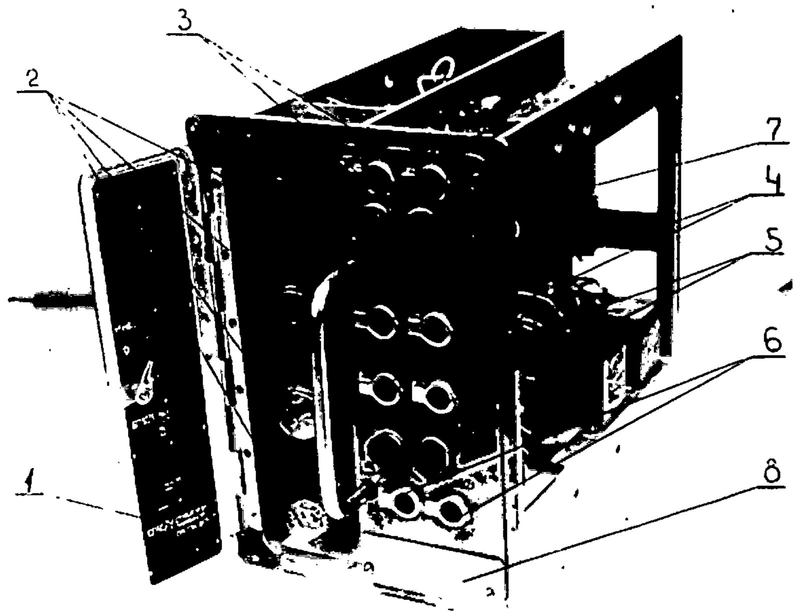

Fig. 128. Unit RU-2.

1 - label on door; 2 - tubes in tube channel; 3 - channel-switching control; 4 - scale control; 5 - vertical alignment control; 6 - horizontal alignment control; 7 - illuminating bulb holders; 8 - plug cover.

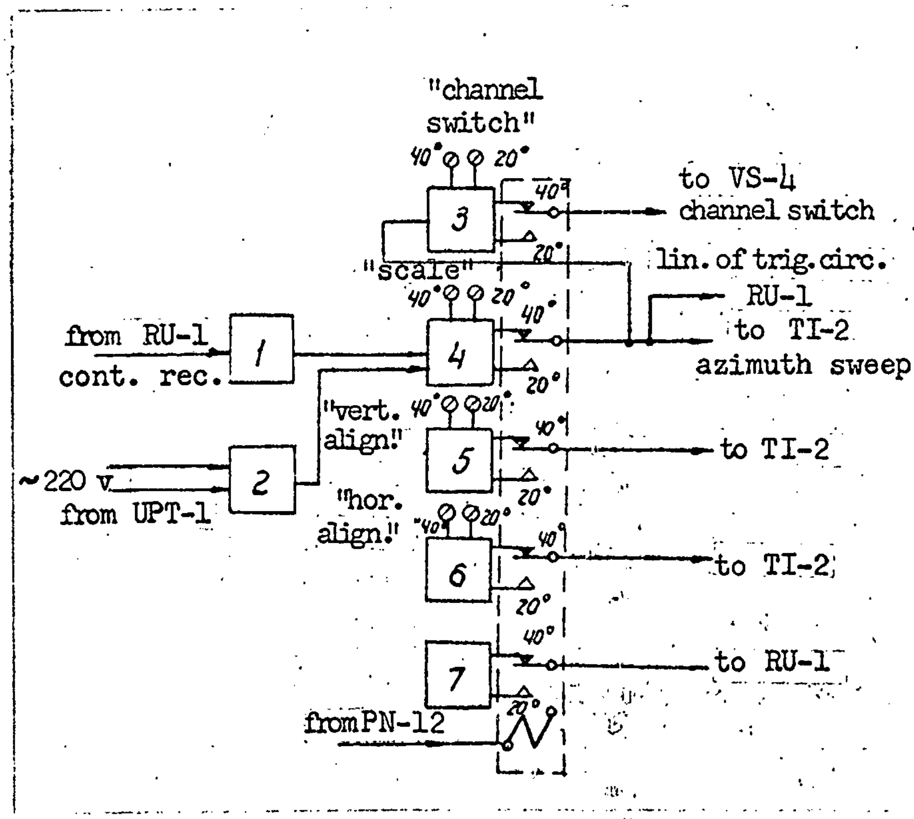

Fig. 129. Functional Diagram of Unit RU-2.

1 - amplifiers; 2 - screen grid rectifiers; 3 - channel switch; 4 - output stage; 5 - vertical alignment circuit; 6 - horizontal alignment circuit; 7 - circuit for changing value of linearization in unit RU-1 (vertical sweep level).

deflection coils of unit TI-2. The output stage and the differential amplifier have 100% feedback in order to achieve the desired linearity of the output current.

Voltage from the cathode of output tube V3 is fed to unit RU-1 to supply the gating circuit. This same voltage is used to supply the amplifier which generates current for the channel-switching relay in unit VS-4.

The scales are switched by means of a relay located in the unit. The relay receives its energy from unit PN-12. Simultaneously with switching the scales, the relay changes the value of the linearizing voltage from the 6:1 selsyn in unit RU-1 as well as the vertical and horizontal shifts. This adjustment of the scales and the vertical and horizontal sweep alignments serves to match the electrical dial with the optical dial in cabinet IIV-1.

<u>Description of the schematic diagram of the unit.</u> Figure 130 gives a schematic diagram of unit RU-2.

The controlled rectifier output voltage from unit RU-1 passes through filter R9, C1 and resistor R10 to the grid of the differential amplifier V2a.

The differential amplifier uses tube V2. Voltage from the output of the amplifer moves through divider R15, R16 to the grid of the elevation sweep output tube V3, the plate load of which are the vertical deflection coils in unit TI-2.

The cathode circuit of V3 contains resistors R27 and R30 used to control the sweep scales.

In order to compensate for nonlinearity of the characteristic of tube V3, a feedback voltage is taken from its cathode and applied to the left half of the differential amplifier tube V2, while the screen grid of V3 is supplied from a separate rectifier. The screen voltage is stabilized by means of voltage stabilizer V4. (p 318)

The sweep scales are switched by changing the cathode resistances of output tube V3. The operating sector of the sinusoidal voltage envelope of the 1:1 selsyn transformer is selected from 0 to 40° for the 40° scale and from +2.5° to +22.5° for the 20° scale relative to the electrical zero point of the 1:1 selsyn (or from -5° through 0° to -325° for the 40° scale and from -2.5° through 0° to 342.5° for the 20° scale relative to the zero on the scale of the 1:1 selsyn).

When the scales are switched it is necessary that the vertical alignment of the beam in the display be changed. For this purpose, the grid potential of vertical alignment tube V3 in unit TI-2 is formed in unit RU-2 by potentiometers R33 (40° scale) and R34 (20°

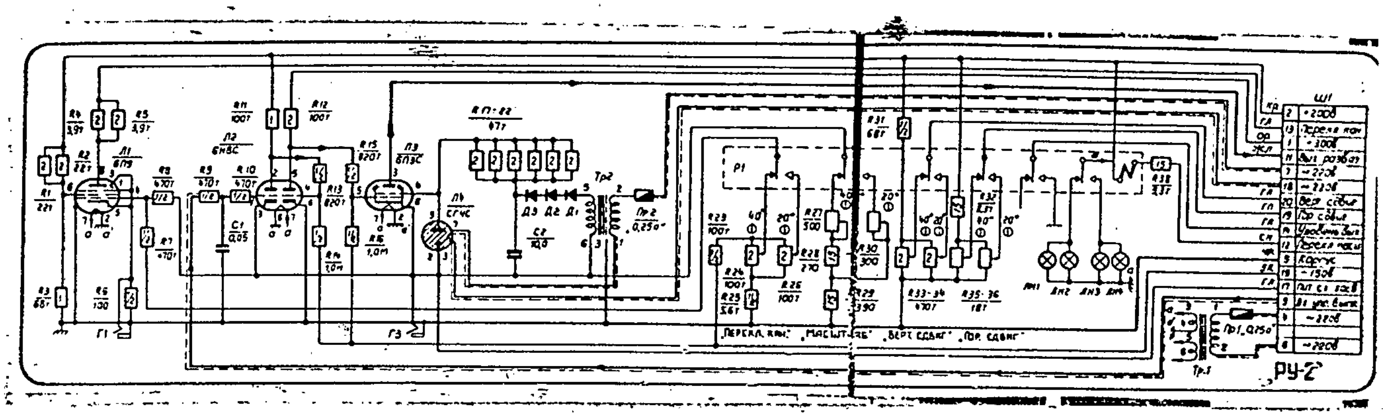

Fig. 130. Schematic Diagram of Unit RU-2.

Various range sectors are examined at different elevation scales. Therefore, when the scales are switched it is also necessary to change the horizontal alignment of the beam in the display at the same time. This is done by supplying voltage to the grids of the horizontal alignment tubes (V1 and V2) of unit TI-2 from potentiometers R35 (40° scale) and R36 (20° scale), located in unit RU-2 and switched simultaneously when the elevation scales are switched.

The channel-switching circuit operates with tube V1, to the plate circuit of which is connected the winding of the relay located in unit VS-4.

The control grid of tube V1 is connected through resistor R8 to the cathode of output tube V3. The moment that tube V1 fires is determined by the bias applied to its control grid from dividers R24 (40° scale) and R26 (20° scale). (p 319)

When the 20° scale is used, only the following controls are illuminated: "20° Scale," "20° Vertical Alignment," "20° Horizontal Alignment," "20° Channel Switch."

When the 40° scale is used, the following controls are illuminated: "40° Scale," "40° Vertical Alignment," "40° Horizontal Alignment," "40° Channel Switch."

Relay R1, which is controlled from unit PN-12, is used in switching all of the above controls.

Voltage from the cathode of output tube V3 is applied to the tube gating circuit in unit RU-1.

Monitoring the operation of the unit. Unit RU-2 is monitored with the aid of two test jacks:

G1 -- for monitoring the current in tube V1;
G3 -- for monitoring the output voltage at the cathode of tube V3.

Design of the unit. Unit RU-2 is built in the form of a self-contained instrument mounted on a standard chassis. On the front panel of the unit are the shafts of 8 potentiometers and four illuminating bulbs.

The tube compartment of the unit contains four tubes (6P9, 6N8S, 6P3S, and SG4S) and two test jacks.

Two transformers are located on the chassis of the unit.

Small components (resistors and capacitors) are attached to a mounting plate within the unit.

The unit has one plug connector.

Weight of the unit is 7.2 kg.

6. Video Signal Unit VS-4.

Function. The video signal unit VS-4 (Figure 131) mixes and amplifies the scale marker pulses and reflected signals in one channel and applies them to the grid of the cathode-ray tube. (p 321)

Technical data on the unit. The magnitude of the output signal of the unit may be controlled within limits of 0 to 70 v. The passband of the unit is 1.5 Mc. The unit provides for switching between the slant and vertical channels.

Functional diagram of the unit. Figure 132 gives a functional diagram of unit VS-4.

The unit consists of the following elements:

-- input dividers;
-- wideband amplifier;
-- output stage;
-- control tube;
-- relay RS-52.

Reflected signals from the vertical and slant channels and range and azimuth scale markers are applied to the input of the unit.

At the input of each channel is a switch. When the switch is closed, all signals pass to the input dividers, are mixed in one common channel, and are applied to the wideband amplifier. The amplifier consists of two amplification stages.

Common gain control is provided in the first stage of the amplifier.

A gain control for the scale markers makes it possible to change the amplitude of the scale markers relative to the video signals.

A limit control in the second amplification stage is used to prevent defocusing of the signals on the screen of unit TI-2 when signals of large amplitude appear at the input of unit VS-4. (p 323)

The output stage of the unit is a cathode follower. Range and azimuth gating pulses are applied to unit VS-4 to trigger the circuit. If gating pulses are not present, signals do not pass to the input of the amplifier.

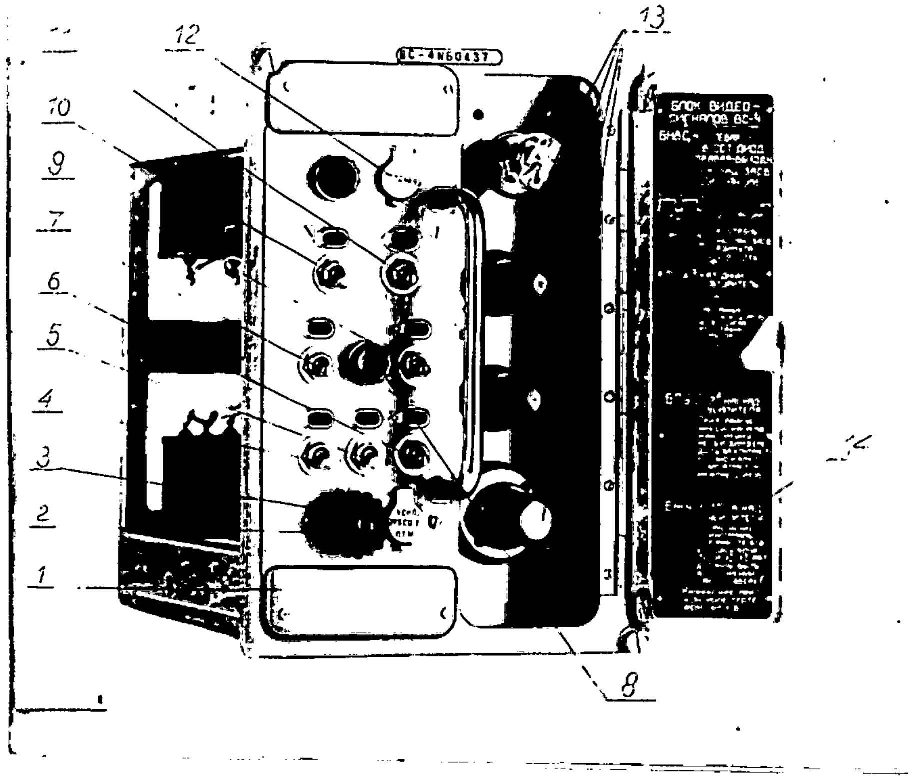

Fig. 131. Unit VS-4.

1 - plug cover; 2 - common gain control; 3 - scale marker gain control; 4 - toggle switch for 10-km markers; 5 - toggle switch for 50- and 100-km markers; 6 - azimuth marker toggle switch; 7 - reserve toggle switch; 8 - illuminating bulb holder; 9 - reserve toggle switch; 10 - toggle switch for vertical channel signals; 11 - toggle switch for slant channel signals; 12 - limit control; 13 - tubes in tube channel; 14 - label on door.

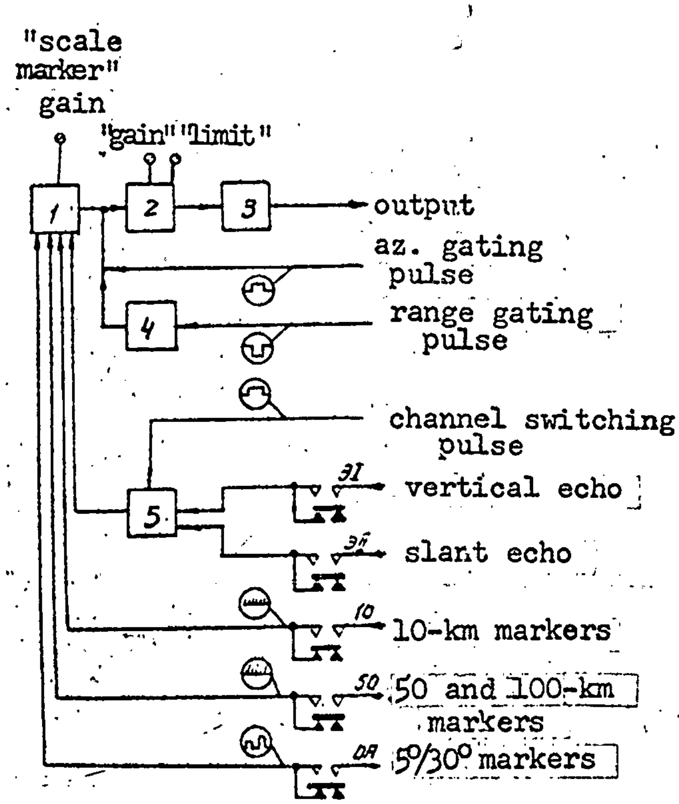

Fig. 132. Functional Diagram of Unit VS-4.

1 - input dividers; 2 - wideband amplifier; 3 - output stage; 4 - control tube; 5 - relay RS-52.

Description of the schematic diagram of the unit. Figure 133 gives a schematic diagram of unit VS-4.

The circuit of the unit receives the following signals:

-- signals of the vertical channel;
-- signals of the slant channel;
-- 10-km range markers;
-- 50- and 100-km markers;
-- azimuth markers.

All of the above signals pass to the input dividers in the same manner as in unit VS-3. Refelcted signals from the vertical and slant channels are fed to relay RS-52 which alternately applies vertical and slant signals to the grid of the amplifier tube.

The relay coil is controlled by the elevation sweep circuit in unit RU-2.

The circuitry of unit VS-4 is identical to that of unit VS- 3 with the exception of the input circuits. The circuit contains the following controls:

-- seven single-pole switches for individually switching any of the channels on or off;
-- common gain control;
-- scale marker gain control;
-- limit control.

Design of the unit. Unit VS-4 is built in the form of a self-contained instrument mounted on a standard chassis. The tube channel contains four tubes (one 6Zh4, two 6P9, one 6N8S) and four test jacks. All controls are on the front panel. The unit has two plug connectors. (p 325)
Weight of the unit is 6 kg.

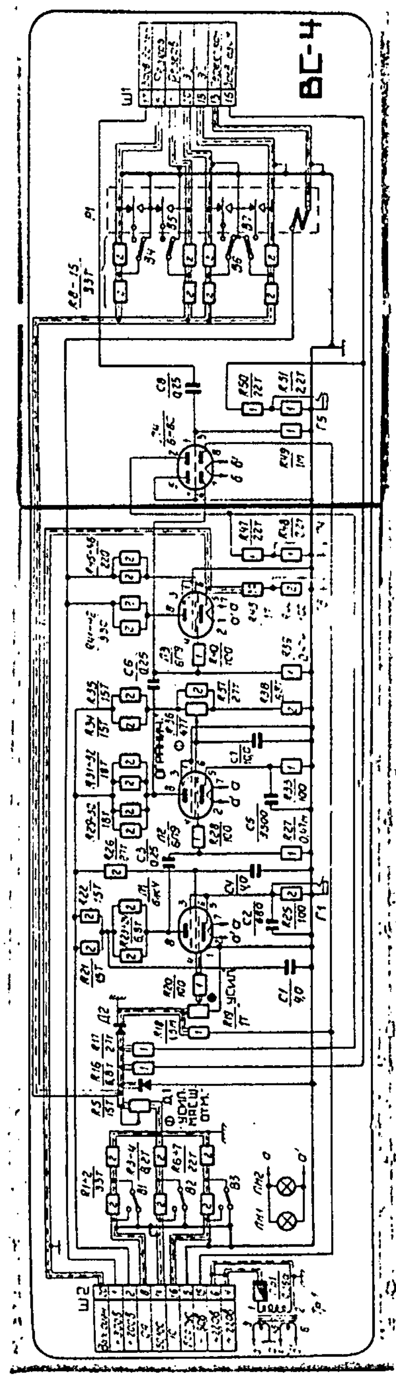

Fig. 133. Schematic Diagram of Unit VS-4.

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CHAPTER SIX

AZIMUTH-RANGE INDICATOR IAD-1

1. General Information About The Operation of Indicator

The azimuth-range indicator IAD-1 (Figure 134) is designed for exact determination of the target coordinates in an arbitrarily chosen sector. The indicator ensures the highest possible resolution, regardless of image focusing. A sector of the observed space is displayed on the indicator screen. Precise target coordinates are obtained by means of an enlarged sweep scale and by applying 2-km range markers and 1-degree azimuth markers to the indicator.

The azimuth-range indicator, like the IKO-1 and IIV-1, is an oscilloscopic device with horizontal and vertical sweep and an intensity-modulated signal.

The sector selected for scanning is displayed on the screen of the cathode-ray tube. The horizontal sweep is proportional to the azimuth scale, the vertical-- to the range scale. The circuits of the horizontal sweep are supplied with voltage from the synchronous tracking system which transmits the turn angle of the antenna. The range and azimuth sweep voltages act on the deflecting system of the cathode-ray tube. (p 327) The voltages of the reflected signals and the range and azimuth scale markers influence the control electrode of the cathode-ray tube in the same manner as in IKO-1.

The reflected signals appear on the screen in the form of horizontal dashes, the range scale markers appear in the form of horizontal lines which correspond to fixed ranges, and the azimuth scale markers -- in the form of a number of vertical lines corresponding to the fixed angles of turn of the antenna system (Figure 135).

Technical data. 1. Display of the target is by an intensity spot signal on the screen of the cathode-ray tube.

2. Sweeps are horizontal (azimuth) and vertical (range).

3. The operating mode of the cabinet is scanning an arbitrarily selected sector covering 20° or 60° in azimuth.

4. The range scales are 30, 50, and 100 km.

5. Delay of the start of the sweep may be adjusted from 40 to 350 km in steps of 10 km.

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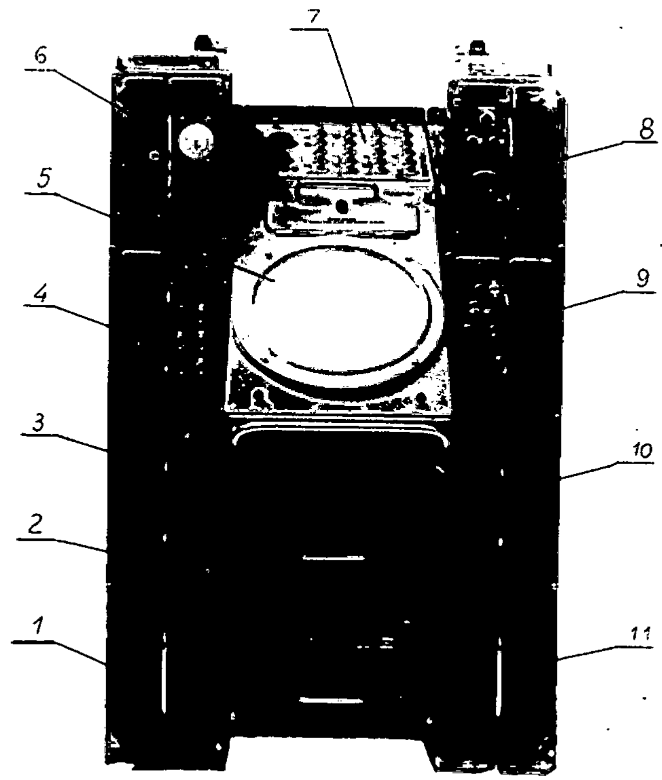

Fig. 134. Cabinet IAD-1.

1 - unit BP-300; 2 - unit UPT-1; 3 - unit BP-200; 4 - unit RD; 5 - unit TI-3; 6 - unit ZR-3; 7 - connector panel; 8 - unit RA; 9 - unit VS-3; 10 - unit BP-7; 11 - unit BP-150.

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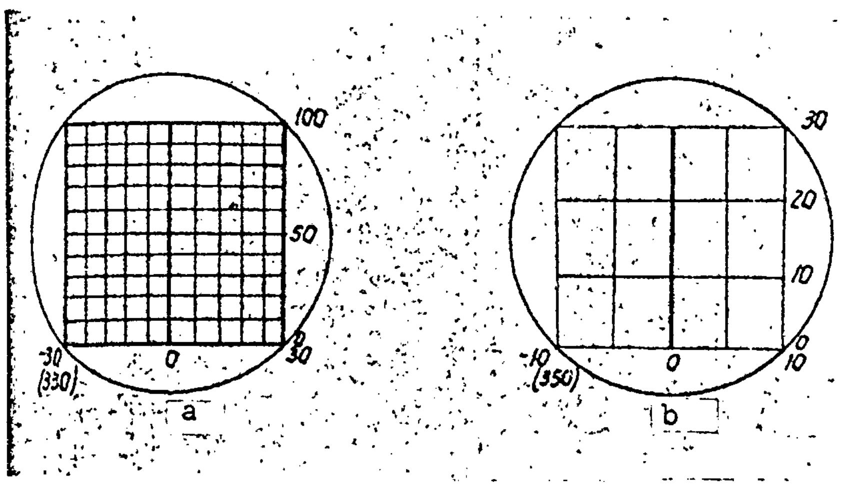

Fig. 135. Image of Electrical Scale Grid on the Screen of the Azimuth-Range Indicator.

a - 100-km range scale, azimuth 60°; b - 80-km range scale, azimuth 20°.

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6. The exact coordinates of targets are determined from the position of the reflected signal marks relative to the range and azimuth electrical scale marker grid.

7. Separate or simultaneous observation of the following are possible: range scale markers (10,50, 100 km) and azimuth scale markers (5° and 30°); 2-km and one-degree scale markers which form the scale marker grid; reflected signals from the vertical and slant channels.

Make-up of cabinet IAD-1. The azimuth-range indicator is housed in a standard cabinet and consists of the following units: (p 329)

-- indicator tube TI-3;
-- sweep delay unit ZR-3;
-- range sweep unit RD;
-- video signal unit VS-3;
-- azimuth sweep unit RA;
-- +300 volt power supply unit BP-300;
-- +200 volt power supply unit BP-200;
-- -150 volt power supply unit BP-150;
-- +7.1 kv power supply unit BP-7.

Units TI-3 and UPT-1 are centralized. In the left compartments are mounted the following units (from top to bottom): ZR-3, RD, BP-200 and BP-300. In the right compartments are units RA, VS-3, BP-7, and BP-150.

A wiring diagram of cabinet IAD-1 is shown in Figure 136.

As can be seen from the diagram, almost all the units in cabinet IAD-1 are of general use except units RA and TI-3. Unit RA forms horizontal-sweep voltages for the indicator and unit TI-3 serves the same purpose as unit TI-2 in cabinet IIV-1. All the circuits of cabinet IAD-1 are the same as those in IKO-1 and IIV-1.

The circuits which form the vertical sweep and the video signal circuit are the same as in IKO-1, and the circuits which form the angle sweep and blanking pulses are the same as in IIV-1. A description of the general use units is found in the appropriate chapters. Units ZR-3, RD, and VS-3 are described in chapter three, sections 3, 4, and 5.

All the units in the azimuth-range indicator receive voltage from units BP-300, BP-200, BP-150, and BP-7.

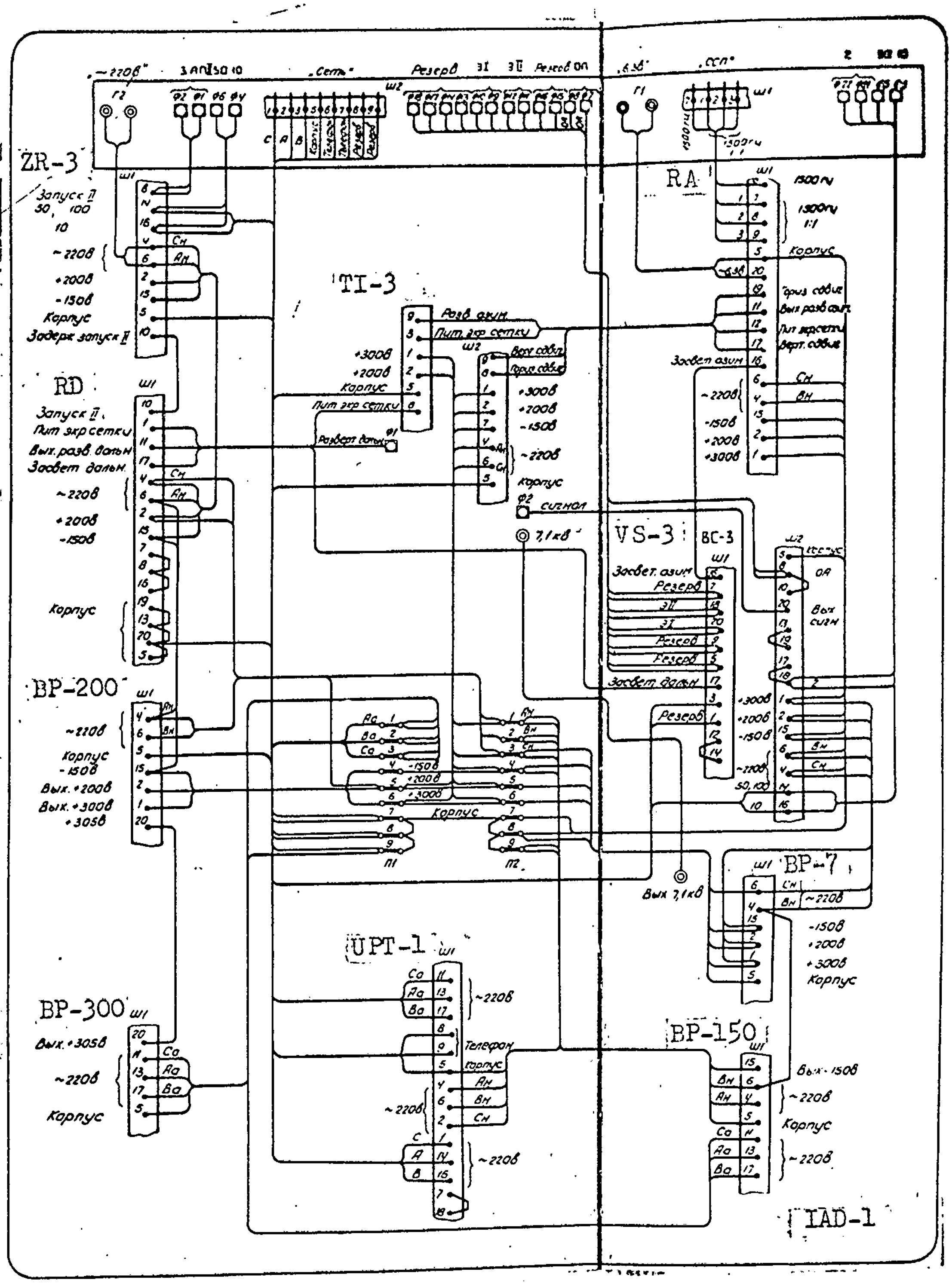

Fig. 136. Circuit Diagram of Cabinet IAD-1.

2. Scope Unit TI-3. (p 331)

Unit TI-3 is identical to TI-2 except for the direction of the sweep. The change in sweep direction is achieved by turning the deflecting coil 90° and changing the connections of the conductors which lead to the range sweep and sweep shift circuits.

The range sweep corresponds to a vertical deflection of the beam, and the azimuth sweep--to a horizontal deflection.

Thus, the image on the screen corresponds to the true location of the radar station in space and permits guidance during the approach of guided aircraft toward one another (when the distance separating the planes does not exceed the scale on the screen of the indicator).

3. Azimuth Sweep Unit RA.

Function. Azimuth sweep unit RA (Figure 137) is designed to supply the horizontal deflecting coils of unit TI-3 in cabinet IAD-1 with a current which varies in direct proportion to the angle of turn of the antenna system. Moreover, the unit forms the screen gate pulses in the operational range of turn angles of the antenna and ensures the change of control voltage in the vertical and horizontal shift tubes in unit TI-3.

Technical data. The current generated by unit RA varies within the limits of zero to a maximum in direct proportion to the angle of turn of the antenna within the limits of ± 30°. (p 333)

Scale regulation permits a continuous variation of the angle of turn of the antenna from 20 to 60 degrees. The far left position of the "Scale" control is limited by a stop.

During the forward sweep, the unit forms a positive square gating pulse in the indicator tube. The unit ensures a change of the control voltages applied to the horizontal and vertical shift tubes of unit TI-3 within the limits of zero to 50 v.

Functional diagram. A functional diagram of the unit is given in Figure 138.

The following elements are included in the unit:

-- selsyn transformer SS-405;

-- cathode follower;

-- controlled rectifier;

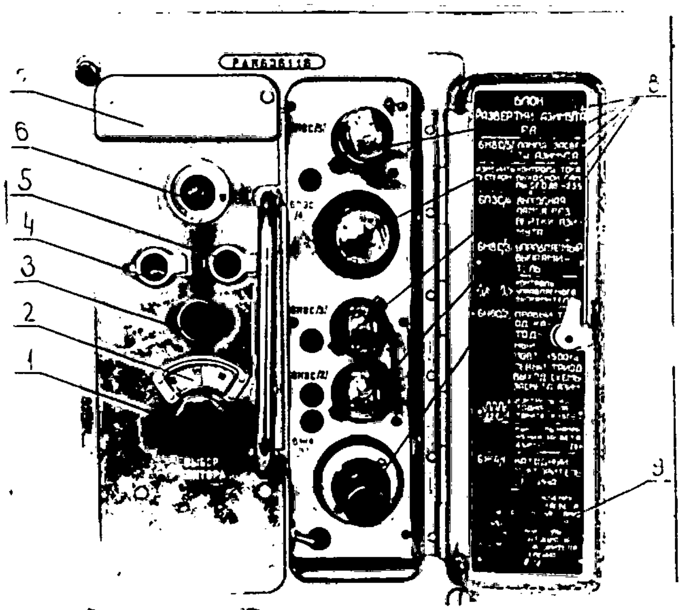

Fig. 137. Unit RA.

1 - azimuth coverage selector knob; 2 - reading dial; 3 - illuminating bulb holder; 4 - vertical shift control; 5 - horizontal shift control; 6 - scale control; 7 - plug cover; 8 - tubes in tube channel; 9 - label on door.

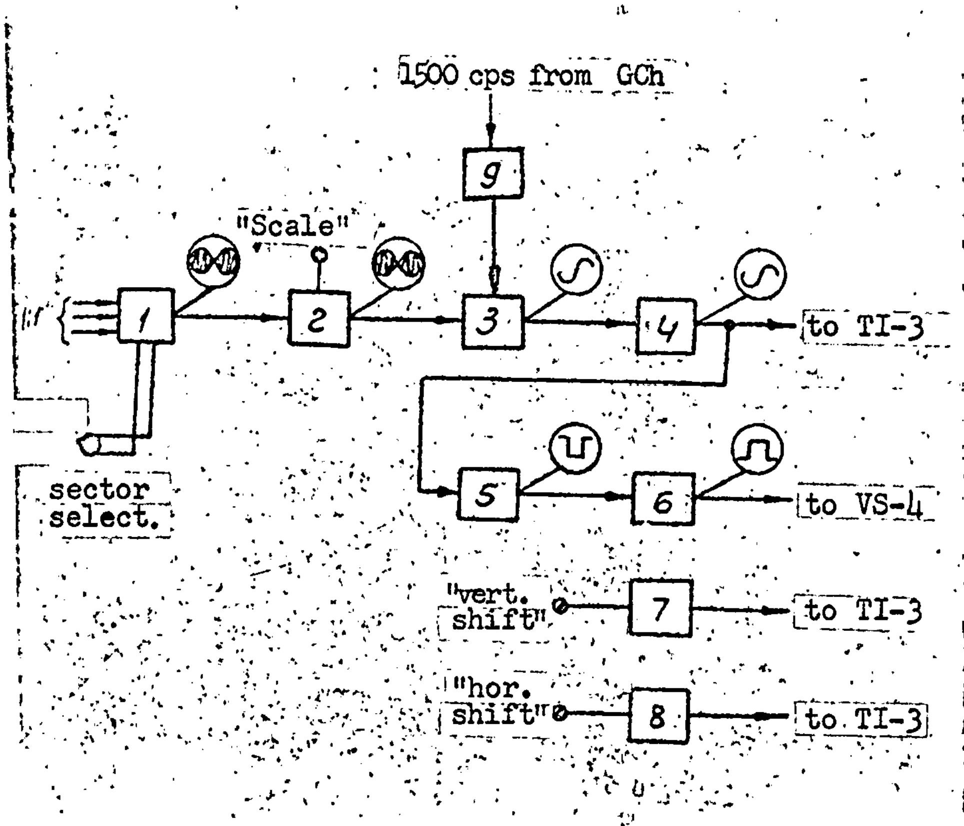

Fig. 138. Functional Diagram of Unit RA.

1 - selsyn transformer SS-405; 2 - cathode follower; 3 - controlled rectifier; 4 - output stage; 5 - differential amplifier; 6 - amplifier; 7 - vertical shift circuit; 8 - horizontal shift circuit; 9 - cathode follower.

-- output stage;

-- differentiating circuit and amplifier;

-- amplifier;

-- vertical shift circuit;

-- horizontal shift circuit.

Voltage from the 1:1 selsyn transformer of secondary selsyn unit VD-1 is applied to the selsyn transformer in unit RA. The selsyn transformer voltage is fed through the cathode follower to the circuit of the controlled rectifier.

A 1500-cps control voltage is applied through the cathode follower to the same rectifier. (p 335)

The output voltage of the controlled rectifier is linear in the interval of angles from -30 to + 30 degrees. The voltage from the controlled rectifier is applied to the output stage whose plate load are the deflection coils of unit TI-3.

In order to obtain positive square gate pulses, the voltage from the cathode load of the output tube is differentiated and amplified.

The unit has three controls.

The "Vertical Shift" and "Horizontal Shift" controls are used to vary the control voltage at the vertical and horizontal shift tubes in unit TI-3. The "Scale" control is designed for continuously varying the scale.

Description of the schematic diagram of the unit. Figure 139 gives a schematic diagram of unit RA.

A three-phase, 1500-cps voltage (1:1) from secondary selsyn unit VD-1 is taken from the input of unit RA (contacts 7, 8, 9) and applied to the three-phase winding of the selsyn transformer. The voltage from the rotor of the selsyn transformer is fed through variable resistor R1 and fixed resistor R5 to the grid of the cathode follower, which incorporates tube V1 and whose cathode load is connected to the -150 v bus bar. By adjusting variable resitor R1 it is possible to control the scale.

The screen grid circuit of tube V1 contains choke coil Dr1 and capacitor C2 for maintaining a constant voltage at the screen grid (relative to the cathode), resulting in a linear voltage transmission. (p 337)

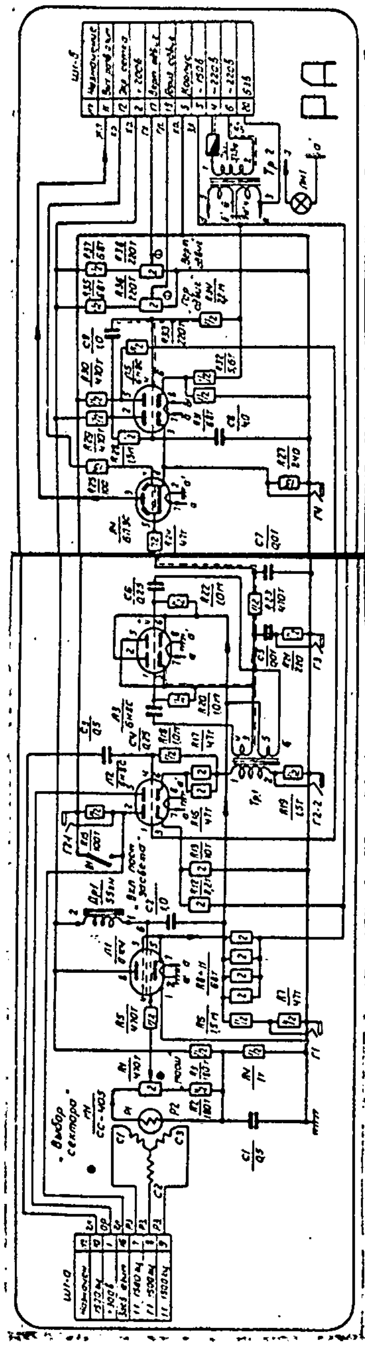

Fig. 139. Schematic Diagram of Unit RA.

Voltage from the cathod load of tube V1 (resistors R8, R9, R10, R11) is applied to the controlled rectifier (tube V3). In order to regulate this rectifier, a 1500-cps voltage from unit GCh is fed to unit RA. This voltage is applied to the grid of the cathode follower (tube V2b) through capacitor C3. Transformer Tr1 serves as the load of the cathode follower; the Tr1 voltage is applied to the rectifier. The rectified voltage, which is equal to the voltage envelope of the selsyn transformer, is taken from the output of the rectifier (capacitor C5) through filter R23, C7, and fed through resistor R24 to the grid of output tube V4.

The deflecting coils of unit TI-3 serve as the plate load of output tube V4. The operating mode of the output tube is selected so that a sector from -30 to +30 degrees of the voltage envelope of the selsyn transformer can be viewed on the indicator screen. It is possible to regulate the scale by means of potentiometer R1 from which the selsyn voltage is applied to the grid of tube V1. The voltage from the cathode of output tube V4 is fed to the cathode of V5a in the gating circuit.

When the voltage at the cathode of V5a increases the voltage at the grid increases with a certain delay due to the time constant of the grid circuit (R28, C8). An amplified voltage with the same phase as that at the cathode is produced at the plate. After differentiation of this voltage, a positive pulse is formed in the grid circuit of V5b and triggers the tube. The plate of V5b is connected to ground through resistor R30. Tube V5b is blocked at the cathode. Thus, a negative voltage appears at the plate load of V5b during the forward movement of the sweep.

Tube V2a is the output of the gating circuit. The resistance in video signal unit VS-3 is the principal plate load of this tube. The potential at the cathode of V2a is selected at 80 to 100 v. The grid of the tube is connected through resistor R33 with the plate of tube V5b.

When tube V2a conducts, a current on the order of 5 ma flows through it. While the voltage is rising at the cathode of V5a a negative pulse arrives at the grid of V2a and cuts it off. The current ceases to flow through the plate load of tube V2a, located in unit VS-3, and the input diode of unit VS-3 starts to conduct. When the voltage decreases at the cathode of V5a, the voltage at its grid also diminishes, since capacitor C8 discharges through the grid-cathode circuit of tube V5a. The voltage at the plate also diminshes. After differentiation of this voltage, a negative pulse appears in the grid circuit of tube V5b which further blanks the tube. Therefore, at the grid of V2a will appear a positive voltage and the tube will conduct. (p 339

To turn on the continuous gating of the receiver, which is necessary when tuning the indicator, unit RA has switch V1 which grounds the conductor leading to unit VS-3.

Monitoring the operation of the unit. Unit RA is monitored by means of five test jacks.

G1 -- for monitoring the voltage of the selsyn transformer at the cathode of tube V1;

G2-1 -- for monitoring the azimuth gating voltage at the plate of tube V2a;

G2-2 -- for monitoring the 1500-cps voltage at the cathode of tube V2b;

G3 -- for monitoring the operation of the controlled rectifier (tube V3) up to the filter;

G4 -- for monitoring the output voltage at the cathode of tube V4.

Design of the unit. Unit RA is built in the form of a self-contained instrument mounted on a standard chassis.

The tube channel contains five tubes (one 6Zh4, three 6N8S, and one 6P3S), five test jacks, and a gating selector switch.

The rotor shaft of the selsyn transformer extends through the front panel.

In addition, the shafts of three potentiometers which control the scale, vertical shift, and horizontal shift are accessible at the front panel. A light for illuminating the controls is also on the front panel. The unit has one plug connector.

The controlled rectifier transformer and the filament transformer are mounted on the chassis of the unit. (p 340)

The unit weights 10 kg.

CHAPTER SEVEN (p 341)

POWER SUPPLY EQUIPMENT

1. General Information

The remote control cabinet, the master voltages cabinet, and each indicator cabinet receive d-c and a-c electrical power from the power supply group which forms a component part of each cabinet.

The power supply units generate stabilized d-c voltages of +200 v, -150 v, and +7.1 kv and an unstabilized voltage of +300 v. The units are turned on and off from a centralized position by means of toggle switches which establish the time sequence for cutting in the filament and plate voltages.

The power supply complex includes the following:

BP-300 -- +300 v unstabilized voltage unit;

BP-200 -- +200 v stabilized voltage unit;

BP-150 -- -150 v stabilized voltage unit;

BP-7 -- +7.1 kv stabilized voltage unit;

UPT-1 -- power supply control unit.

A wiring diagram for the power supply units in each cabinet is given in Figure 140.

2. BP-300 Power Supply Unit.

Function. Unit BP-300 (Figure 141) provides a rectified voltage of +305 v which is applied to the filter of the rectifier located in unit BP-200. (p 344)

Technical data on the unit. Power supply unit BP-300 generates an unstabilized rectified voltage of +305 v ±15 v at a load current of 750 ma.

The current consumed by the unit from the power line at a load current of 750 ma and a line voltage of 220 v does not exceed 0.8± 0.15 a for each phase.

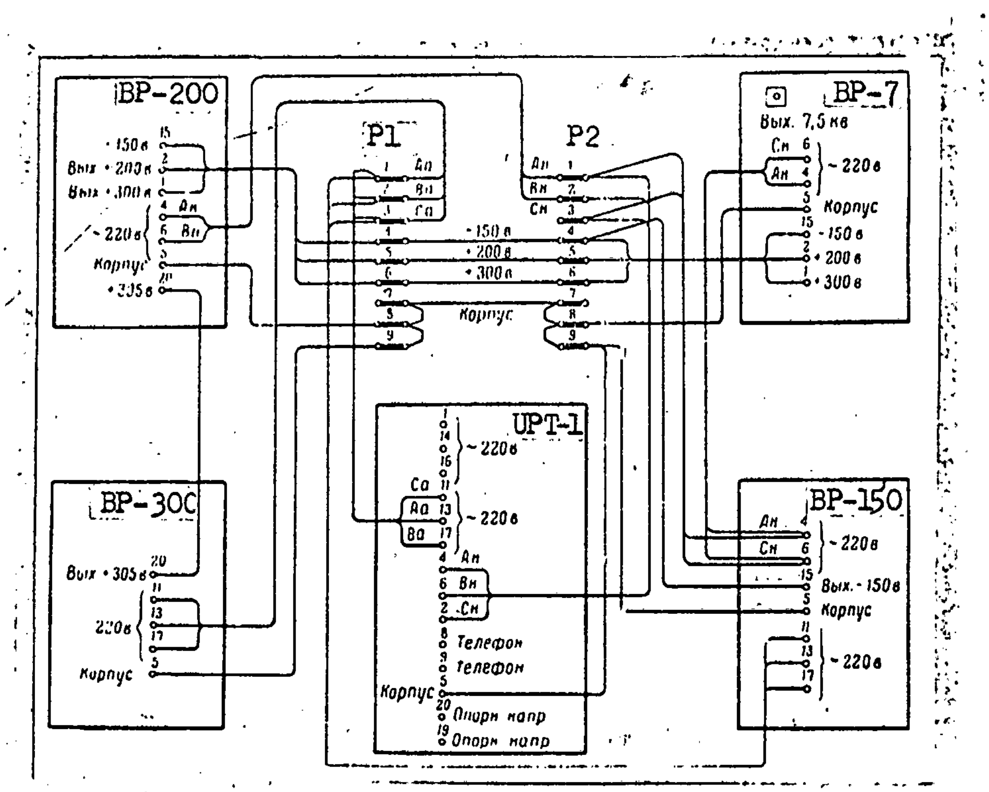

Fig. 140. Wiring Diagram for the Power Supply Units.

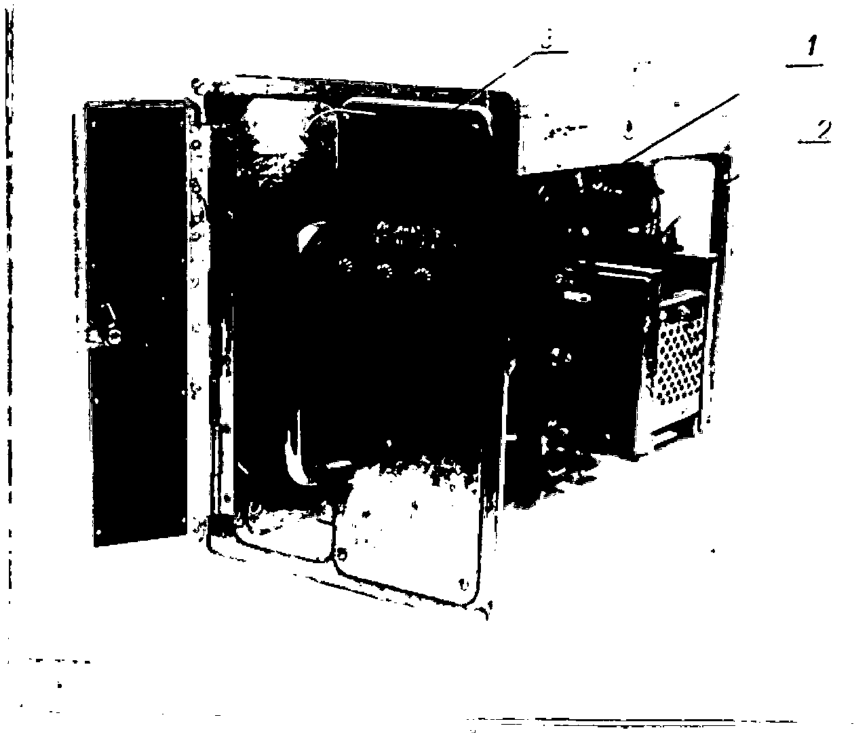

Fig. 141. Unit BP-300.

1 - fuse condition indicators; 2 - fuses; 3 - plug cover.

Pulsations of the rectified voltage do not exceed 70 v peak-to-peak at any value of load from 0 to 750 ma.

The protection circuit of the unit cuts off the +305 v output voltage in the event of short circuits at the load.

Functional diagram of unit BP-300. A functional diagram of the unit is given in Figure 142. It includes a three-phase transformer and a selenium rectifier (without filter).

An a-c voltage of 220 v, 50 cps is applied to the primary windings of the three-phase transformer. Voltage from the secondary windings is applied to a selenium rectifier consisting of six identical diode rectifiers connected in a bridge circuit.

The rectified voltage of +305 v is applied to unit BP-200.

Description of the schematic diagram. A schematic diagram of unit BP-300 is given in Figure 143.

A three-phase a-c voltage of 220 v, 50 cps is taken from unit UPT-1 through pins 11, 13, and 17 of the plug connector and applied to the primary windings of three-phase transformer Tr1, which is connected as a star circuit. (p 347)

Two-amp fuses (Pr1, Pr2, Pr3) are connected to each of the primary winding phases of the transformer. The condition of the fuses is monitored by neon bulbs MN-5 (NL1, NL2, NL3). Resistors R1, R2, R3 (470 kilohm, 0.5 w) are connected in series with the bulbs. The bulbs are connected in parallel with the fuses and light when a fuse burns out.

The secondary windings of the three-phase transformer raise the primary voltages and supply the selenium rectifier (D1, D2, D3, D4, D5, and D6), which is connected in a six-phase circuit. The secondary windings are also connected in a star circuit. The rectifiers are type TVS-40-112 s with a square cross-section of 40 x 40 mm and 12 disks per unit. The rectifier provides a voltage of +305 v at a maximum current of 750 ma.

The negative pole of the rectifier is connected to the chassis and the positive pole leads to unit BP-200 through a 20-pin plug connector.

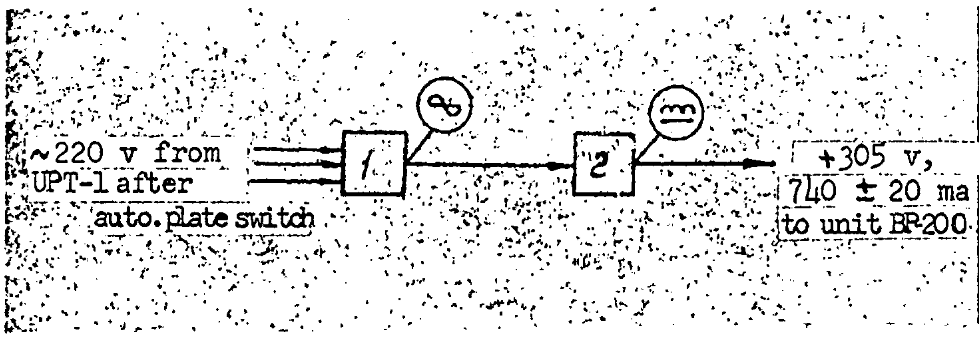

Fig. 142. Functional Diagram of Unit BP-300.

1 - three-phase transformer; 2 - selenium rectifier.

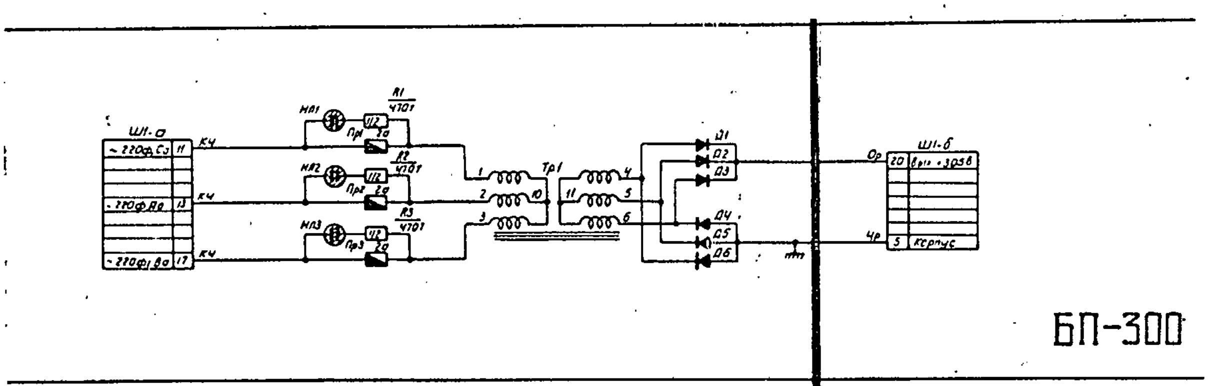

Fig. 143. Schematic Diagram of Unit BP-300.

Design of the unit. Unit BP-300 is built on a standard chassis and is located in the first lower compartment of the cabinet. Four of the rectifiers (D1, D2, D3, and D4) are located on pins and are positioned cross-wise in the unit, while the fifth and sixth rectifiers (D5 and D6) are located in the top part of the unit. The three-phase transformer Tr1 is positioned across the chassis at the rear of the unit and occupies both compartments. The transformer is built of a standard iron Sh32 (doubled) with a core 64 mm long; grade of the iron is E42. The winding data are identical for the coils on each rod of the transformer. There are three fuses on the front panel of the unit which are connected in phase with the primary winding of the transformer. Above the fuses are neon bulbs which indicate the condition of the fuses. The unit weighs 11.7 kg. (p 348)

3. BP-200 Power Supply Unit.

Function. Unit BP-200 (Figure 144) is used to supply the plate circuits of the tubes in the display equipment with a stabilized voltage of +200 v and an unstabilized voltage of +300 v.

The latter voltage is generated by unit BP-300 and passes only through a smoothing filter in unit BP-200.

Technical data on the unit. Power supply unit BP-200 generates a stabilized voltage of +200 ± 6 v at a load current of 320 to 330 ma and an unstabilized voltage of +300 v at a load current of 750 ma; the unit receives its power from a +200 v network.

/Pulsations of rectified voltages do not exceed:

-- 0.012% for the +200 v circuit (24 mv peak-to-peak);

-- 1.0% for the +300 v circuit (3 v peak-to-peak).

Stability of the +200 v rectified voltage with a simultaneous change in load current of the output circuit from 270 ma to zero and a change in line voltage by ±5% should not be worse than 0.8%. (p 350)

A network-protection circuit removes the +200 volts at the output of the unit in the event of a short-circuit at the load.

Functional diagram of power supply unit BP-200. A functional diagram of unit BP-200 is given in Figure 145.

It includes the following elements:

-- +300 v rectifier filter;

-- electronic stabilizer for the 200 v circuit, consisting of a control tube, control stage, and voltage divider.

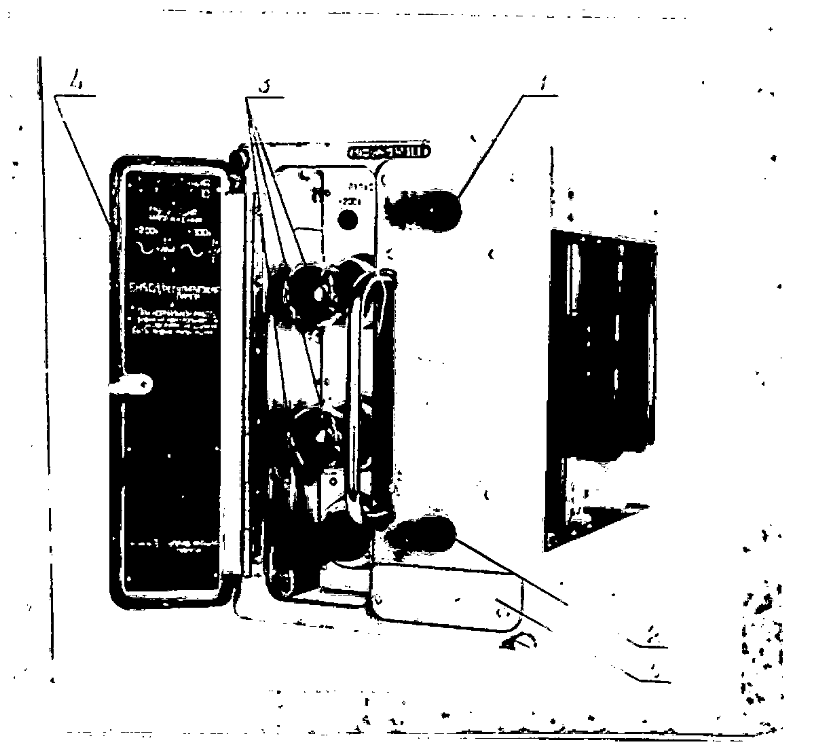

Fig. 144. Unit BP-200.

1 - light indicating presence of voltage; 2 - fuse; 3 - tubes in tube channel; 4 - label on door; 5 - plug cover.

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A rectified pulsating voltage of +305 v is applied to the filter input from unit BP-300.

The L-shaped filter is of the inductance-capacitance type with a smoothing factor on the order of 30.

The +300 v from the filter output passes through a plug connector to external loads and is used within the unit to supply the electronic stabilizer circuit.

The electronic stabilizer circuit includes a regulating element connected in series with the load and a control element connected to the output of the unit by means of a divider of temperature-compensated resistors.

Description of the schematic diagram. A schematic diagram of unit BP-200 is given in Figure 146.

An unstabilized voltage of +305 v from unit BP-300 passes through pin 20 to plug connector Sh1 to the single-mesh L-shaped filter. (p 353)

The filter consists of inductance Dr1 and capacitors C1, C2, C3, and C4.

The inductance of the choke is approximately 1.2 henrys at a magnetization current of 750 ma.

A voltage of +300 v is taken from the output of the filter and applied to the input of the electronic stabilization circuit and to pin 1 of plug connector Sh1.

The input of the electronic stabilization circuit are the plates of two regulating tubes V1 and V2 (6N5S), all electrodes of which are connected in parallel.

Grid suppressor resistors R1, R4, R5, and R8 are connected to the grid circuit of each triode.

An output voltage of +200 v is taken from the cathodes of the regulating tubes through balancing resistors R2, R3, R6, and R7.

The plate of control tube V3 supplies the control voltage for the grids of the regulating tubes.

Pentode V3, type 6Zh4, is used as the control tube. The plate of this tube is connected to the +200 v output bus through a load equal to 330 kilohms (R9). The cathode of the control tube is connected to the chassis of the unit. The screen grid of V3 is supplied with +200 v from divider R10 and R11.

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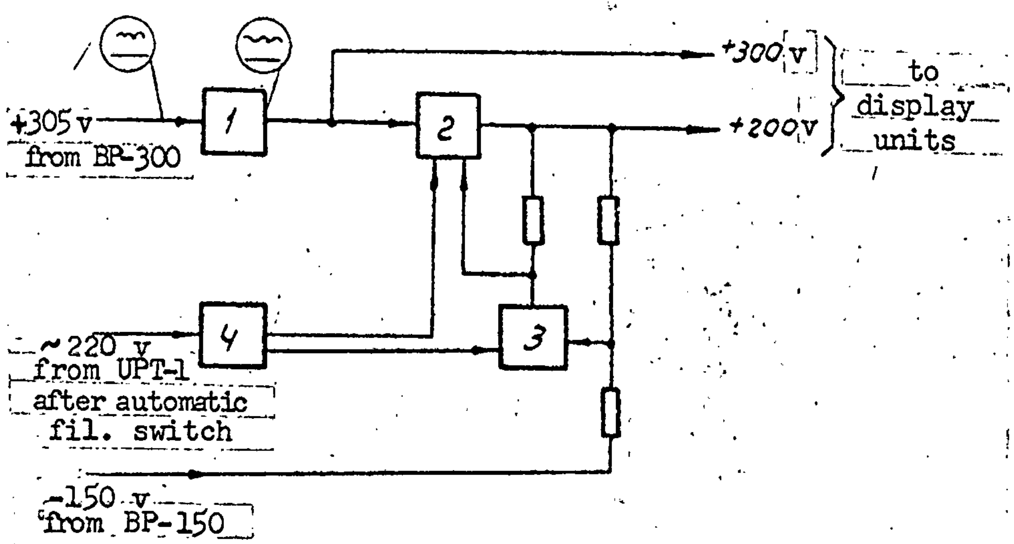

Fig. 145. Functional Diagram of Unit BP-200.

1 - filter; 2 - regulating stage; 3 - control stage; 4 - filament transformer.

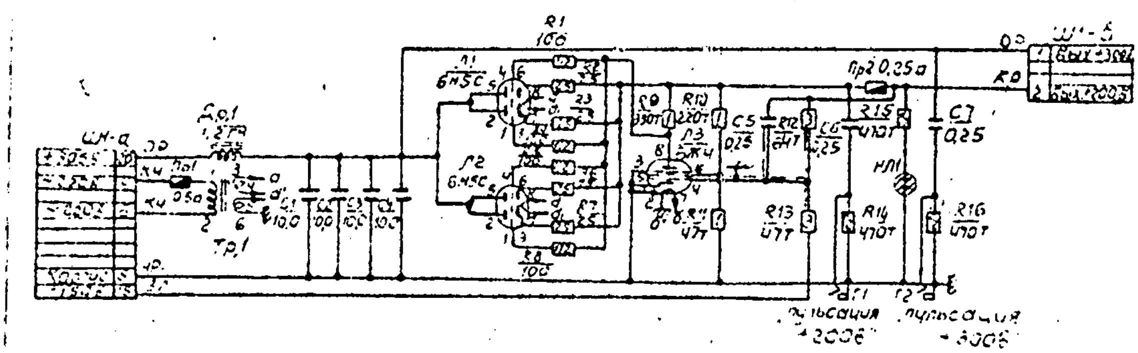

Fig. 146. Schematic Diagram of Unit BP-200.

A voltage from the output of the electronic stabilizer -- the middle point of a divider consisting of compensated resistors R12, R13 connected between the +200 and -150 v busses -- is applied to the control grid of tube V3. The -150 volts from unit BP-150 is applied to unit BP-200 and represents a reference voltage for the +200 v electronic stabilization circuit. Thus, a follow-up system of two voltages is created: a change in the -150 v reference voltage causes a proportional change in the +200 v output voltage. (p 354)

In view of the high precision of the compensated resistors, which are manufactured with a tolerance of ±1%, the spread of the +200 v output voltage is on the order of ±3%.

The filament circuits of the tubes in the unit are supplied from a standard filament transformer Trl.

This transformer is turned on by means of a toggle switch in unit UPT-1 which is connected to unit BP-200 through pins 4-6 of plug connector Shl.

Fuse Prl is included in the primary winding circuit of the filament transformer.

Neon bulb NL1, which signals the presence of +200 v, is connected in parallel with the load at the output of the unit. When a short circuit occurs at the load of the +200 v circuit, output fuse Pr2 (0.25 a) burns out and signal light NL1 is extinguished.

Monitoring the operation of the unit. Two test jacks are used to monitor pulsations of the output voltages in the unit:

-- G1 -- for monitoring pulsations of the +200-v voltage;

-- G2 -- for monitoring pulsations of the +300-v voltage.

Design of the unit. Unit BP-200 is a tube unit whose elements are arranged on a standard chassis.

The unit is located in the lower left compartment of the cabinet above unit BP-300.

The filter of the +300 v rectifier consists of a choke and four capacitors. The magnetic circuit of the choke is formed by standard type-Sh32 plates with a 40 mm core. Two 6N5S tubes and one 6Zh4 tube are in the tube channel. The filament transformer is located behind the tube compartment. The transformer is made of Sh16 iron (doubled) with a core size of 40 mm. (p 355)

On the front panel are a fuse and a neon bulb which signals the presence of voltage at the output of the unit and the condition of fuse.

The unit weighs 10.7 kg.

4. BP-150 Power Supply Unit.

Function. Power supply unit BP-150 (Figure 147) is used to supply the mixing circuits of the display equipment with -150 volts at load currents up to 110 ± 10 ma. The -150 v circuit is used at the same time as the source of reference voltage in units BP-200 and BP-7.

Unit BP-150 as well as the entire cabinet is turned on and off by means of toggle switches on the front panel of unit UPT-1.

Techincal data on the unit. The unit is powered by a three-phase voltage of 220 v, 50 cps.

The rectified output voltage of the unit varies from -140 v to -160 v.

Pulsations of the rectified voltage do not exceed 0.01% (15 mv peak-to-peak). (p 357)

Instability of the rectified -150 v with a simulataneous change in load current of the output circuit from 0 to 110 ma and a change in line voltage of ±5% does not exceed 0.67% (1 v).

A protection circuit for the -150 v unit disconnects the supply voltage at the input of the unit in the event of short circuits at the load.

Functional diagram of the unit. A functional diagram of power supply unit BP-150 is given in Figure 148.

The unit consists of the following elements:

-- three-phase plate transformer;

-- filament transformer;

-- selenium rectifier;

-- smoothing filter;

-- regulating tube;

-- control stage;

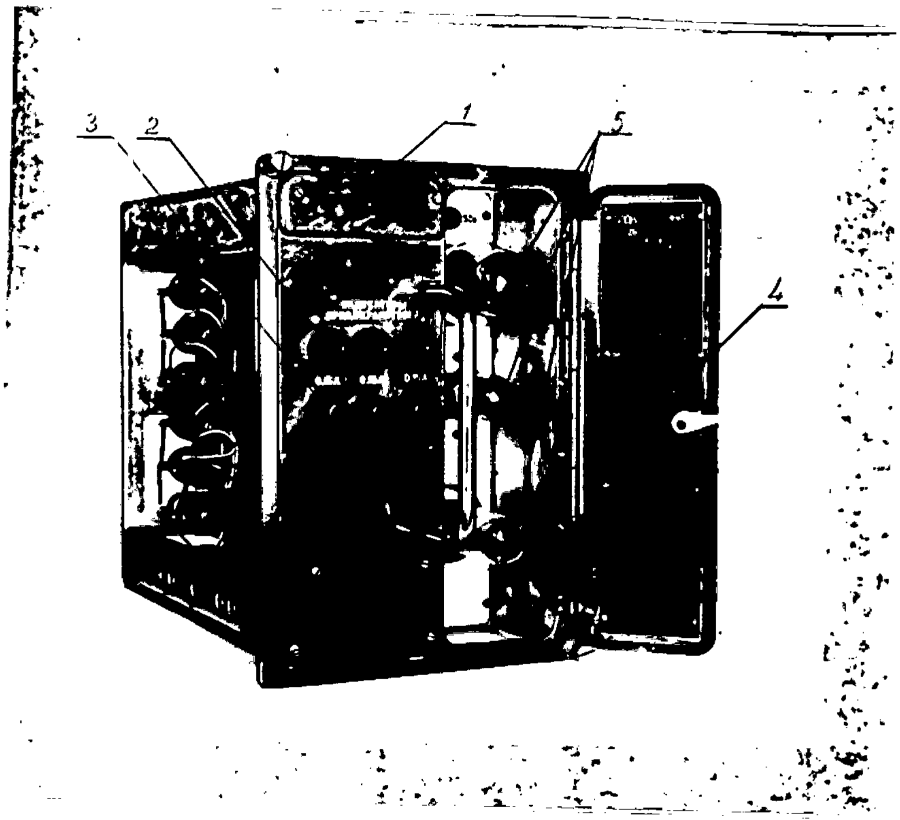

Fig. 147. Unit BP-150.

1 - plug cover; 2 - fuse condition indicators; 3 - fuses; 4 - label on door; 5 - tubes in tube channel.

The three-phase plate transformer is used to transform the three-phase line voltage of 220 v, 50 cps.

The filament transformer supplies the filament circuits of the tubes in the units.

The selenium rectifier is based on a six-phase bridge circuit with selenium elements and converts the alternating current taken from the secondary winding of the three-phase plate transformer to a d-c pulsating voltage.

Twin triode V1 (6N5S) with parallel-connected electrodes is used as the regulating tube in the unit. (p 359)

Triode V2 (6N9S) serves as the control tube.

The reference voltage for this tube is taken from stabilovolt (voltage stabilizer) V3 (SG3S).

Description of the schematic diagram. A schematic diagram of unit BP-150 is given in Figure 149.

A three-phase a-c voltage of 220 v from unit UPT-1 passes through pins 11, 13, and 17 of the plug connector to the primary windings of the three-phase transformer which is connected as a star.

A 0.15 a fuse is connected to each of the phases of the primary winding of this transformer. The condition of the fuses is monitored from neon bulbs MN-5 connected in series with 47-kilohm resistors.

These bulbs are connected in parallel with the fuses and light when the fuses burn out. The secondary windings of the three-phase transformer are star-connected and supply voltage to the selenium rectifiers. Type AVS-25-62 selenium rectifiers are used. Filter capacitor C1 is connected to the output of the rectifier.

The rectified voltage is applied to the plates of regulating tube V1 (6N5S), both halves of which are connected to each other in parallel. The cathodes of this tube are connected to the chassis of the unit.

The grids of regulating tube V1 are connected through grid suppressor resistors R4, R5 (100 ohms each) to the plate of tube V2a (6N9S).

The control system of the electronic stabilization circuit consists of a two-stage amplifier based on the two triodes of tube V2 (6N9S). (p 361)

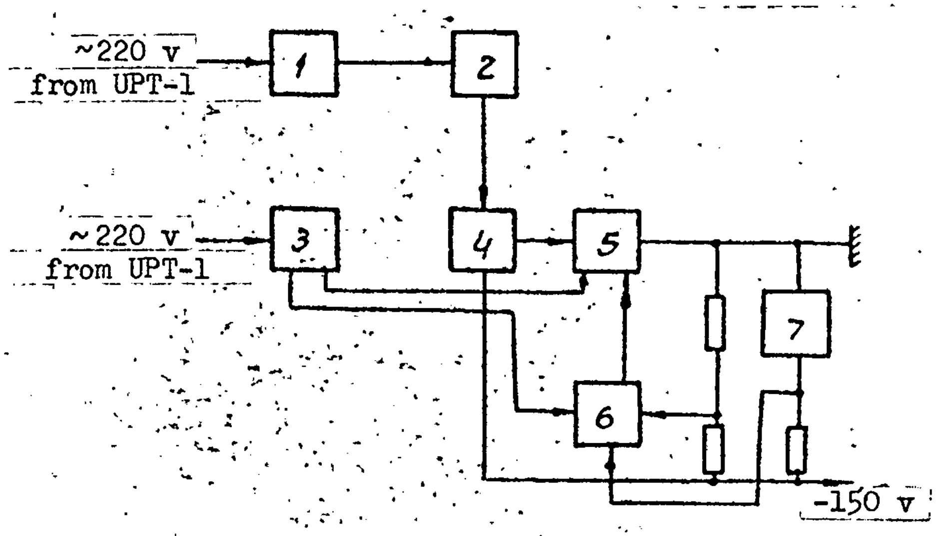

Fig. 148. Functional Diagram of Unit BP-150.

1 - three-phase transformer; 2 - selenium rectifier; 3 - filament transformer; 4 - filter; 5 - regulating stage; 6 - control stage; 7 - reference voltage circuit.

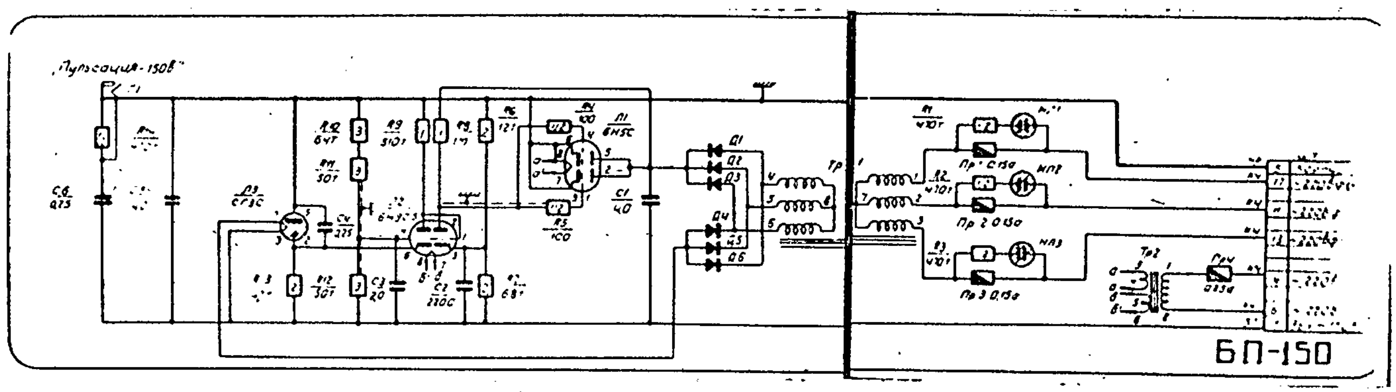

Fig. 149. Schematic Diagram of Unit BP-150.

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The principle of operation of the -150-v voltage stabilization circuit is as follows: A change in output voltage caused by fluctuations in line voltage or changes in load current is transmitted to the grid of tube V2b (6N9S) through an input divider consisting of compensated resistors R10, R11, and R12. Since the cathode of the right triode has a fixed potential maintained by stabilovolt V3 (SG3S), a change in output voltage will lead to an increase in the negative voltage at the grid of triode V2b. This in turn causes an increase in the positive potential at the plate of the right triode and a simultaneous increase in potential at the grid of the left triode. As a result, the potential at the plate of the left triode becomes more negative. The voltage at the grids of regulating tube V1 (6N5S) drops. The current in the tube decreases and the voltage drop in the tube increases, thus compensating for the change in output voltage.

Power for the stabilovolt is provided by connecting it through voltage-dropping resistor R13 to the rectifier output. Capacitor C4 is connected in parallel with the stabilovolt to prevent the possibility of exciting relaxation oscillations in the circuit. The plate of the right triode is connected to the grid of the left triode and to load resistor R9, the other end of which is connected to the chassis of the unit.

The cathode of triode V2a is connected to the middle point of a low-resistance divider, which is connected to the output of the rectifier and consists of resistors R6 and R7. This divider creates an almost constant potential at the cathode of triode V2a with respect (p 362) to its control grid.

The plate of the left triode is connected through resistor R8, which forms its plate load, to the input of the electronic stabilization circuit. Capacitor C5 is connected to the output of this circuit to prevent the origination of spurious oscillations.

A voltage is applied through capacitors C2 and C3 to the grid of the right triode and to the cathode of the left triode of V2 for more effective smoothing of voltage pulsations.

The -150 v circuit and the circuits of transformers Tr1 and Tr2 in unit BP-150 are protected against short-circuits. In the event of a short-circuit at the output of the -150 v rectifier, 0.15 a network fuses in the primary winding of the three-phase transformer burn out. If the stabilovolt (SG3S) is not functioning there will be no voltage at the output of the rectifier, since the negative side of the rectifier will be opened by the blocking contacts (3 and 7) of the stabilovolt.

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Test jack G1 is connected at the output of the rectifier through blocking capacitor C6 for the purpose of monitoring pulsations of the -150 v stabilized voltage.

Design of the unit. Unit BP-150 is built on a standard chassis. The tube channel contains tubes and the test jack.

The selenium stacks are located in the left rear part of the unit in a single vertical row.

The voltage divider using compensated resistors consists of three resistors wound with 0.05 mm constantan wire on a plastic frame. (p 363)

These resistors are attached to the chassis of the unit with a certain distance separating one from the other.

The type MLT resistors are attached directly to the mounts of the tube sockets and the tube seating contacts.

On the front panel are three fuses with their indicators (neon bulbs).

The unit weighs 5.8 kg.

5. BP-7 Power Supply Unit.

Function. Unit BP-7 (Figure 150) is used to supply 7.1 kilovolts to the plate of the cathode-ray tube is the indicator cabinet.

Technical data. The stabilized, rectified output voltage is 7.1 kv ±500 v with a load current of 200 microamps.

Pulsations of the rectified voltage do not exceed 45 v. Total stability of the rectified voltage of +7.1 kv is ±1.4%. The frequency of the oscillator supplying the rectifier is within limits of 15 to 20 kc.

The circuit of the unit permits brief short-circuits.

Functional diagram of the unit. A functional diagram of unit BP-7 is given in Figure 151; it includes the following elements:

-- higher-frequency oscillator using tube 6P3S; (p 366)

-- high-voltage transformer;

-- high-voltage kenotron 1Ts7S;

-- filter;

-- control stage;

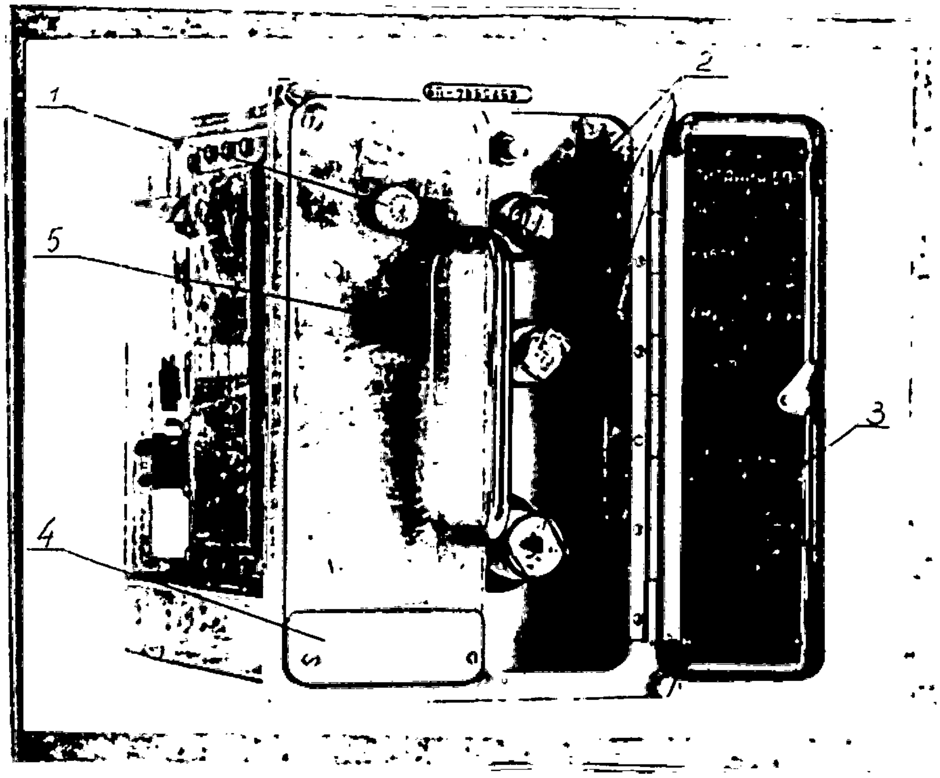

Fig. 150. Unit BP-7.

1 - light indicating presence of voltage; 2 - tubes in tube channel; 3 - label on door; 4 - plug cover; 5 - fuse.

-- feedback rectifier stage using tube 6Kh6S;

-- filament transformer.

Description of the schematic diagram. A schematic diagram of unit BP-7 is given in Figure 152.

The high voltage is produced by a high-frequency oscillator (15 to 20 kc) based on tube V3, type 6P3S.

The primary winding of the high-voltage transformer (taps 1-3) serves as the inductance of the oscillatory circuit, while the capacitance of the circuit is the distributed capacitance of this same transformer.

A plate voltage of +300 v is applied to tap 3 of the primary winding of the transformer and simultaneously to the screen grid of tube V3 in the oscillator stage.

A high a-c voltage is produced in the secondary winding of the transformer (taps 5, 6). This voltage is rectified by high-voltage kenotron V4, type 1Ts7S. The filament circuit of the kenotron is supplied by a high-frequency voltage from the third winding (taps 7-8) of the high-voltage transformer.

The rectifier operates with a capacitive load -- filter F1, consisting of two capacitors connected in parallel with a high-ohm resistor which provides for capacitor discharge when the load is removed. (p 368)

The output voltage is stabilized both with respect to the load and to changes in the supplying line voltages of +200 and +300 volts.

Voltage stabilization is provided by an auxiliary winding on the transformer (taps 4-5), rectifier V1, type 6Kh6S, with capacitive filter S1, and control tube V2, type 6N9S.

The positive rectified voltage is applied through resistor R1 to the grid of the right half of the control tube V2. A reference voltage of -150 v is also applied to this grid through fixed resistor R2 and variable resistor R3.

The voltage taken from the cathode of the right half of V2 is applied to the grid of the left half of this tube, while voltage from the plate of the left half of tube V2 is applied to the control grid of oscillator V3 through spacing capacitor C4.

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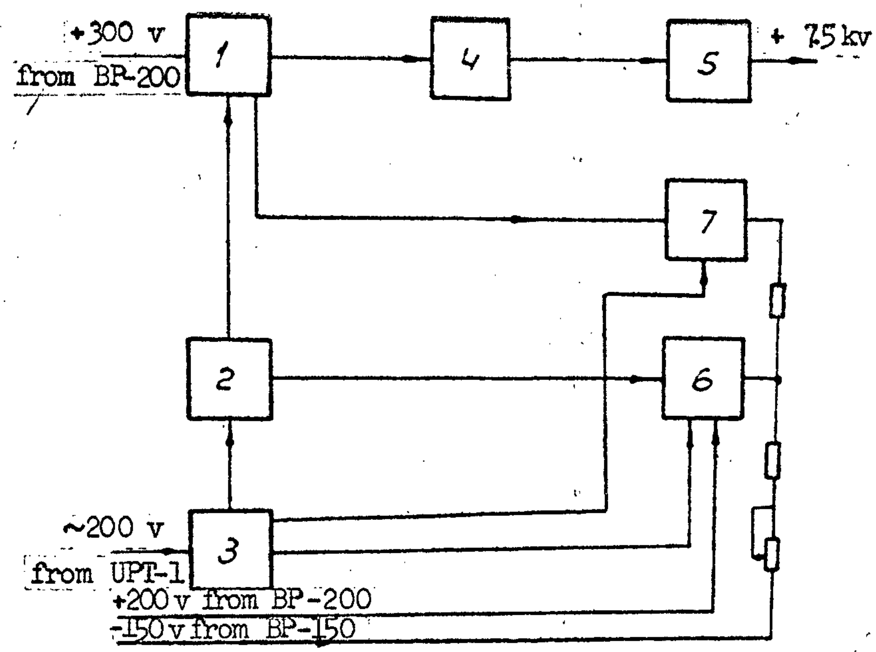

Fig. 151. Functional Diagram of Unit BP-7.

1 - high-voltage high-frequency transformer; 2 - oscillator stage; 3 - filament transformer; 4 - rectifier; 5 - filter; 6 - control stage; 7 - feedback rectifier stage.

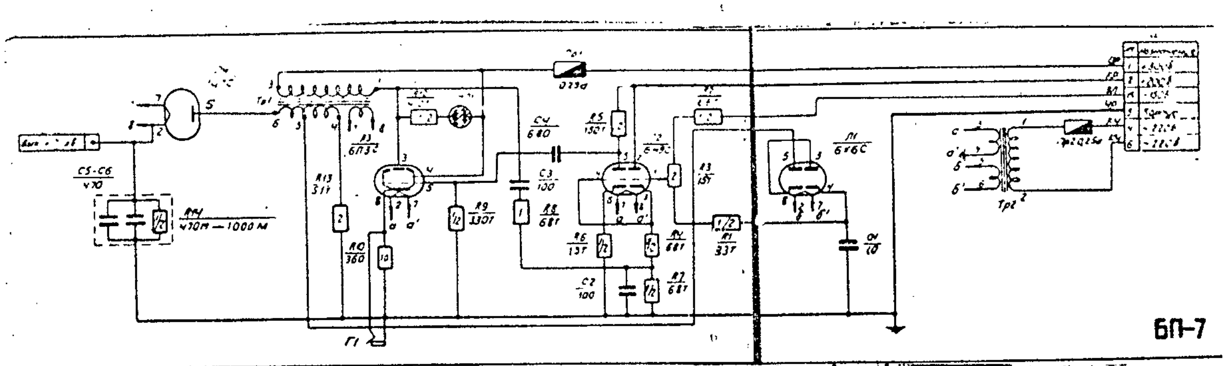

Fig. 152. Schematic Diagram of Unit BP-7.

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In the event of changes in the a-c output voltage (due to changes, for example, in the +300 v supply voltage) the voltage in the auxiliary winding changes simultaneously and this is transmitted to the control grid, causing a corresponding change in the voltage at the grid of the oscillator which compensates for the change in supply voltage.

Stabilization with respect to load current is accomplished by means of resistor R13 through which the load current of the rectifier passes. The voltage drop across this resistor is impressed on the voltage in the auxiliary winding of the transformer. (p 369)

In the event of a change in load current, the total voltage at capacitor C1 and, consequently, at the grids of tubes V2 and V3 changes, providing compensation for the resultant changes and stabilizing the high voltage at the output.

Neon bulb NL1, type MN-5 , is connected in parallel with the primary winding of the transformer through voltage-dropping resistor R12 for the purpose of indicating the presence of high-frequency oscillations. The bulb goes out if fuse Pr1 fails.

Monitoring the operation of the unit. Test jack G1, to which is applied a voltage from cathode resistor R10 of tube V3, is used to monitor the frequency generated in the unit.

Design of the unit. All parts of the unit are mounted on a standard chassis.

Tubes 6P3S, 6N9S, and 6Kh6S are located in the tube channel. The high-voltage kenotron is located beside transformer Tr1 on a bracket attached to the high-voltage transformer. The high-frequency, high-voltage transformer is in the left compartment of the unit.

The transformer has two high-voltage and five low-voltage insulators. (p 370) One high-voltage insulator has two leads for supplying the filament of kenotron 1Ts7S, and the second has one lead for supplying the plate of this kenotron.

In the right part of this compartment are the capacitor unit of filter F1, standard filament transformer Tr2, and the resistors.

Within the hermetically sealed filter are two type KVKG-6-470-III capacitors and a type KLV-0.5-470-1000-III discharge resistor designed for an operating voltage of 10 kv.

The unit weighs 10 kg.

6. Power Supply Control Unit UPT-1.

Function. Unit UPT-1 (Figure 153) serves for switching on and off the d-c and a-c voltages which supply all the circuits of the equipment in the cabinet.

The unit performs the following functions:

-- switches on the filament voltage;
-- switches on the d-c voltages with a time delay after the filament voltage has been switched on;
-- switches off the d-c voltages while the filament voltage is on;
-- switches off the filament voltage simultaneously with the d-c voltages;
-- protects the 220-volt, 50-cps, three-phase supply network against short-circuits within the cabinet. (p 372)

The unit is equipped with a type TAI-43 phone for communication with other vehicles and has two jacks for connection of the consumer to two phases of the 220-volt, 50-cps network.

Technical data on the unit. A three-phase line voltage of 220 v, 50 cps is applied to the unit.

When the filament voltage switch and the intermediate relay are truned on, a three-phase voltage of 220 v, 50 cps appears at their output contacts.

When the filament voltage switch is turned on, the reference voltage circuit of the SSP system is closed.

The time delay between turning on the filament voltage and turning on the plate voltage is 60 ± 25 seconds.

Functional diagram of the unit. A functional diagram of unit UPT-1 is given in Figure 154.

The unit includes the following elements:

-- filament toggle switch, type TV1-2;
-- plate toggle switch, type TV1-2;
-- intermediate relay, type RA-4P;
-- thermorelay, type TRV-18;
-- telephone set, type TAI-43.

A 220-v, 50-cps, three-phase a-c voltage is applied to the input of the filament toggle switch and then to the input terminals of the intermediate relay.

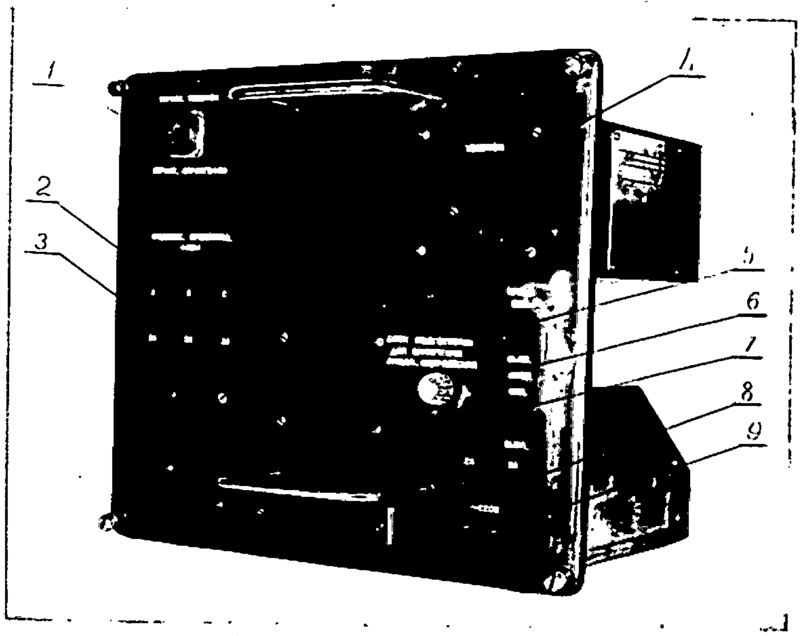

Fig. 153. Unit UPT-1.

1 - throat microphone-headset plug; 2 - 220-volt, 50-cps fuse indicators; 3 - 220-volt, 50-cps fuses; 4 - phone; 5 - filament voltage toggle switch; 6 - ready light for switching on plate voltage; 7 - plate voltage toggle switch; 8 - 220-volt, 50-cps fuses; 9 - 220-volt, 50-cps jacks.

After switching on of the filament toggle switch, the thermorelay delays switching on of the intermediate relay for the time needed to heat the electron tube filaments in all units of the indicator cabinet. (p 374)

The 220-v, 50-cps three-phase a-c voltage is admitted from the output terminals of the filament toggle switch to power supply units BP-150, BP-200, and the indicator units, while the same voltage is admitted from the output terminals of the plate toggle switch to units BP-150 and BP-300 which rectify the a-c current.

Schematic Diagram. A schematic diagram of the unit is shown in Figure 155.

The 220-v, 50-cps three-phase a-c voltage from contacts 1, 14, and 16 of plug Sh1 is fed to input terminals of filament toggle switch V2, then through fuses Pr1, 2, and 3 to contacts 3, 5, 7, and 10 of intermediate relay R2, as well as to contacts 2, 4, and 6 of plug Sh1.

Phase A is admitted after fuse Pr3 to contact 18 of Sh1 and through a jumper in the cabinet contactor of unit BV3 is returned to contact 7 of Sh1. Phase A passes from contact 7 of Sh1 to contact 1 of thermorelay R1 and contact 12 of intermediate relay R2.

Phase B is admitted through normally closed contacts 4-5 of intermediate relay R2 to resistor R1 and then to contact 8 of thermorelay R1. When the toggle switch "Filament" is in the "On" position, the coil of thermorelay R1 becomes energized and its contacts 1 and 5 close after 25 to 60 sec.

As a result of this, phase A is applied to the second end of the electromagnet coil of intermediate relay R2 (contacts 14 and 13), and the intermediate relay operates since its coil is now connected to phases A and B.

Operation of intermediate relay R2 causes a change in the position of its contacts 2-3, 4-5, 9-10, and 12-13 so that phases A, B and C are now sent to the input of toggle switch "Plate" and the coil of thermorelay R1 becomes disconnected from phase B. The instant intermediate relay R2 triggers is signaled by neon lamp NL1 which is connected to phases B and C through contacts 2 and 9 of the relay. (p 376)

Toggle switch "Plate" is used to switch the plate voltage on and off.

Toggle switch "Filament" (position "Off") is used for complete disconnection of the unit. At this time the coil of intermediate relay R2 becomes de-energized and its contacts 2-3, 4-5, 9-10, 12-13 return to the initial position.

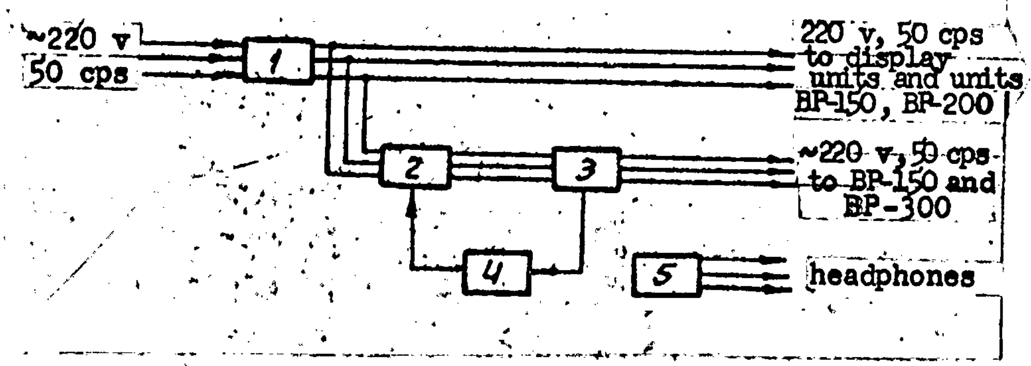

Fig. 154. Functional Diagram of Unit UPT-1.

1 - filament toggle switch; 2 - intermediate relay; 3 - plate toggle switch; 4 - thermorelay; 5 - phone.

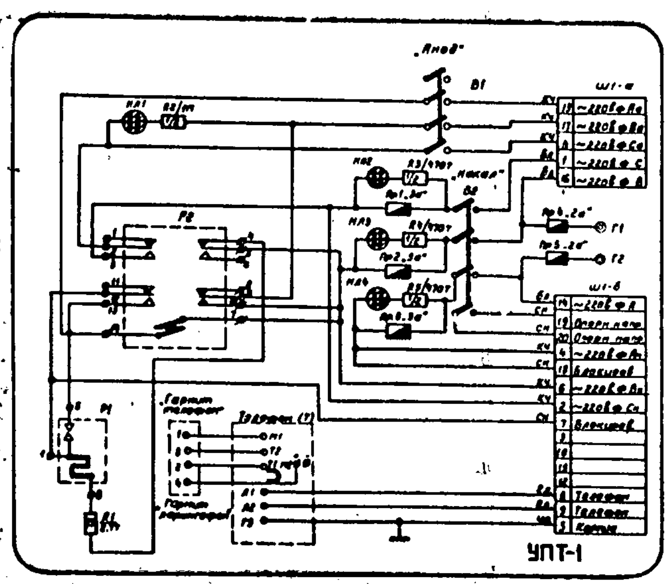

Fig. 155. Schematic Diagram of Unit UPT-1.

To again connect the unit, the toggle switch "Filament" should be placed in the position "On". If the toggle switch "Plate" is in position "On", then, after a certain time needed to heat the plate, the voltage will be turned on automatically.

The telephone set T is connected to the communication line through contacts 5, 8 and 9 of plug Sh1, and through socket K1 to the throat set.

Phases A and B are applied to jacks G1 and G2 which connect auxiliary (external) instruments to the 220-v, 50-cps line.

In case of a blow-out of fuses PR1, PR2, or PR3, the corresponding neon indicator bulbs NL2, NL3, and NL4 begin to glow.

In case of fuse blow-outs in phases A and B, the intermediate relay operates and neon bulb NL1 dims.

Construction of the unit. The unit is mounted on a vertical panel and is located in the lower middle part of the cabinet.

On the inner surface of the front panel are mounted all circuit components of the unit.

On the outside of the front panel are located: the telephone handle, filament and plate toggle switches, hoods for the neon bulbs, fuse sockets, jacks for the auxiliary instruments, a cover for the plug-and-socket connector, and two fixed handles. The weight of the unit is 6.9 kg.

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CHAPTER EIGHT

INDICATOR VEHICLE EQUIPMENT

1. Communication System of the Radar Station.

Function. The communcation system, consisting of the telephone and radiotelephone links and sound and light signaling, serves the radar station during its operation.

Technical Data. The apparatus and communications system equipment provide:

1. Telephone communication between vehicles 1, 2, 3, and 4 and the command guidance post (KPN).

2. Sound and light signaling between vehicles 1, 2, 3, and 4.

3. Ultrashortwave two-way operational radiotelephone communication between vehicle No 2 and the command guidance post (KPN) for distances up to 15 km.

Schematic drawing of the communcation system. A schematic drawing of the communication system is shown in Figure 156. (p 378)

The over-all communication system consists of several individual systems for different modes of communication.

Power supply to the telephone apparatus is taken from the MB (local battery) system, using dry batteries for each TAI-43 phone.

The signal circuit is supplied with power from one of the starting batteries of the diesel engines located in vehicles 3 and 4.

Power supply for the radio telephone system used for communication with the command guidance post is taken from the storage batteries of the radio equipment.

Telephone equipment. In the UPT-1 power supply control units of indicator cabinets DUS-1, IKO-1, IIV-1, IAD-1, and IKO-1 are telephone instruments TAI-43 without cases. The handle of the call inductor and a four-pin socket for connection of the microtelephone field headphone (MTG) and throat microphone gear (LTG) are mounted on the front panel of unit UPT-1.

Under the operator's table in vehicle No 2 is a type P-193M switchboard designed to handle ten telephone lines for various connections between the internal and external telephones of the radar station. A TAI-43 telephone is located on the operator's desk and is used to service the switchboard.

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Telephone communication between vehicles No 1, 2, 3, and 4 is carried out with the aid of TAI-43 telephones installed in these vehicles. (p 380)

Signaling Equipment. During operation of the diesel-electric unit, signal communications should be maintained between vehicle No 2 and vehicles No 3 and 4. For this purpose, vehicles No 3 and 4 are equipped with noise-electrovibration signals (SV), pushbuttons V1 and lamps LN1, and in vehicle No 2 (PDU-1) are a signal lamp LN3 and pushbutton V20. Switching on the noise signal SV and lamp LN1 is achieved simultaneously by pressing pushbutton V20 located in unit PDU-1 of vehicle No 2. A reply light signal is actuated by pushbutton V1 from either vehicle No 3 or 4. The circuit ensures automatic control of signal transmission.

Radiotelephone Equipment. A portable pack-type ultrashort-wave radio station type R-109-d is used for two-way radiotelephone communication between vehicle No 2 and the command guidance post (KPN). It is located under the operator's desk in vehicle No 2. During operation of the radio station, its beam antenna is extended outside the vehicle and is connected to the radio station by wires passing through an opening in the vehicle wall.

2. Ventilating and Heating System of the Vehicle.

Function. The ventilating and heating system of the vehicle is used for heating the vehicle in the winter and for cooling the tube channels in the indicator cabinets and removal of hot air from the cabin during summer.

Description of the System. A schematic drawing of the ventilating system is shown in Figure 157. (p 381)

The ventilating and heating system consists of:

- four fans;
- electric heater;
- heating installation OV-65.

Three of these fans are for exhaust and are located on the outside of the vehicle. Two of these are placed on the front wall of the vehicle and the third on the back wall to the right. A blower-type fan is placed on the back wall door of the vehicle to the left.

One of the first fans serves to ventilate the interior of the vehicle.

During summer this fan removes hot air from the vehicle through two hatches in the roof of the vehicle. During winter the same fan forces hot air from the roof of the vehicle through a duct to the feet of the operator.

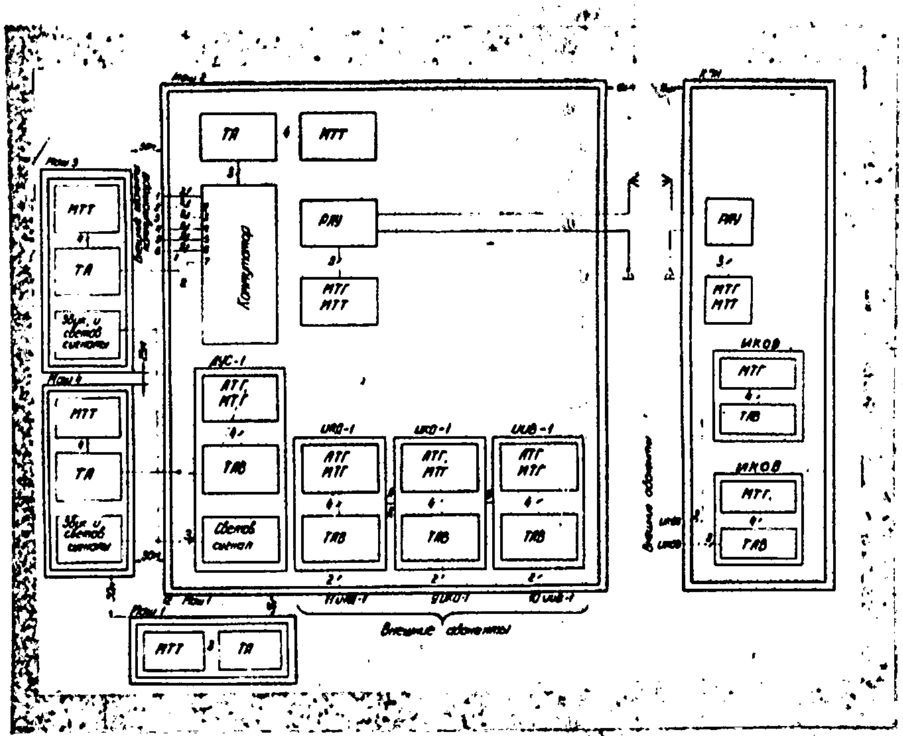

Fig. 156. Diagram of the Communications System.

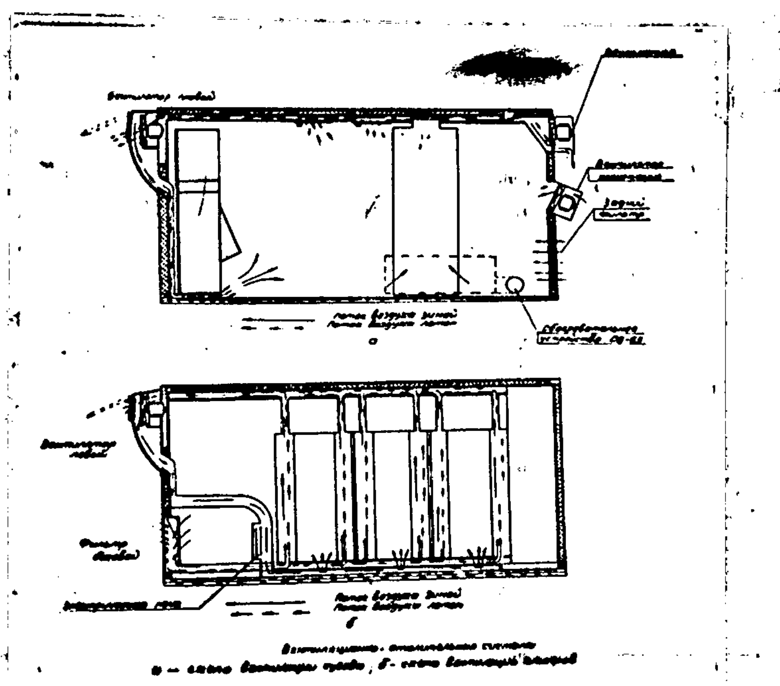

Fig. 157. Diagram of the Ventilation System.

The second fan is used to ventilate the cabinets. During summer the air is drawn from the cabinets and exhausted outside. During winter the hot air from the cabinets is forced through a duct and is exhausted at the feet of the operator.

The third exhaust fan is connected by a duct to cabinet P-11-1 and draws heated air from it.

The fourth fan, when conditions require, pumps air from the outside into the vehicle.

In the vehicle is a switch panel for the ventilating and lighting systems (unit ShchOV). A wiring diagram of the panel is shown in Figure 158. (p 383)

For more effective performance of the ventilating system, a special filter is installed in the door of the vehicle which permits clean air to be drawn into the vehicle.

In the left corner of the vehicle is an auxiliary filter. On the roof of the vehicle are mechanical-linkage handles for switching the ventilating system.

An electric heater is installed in the ventilating duct between cabinets ZN-F1 and IAD-1 for heating the air; the heater switch is located on the wall of the vehicle. Heater OV-65, mounted in an iron housing, is fastened to the right outer wall of the vehicle and is used to heat the vehicle in the winter.

Heater OV-65 is controlled from panel ShchP mounted on the cabinet with the IFF system units. A wiring diagram of OV-65 is shown in Figure 159.

Power supply to heater OV-65 is drawn from a storage battery located under the driver's seat through plugs located on panel RShch-4.

Rectifier VSA-10 is connected in parallel with the storage battery. The rectifier is placed on the floor of the vehicle next to the cabinet with the IFF units.

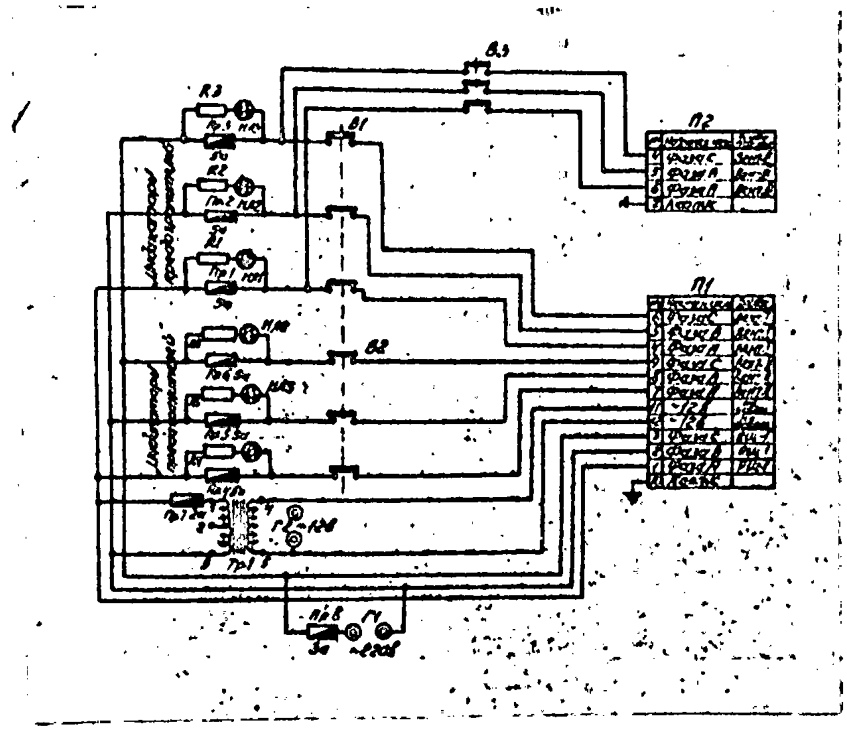

Fig. 158. Wiring Diagram of Unit ShchOV.

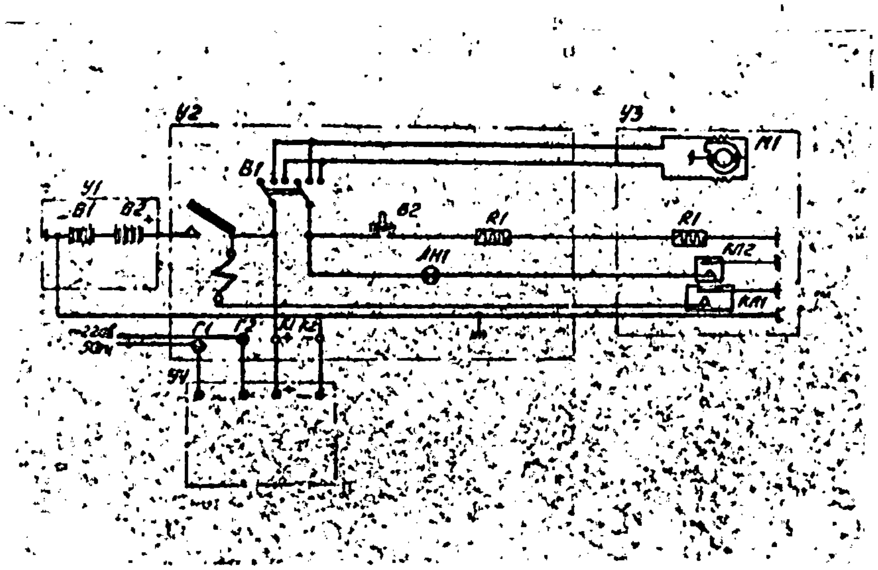

Fig. 159. Wiring Diagram of Apparatus OV-65.

3. Lighting.

The interior of the indicator vehicle is illuminated by four ceiling lights. A special light with enclosed wiring is placed at the operators desk.

All lights are supplied with power from a 12-v transformer located in unit ShchOV.

The vehicle is also provided with an emergency light which draws its power from a storage battery.

4. Arrangment of Cables.

The vehicle has two distributing panels RShch-3 and RShch-4 (Figure 161) The first one is intended for connection of vehicle No 2 with the receiver-transmitter vehicle with the electric power unit; the second functions as an output panel.

Each of the distributing panels has a cable junction box which is provided with external plug connectors.

The cables pass from the junction box to the terminal blocks of the distributing panel from where they branch off to various parts of the vehicle. The cables are placed in closed channels over the cabinets. Over each cabinet the appropriate cable is led from the channel to the cable panel of the cabinet.

Vehicle No 2 is connected to vehicle No 1 with a 50-m cables brand RPShE and PK-49. During transport of the radar station the cables are wound on spools and carried in vehicle No 2 on special brackets.

The cables connecting vehicle No 2 with the electric power station are transported in the electric power supply vehicle.

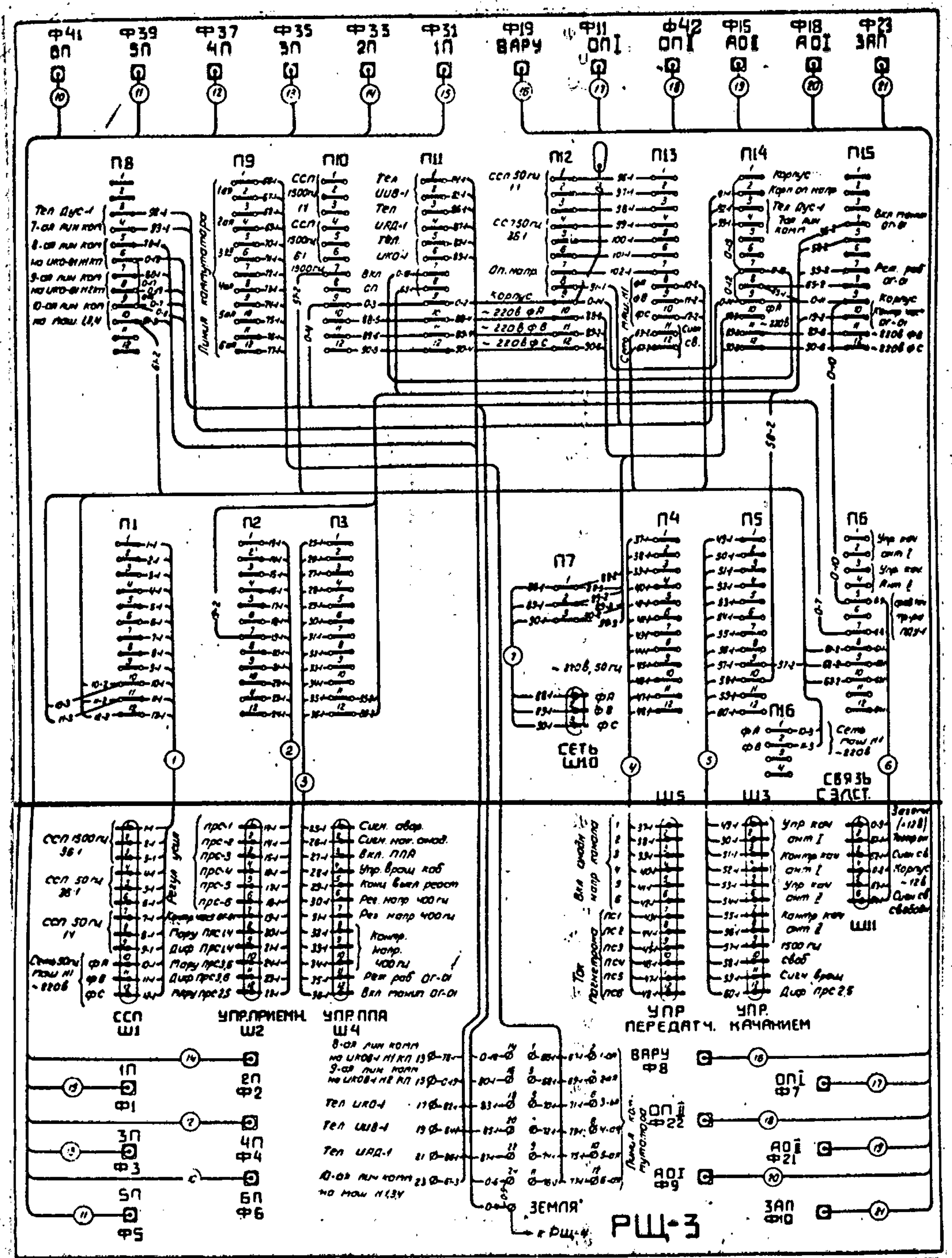

Fig. 160. Distribution Board RShch-3.

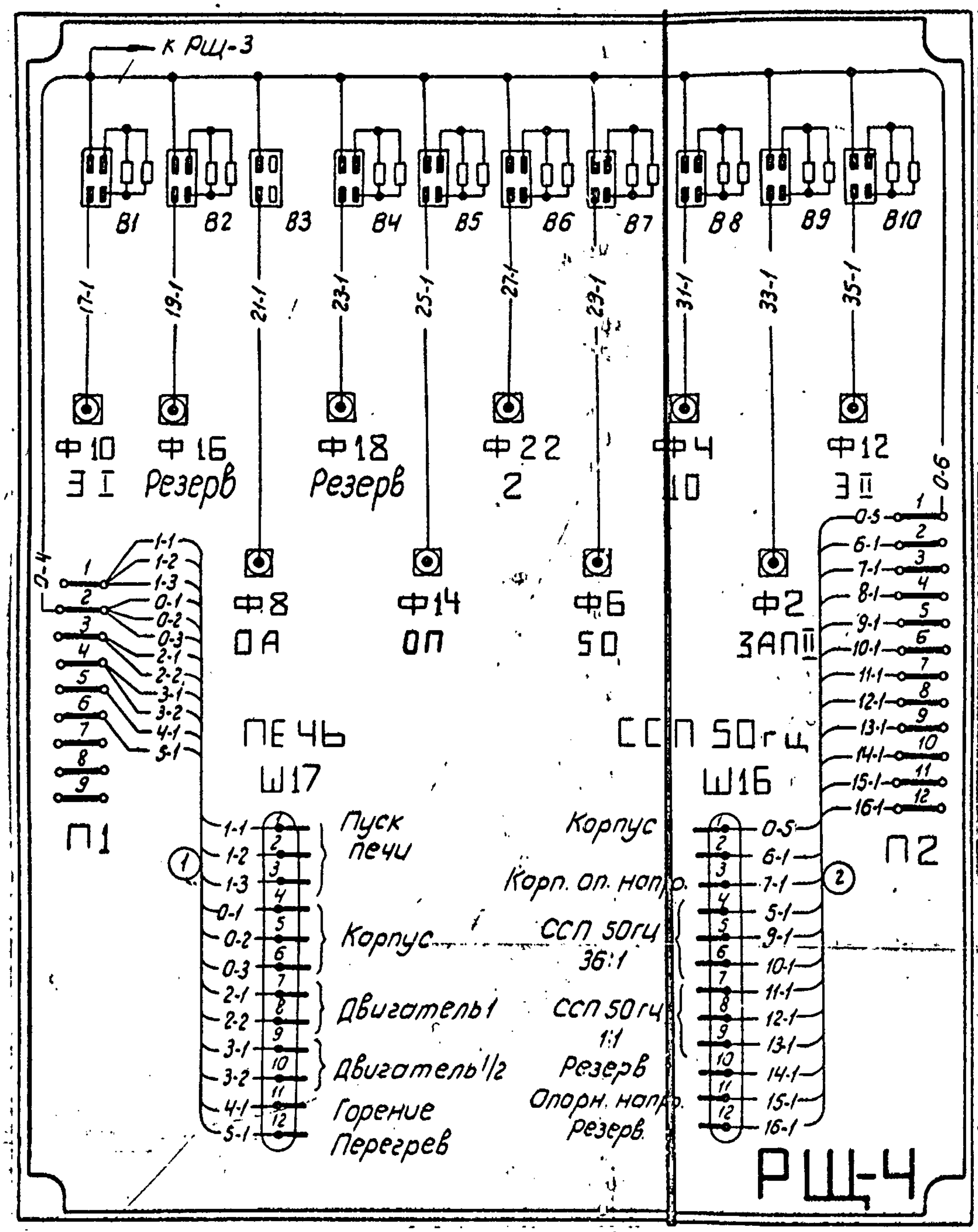

Fig. 161. Distribution Board RShch-4.

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