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INFORMATION REPORT INFORMATION REPORT

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CENTRAL INTELLIGENCE AGENCY

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MOBILE ACQUISITION AND GUIDANCE RADAR P–30–M

TECHNICAL DESCRIPTION YeA1.231.008 TO–B

Part I: THE TRANSCEIVER

(English Translation)

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MOBILE ACQUISITION AND GUIDANCE RADAR P-30-M

TECHNICAL DESCRIPTION YeA1.231.008 TO-B

PART I. THE TRANSCEIVER

Contents

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Table of Conventional Designations

(p 2)

PPS	- Centimeter-wave transceiver cabinet
PS	- Centimeter-wave transmitter
TS	- Thyratron unit of centimeter-wave transmitter
VVS	- High-voltage receifier of centimeter-wave transmitter
PRS-1	- Centimeter-wave receiver
ShU-1	- Control cabinet
TK-03	- Slip ring
APS-1 B,V,G,D, Ye,Zh	- Centimeter-wave antenna switch
BZ	- Trigger unit
ABZ	- Emergency trigger unit
FD-02	- Main selsyn unit
VPL-30	- High-frequency unit
PDU-1	- Remote control panel
RL-30-1	- Radio relay line
MK-1	- Elevating mechanism for vertical beam antenna
MKP	- Elevating mechanism for slant beam antenna
SD1	- Selsyn of horizontal reflector elevating unit
SDP	- Selsyn of slant reflector elevating unit
SMS	- Centimeter-wave magnetron coupling element
VZhS	- Centimeter-wave rigid waveguide
VPS	- Centimeter-wave waveguide coupling
VSS	- Waveguide mixer of centimeter-wave signal
UVCh-1	- Travelling-wave tube microwave amplifier (p 3)
SGS-1	- Flexible centimeter-wave coupling
OV-1	- Vertical reflector radiating element
ON-1	- Slant reflector radiating element
RK	- Distributor box
KK-1 KK-2 KK-3	- Cable junction box
IKO-1	- Plan position indicator
IKO-KPN	- PPI of command guidance post
IAD-1	- Azimuth-range indicator
IIV-1	- Height measurement indicator
DUS-1	- Station remote control cabinet
ZN-F1	- Master voltage cabinet
BP-150	- Power supply unit - 150 volts
VS-3	- IKO-1 and IAD-1 video signal unit
VS-4	- IIV-1 video signal unit
SS-1	- Signal mixer

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Table of Conventional Designations for NRZ-1 Ground Radar Interrogator

B-10	- Transceiver unit
B-11	- Transmitter
B-15	- Receiver
B-22	- Transceiver power supply unit
B-20	- Antenna
B-13	- Antenna drive unit
B-24	- Phase detector unit
B-12	- Control panel
B-14	- Distributing and circuit-protecting unit
B-16	- Indicator

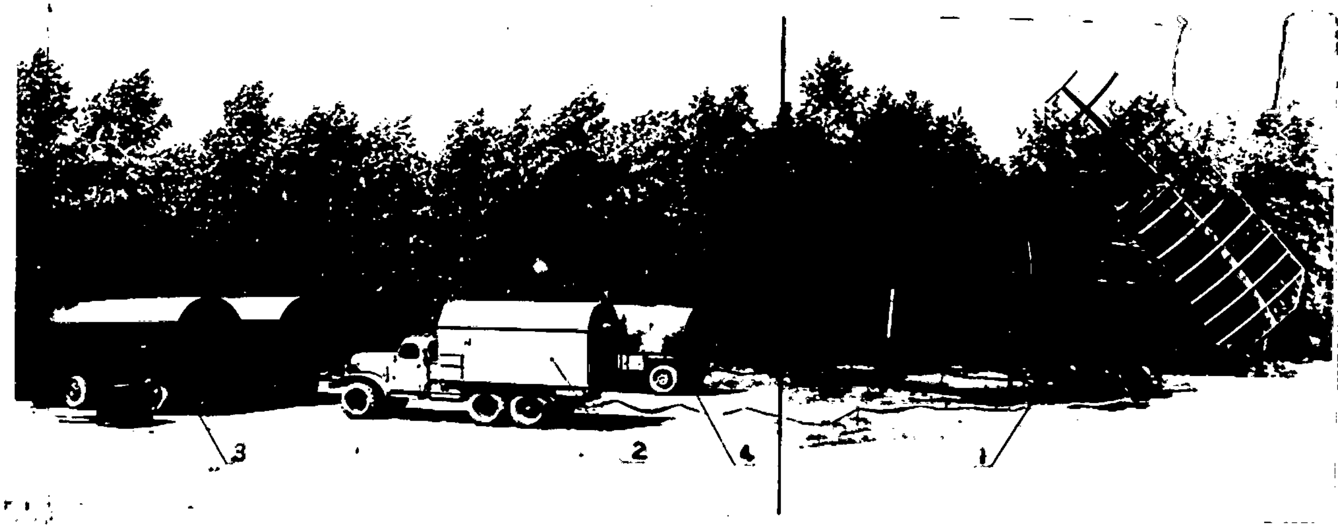

Fig 1. General View of the P-30-M Radar Station (p 5)

1. transceiver vehicle
2. indicator vehicle
3. power vehicle (electric power unit AD-50-T/230)
4. vehicle No 6

Fig 2. Vehicle No 1 (artillery trailer with rotating cabin) in Traveling Condition (p 7)

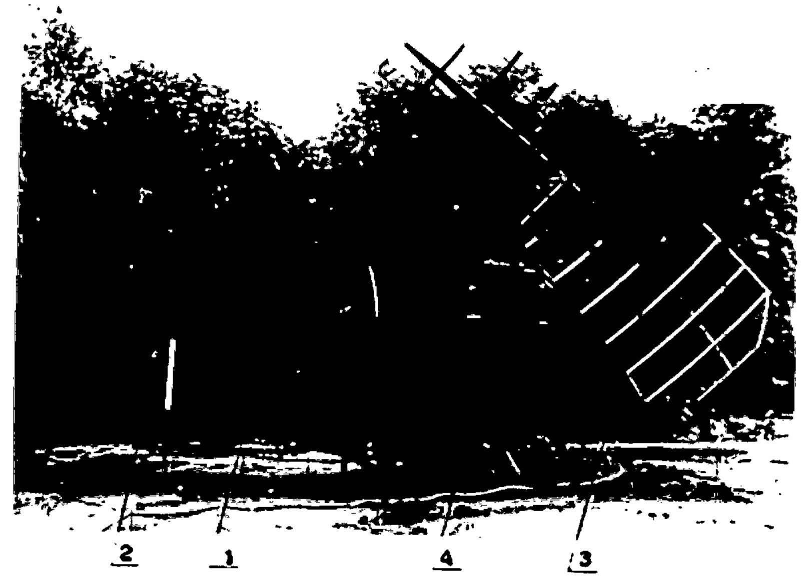

Fig 3. Vehicle No 1 (artillery trailer with rotating cabin) in Deployed Condition (p 8)

1. horizontal reflector
2. radiator of horizontal reflector
3. slant reflector
4. radiator of slant reflector

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CHAPTER ONE (p 4)

GENERAL INFORMATION

1. Function of the Station

1. The P-30M mobile radar (Figure 1) serves for the detection and identification of aircraft, determination of their coordinates, and the guidance of friendly fighter aircraft toward enemy aircraft.

2. Composition of the Station

The P-30M radar unit contains:

-- vehicle No 1 (transceiver cabin) -- trailer type KZU-16;

-- vehicle No 2 (indicator vehicle) -- truck ZIL-157;

-- vehicle No 3 (electrical power unit) -- trailer type 2PN-6;

-- vehicle No 4 (electrical power unit) -- trailer type 2PN-6;

-- vehicle No 5 (prime mover type ATS);

-- vehicle No 6 (antenna stowage) -- trailer type 2PN-4;

-- vehicle No 7 (RL-30-1 power supply) -- trailer type 1-AP-1.5;

-- apparatus and equipment of the command post which are transported in containers and special boxes.

[page 6 - probably text - missing]

-- PPI (IKO-1) cabinet (p 9)

-- azimuth-range indicator (IAD-1) cabinet;

-- height indicator (IIV-1) cabinet;

-- transmitter cabinet P-11-1 of radio relay line RL-30-1;

-- transceiver and indicator cabinet of identification system NRZ-1;

-- identification system unit (B-12);

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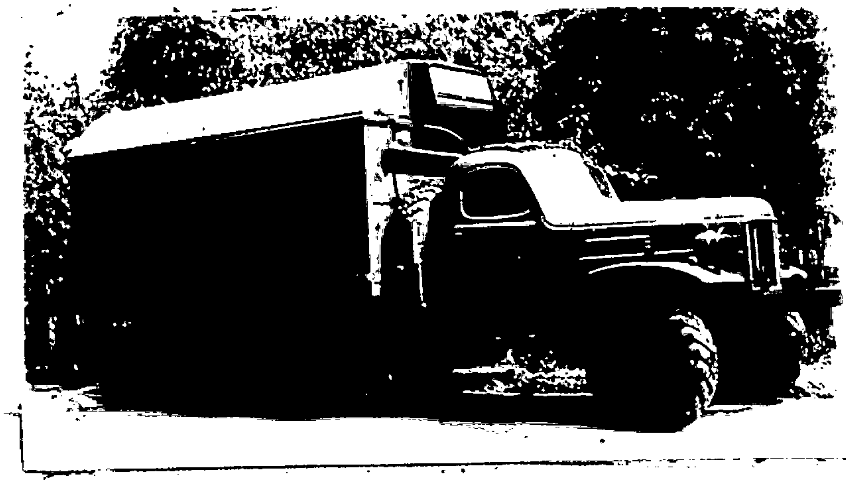

Fig 4. Vehicle No 2 (truck with indicators) (p 10)

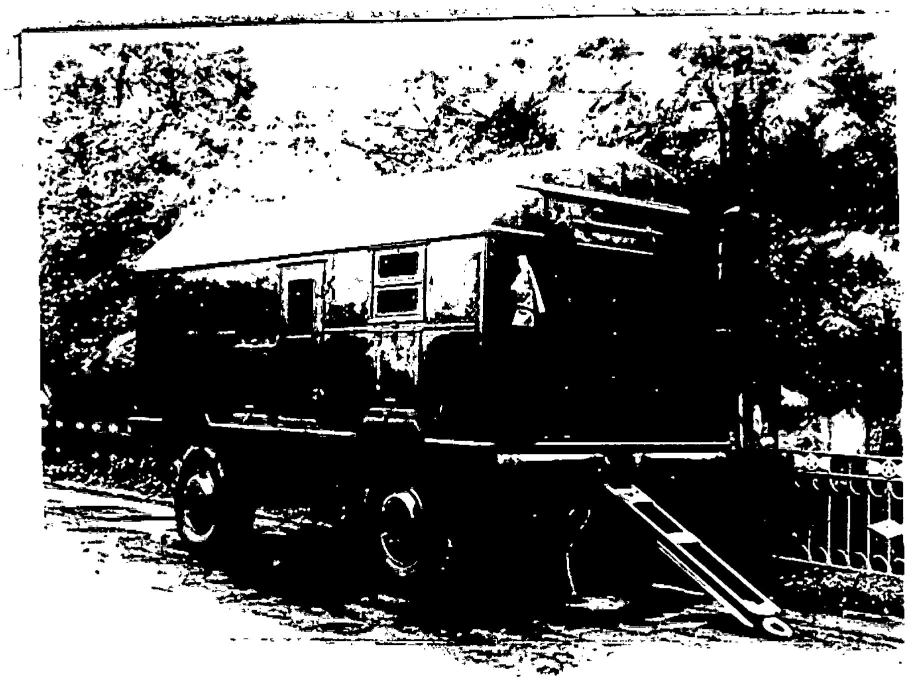

Fig 5. Electric Power Unit (trailer) (p 11)

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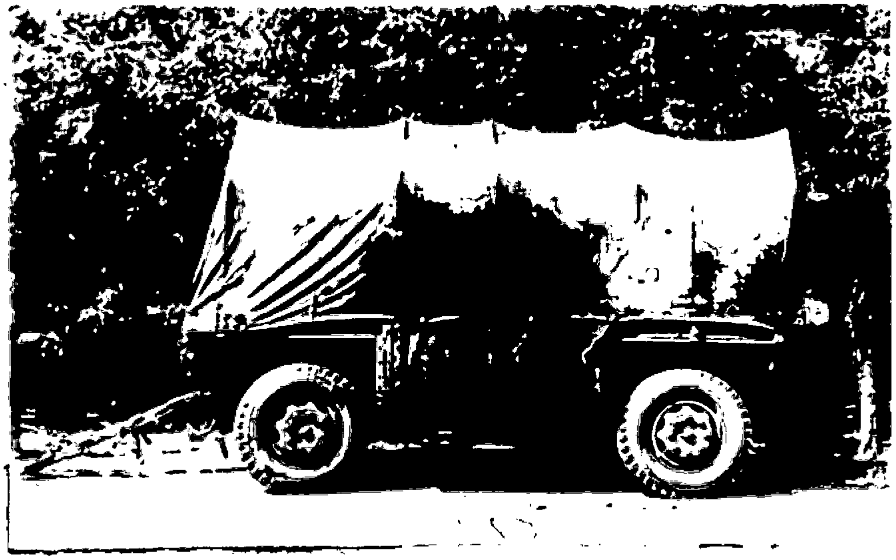
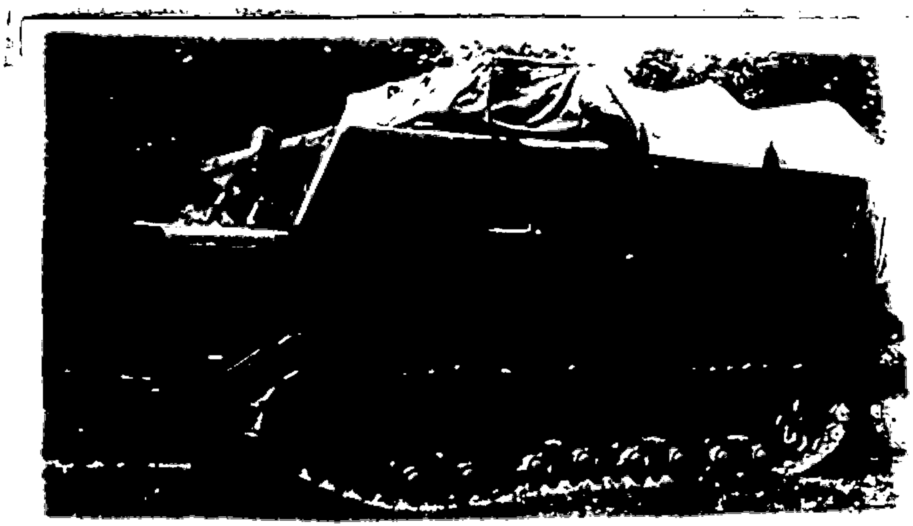


-Fig 6. Vehicle No 6 (trailer) (p 12)



-Fig 7. Prime Mover (type ATS) (p 14)

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-- 10-line telephone switchboard;

-- radio set type R-109D for communication with command post;

-- spare parts cabinet;

-- auxiliary equipment (ventilating-heating units, lights, cable boxes, cable spools with cable, chairs, etc.).

Electrical power unit (vehicles No 3 and 4). This system includes two electrical power units -- main and reserve.

One of the trailers with an electrical power unit is shown in Figure 5.

Each trailer contains:

-- diesel generator type ESD-50-V/230;

-- distributing board;

-- auxiliary equipment (cable boxes, fuel tanks with fuel, etc.).

Vehicle No 6. Figure 6 shows an external view of vehicle No 6. The trailer has special attachments for storing and securing movable parts.

The following components are carried on the trailer platform: [p 13]

-- reflectors in a special container;

-- the riged beam of the reflector;

-- beam for attachment of horizontal reflector;

-- cantilever for attachment of horizontal reflector;

-- high-frequency unit VPL-30 in a special housing;

-- boxes with measuring instruments;

-- box with theodolite, etc.

The body of the trailer is covered with a tarpaulin.

The prime mover (vehicle No 5). Figure 7 shows an overall view of the prime mover.

A jib is located on the front bumper of the prime mover for the purpose of mounting the antenna system of the station. During transport, the jib is secured to the platform of the trailer. In addition, the trailer platform is used to carry boxes with the waveguides and the mast of the transmitting antenna of the RL-30-1 system.

4. Basic Installations of the Station, Their Function and Principles of Operation

The P-30M station contains the following basic installations:

-- centimeter-wave transceiver;

-- NRZ-1 transceiver;

-- station indicators;

-- radio relay line;

-- indicators of the command guidance post;

-- electrical power units.

Centimeter-Wave Transceivers

(p 15)

The centimeter-wave transceivers provide for the detection of aircraft and the determination of their coordinates -- slant range, azimuth, and altitude.

Transceiver of the Identification System

The ground radar interrogator NRZ-1 included in the make-up of the radar unit is designed for operation in a system of radar identification for ascertaining the identity of aircraft equipped with the appropriate identification apparatus.

The principle of operation of the identification system is as follows. An interrogator operates on the principle of automatic radio communication with a special "responder" unit located in the aircraft.

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When an interrogation is sent, the interrogator transmitter generates short high-frequency pulses which are radiated by the antenna in the direction of the interrogated aircraft.

The interrogation signals are received by the aircraft responder, and the responder automatically generates and transmits coded response signals at the same frequency. The response signals are coded on the basis of the duration of the pulses and their phase sequence.

[page 16 (text) missing]

The indicator equipment includes: the plan position indicators, the azimuth-range indicator, the height measurement indicator, the plan position monitoring indicator located in the station's remote control cabinet, and the master voltage cabinet. (p 17)

The plan position indicator (IKO-1) is used to observe the position of the target in space and then to determine its slant range and azimuth.

The display on the screen of the indicator (Figure 8) is produced in a polar coordinate system, since the movement of the electron beam along the radius of the screen (from the center to the edge) corresponds to range scanning, and the rotation of this line corresponds to azimuth [illegible]. As a result, an undistorted plan of the position of the target [illegible] reproduced on the screen of the indicator.

The azimuth range indicator (IAD-1) makes it possible to observe any sector of the zone of operation of the station on an enlarged scale and to more accurately determine the range and azimuth of the target.

The display on the screen of this indicator (Figure 9) is produced in a rectangular coordinate system. Azimuth scanning is carried out on the horizontal axis and range scanning on the vertical.

This display on the screen corresponds to the true position of the target in the chosen sector of space and is used in guidance operations for closing aircraft.

The height measurement indicator (IIV-1) serves for determining the altitude of targets. [p 20)

Two markers from each target (corresponding to the horizontal and vertical channels of the station) are produced on the screen of this indicator (Figure 10). The altitude of the target is read from a scale projected on the screen of a cathode-ray tube by a special optical device.

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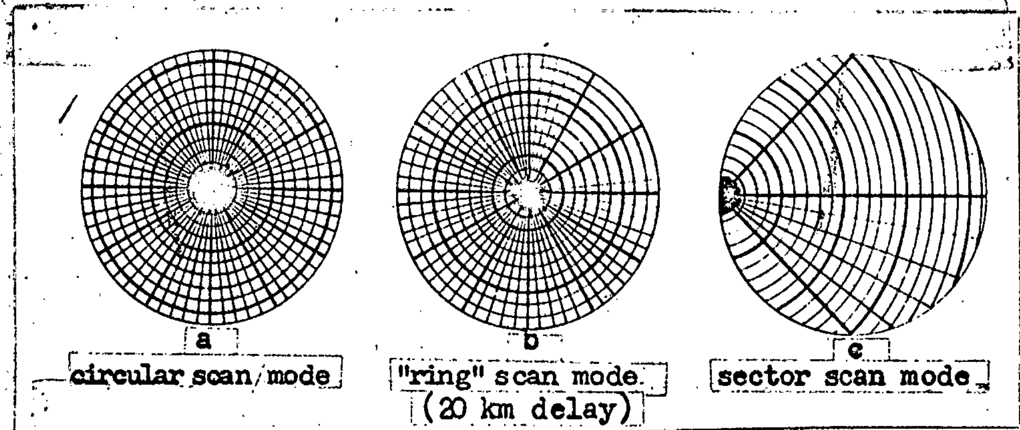

Fig 8. Image on Screen of Plan Position Indicator (p 18)

a. circular scan mode
b. ring scan mode (20-km delay)
c. sector scan mode

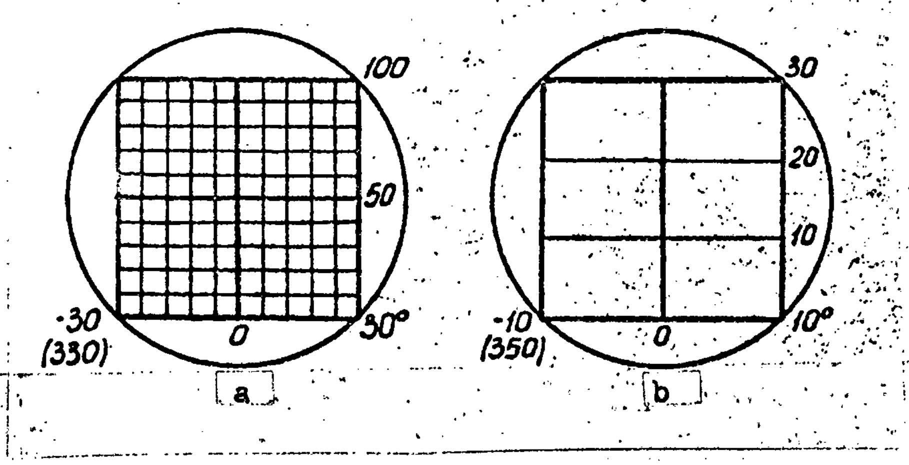

Fig 9. Image on Screeon of IAD-1 Azimuth-Range Indicator (p 19)

a. 100-kilometer range scale
b. 30-kilometer range scale

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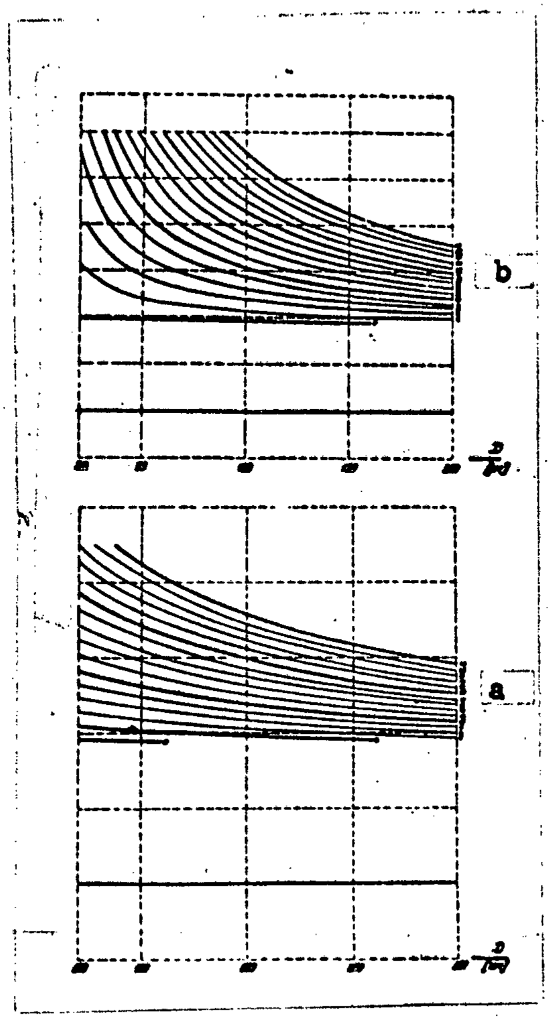

Fig 10. Image On the Screen of the IIV (Height-Measurement) Indicator (p 21)

a. 20-degree angle scale
b. 40-degree angle scale

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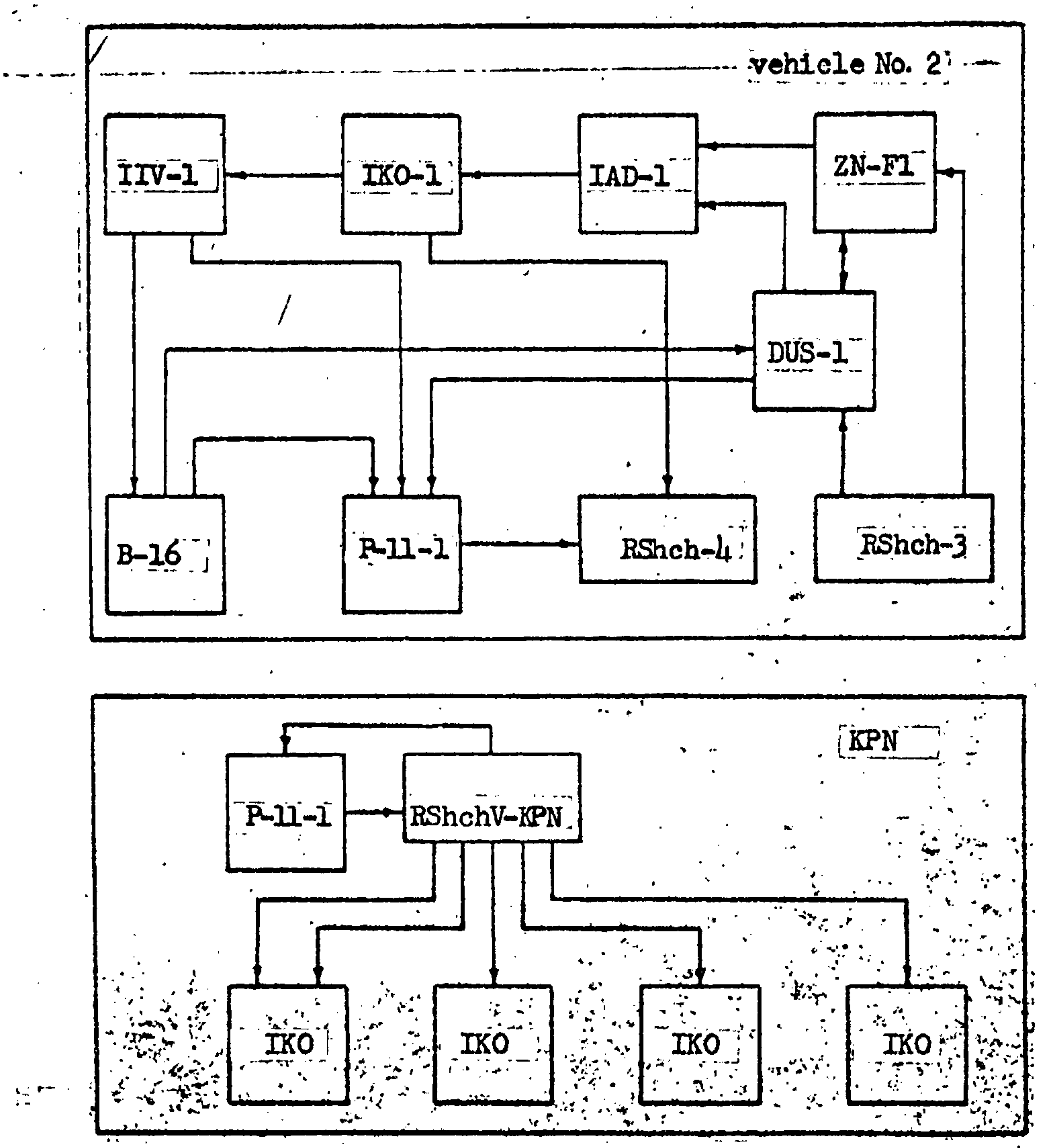

Fig 11. Block Diagram of the Indicator Equipment

(p 22)

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The plan position indicator monitor is identical to the main PPI and is used to evaluate the overall aerial situation and for remote control of the operation of all equipment in the station. This indicator operates in conjunction with the remote control panel of the transceiver apparatus.

The master voltage cabinet includes equipment for the generation of trigger pulses and range markers and voltages for the synchronous tracking system. Also located in the master voltage cabinet in vehicle No 2 is apparatus for protecting the video signals against nonsynchronous pulse noises.

A block diagram of the indicator equipment is given in Figure 11.

The Radio Relay Line

The display of the air situation observed on the PPI scope of the station is transmitted to indicators at the command guidance post by means of a radio relay line (RL-30-1).

The transmitter for the line is located in the indicator vehicle (p 23) of the station. The radio relay line receiver is located at the command guidance post at a distance of not more than 15 km from the station.

Electrical Power Supply Equipment

Power for the station may be taken from a 220-volt, 50-cps three-phase industrial line with a power consumption on the order of 33 kva, or the station may be supplied from its own electrical power units.

Two electrical power units -- the main and the reserve -- are included in the components of the P-30M station. Each unit can provide 8-hour continuous operation of the station. The station need not be shut down when changing from an industrial power source to operation from its own power source or when changing from the main electrical power unit to the reserve.

The station transmitters are supplied with a high-frequency voltage at 400 cps. A frequency converter (type VPL-30) is used for this purpose.

The receiver of the radio relay line and the indicators of the command guidance post are supplied from a separate type AD-5 unit.

An over-all block diagram of the station is given in Figure 12. 50X1-HUM

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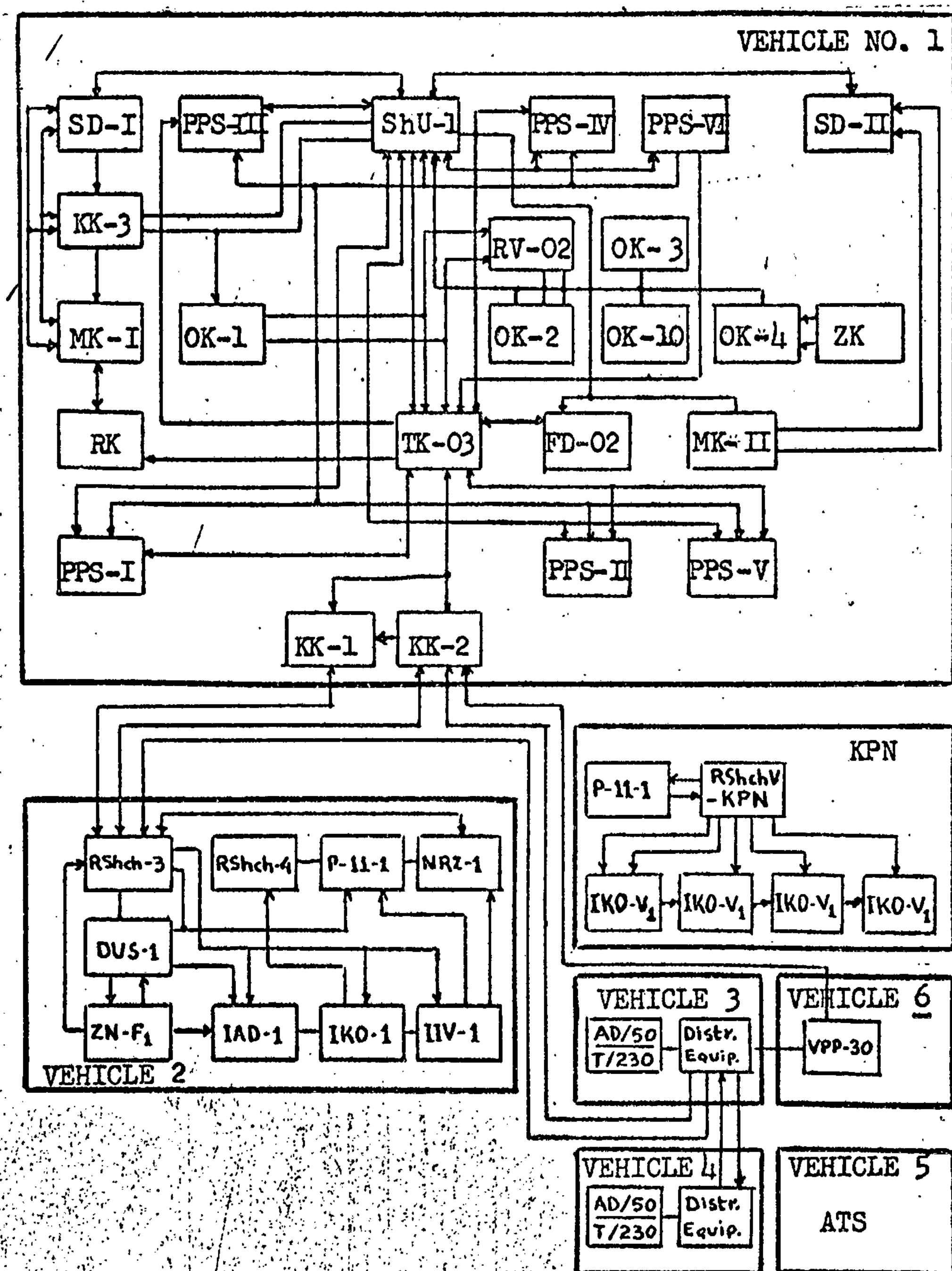

Fig. 12 General Block-Diagram of the Station (p 24)

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CHAPTER II (p 25)

THE ANTENNA EQUIPMENT

1. The Make-Up of the Antenna

The antenna equipment consists of:

-- two antennas for centimeter-wave channels: one vertical beam antenna and one slant beam antenna.

Figure 3 shows the positions of the antenna equipment on the transceiver cabin.

The vertical beam antennas use horizontal reflector 1. The radiator unit 2 consists of a bank of radiating elements.

The slant beam antennas use slant reflector element 3 with radiating element unit 4.

The radiating elements of the horizontal and slant reflectors are shown in Figures 13 and 14.

2. The Vertical Beam Antenna for Centimeter-Wave Channels

The vertical beam antenna for centimeter wave channels consists of one horizontal reflecting element and a unit of the radiating elements (Figure 15).

The initial position of the reflector is with its optical axis at an angle of plus $4^{o}20'$ to the horizontal.

Figure 16 shows an over-all view of the directivity pattern of the antenna in the vertical plane with the radiator in the initial position.

Each of the radiating elements is connected to a separate transceiver (channels one, two and three). (p 30)

The horn antenna of the second channel is positioned on the optical axis of the reflector, since the maximum directivity pattern of this channel coincides with the direction of the optical axis of the reflector. The horn radiator of the first channel is positioned above the radiator of the second channel and, in keeping with its

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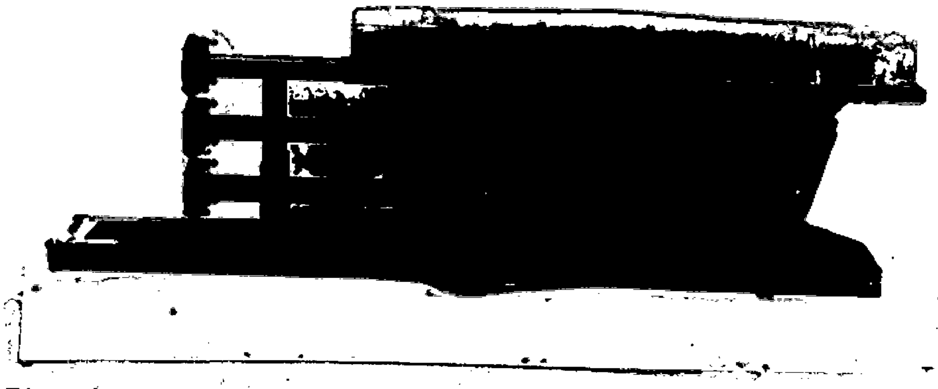


Fig 13. Radiating Elements of the Horizontal Reflector (p 26)

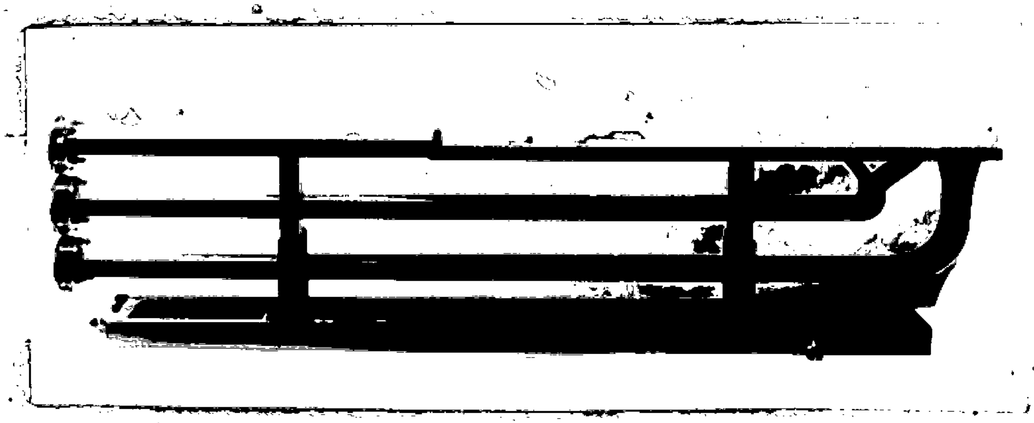


Fig 14. Radiating Elements of the Slant Reflector (p 27)

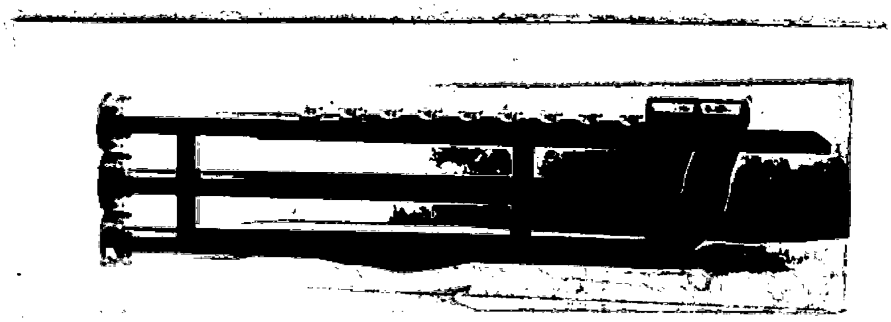
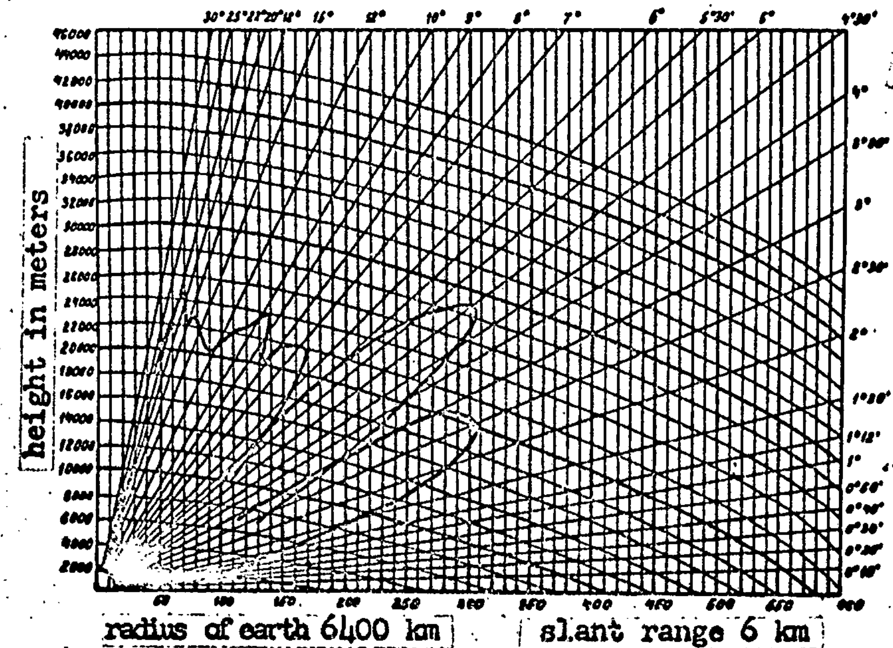


Fig 15. Radiating Elements of the Vertical-Beam Antenna (without protective cover and lock) (p 28)



-Fig 16. Directivity Pattern of the Vertical-Beam Antenna in the Vertical Plane

(p 29)

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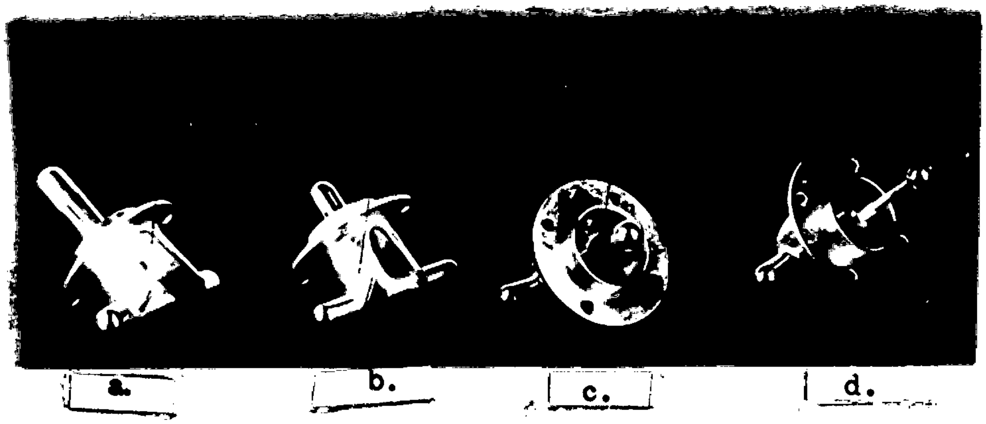

Fig 17. Types of Dipoles (p 31)

a. large cap-type dipole
b,c. small cap-type dipoles
d. ball-type dipole

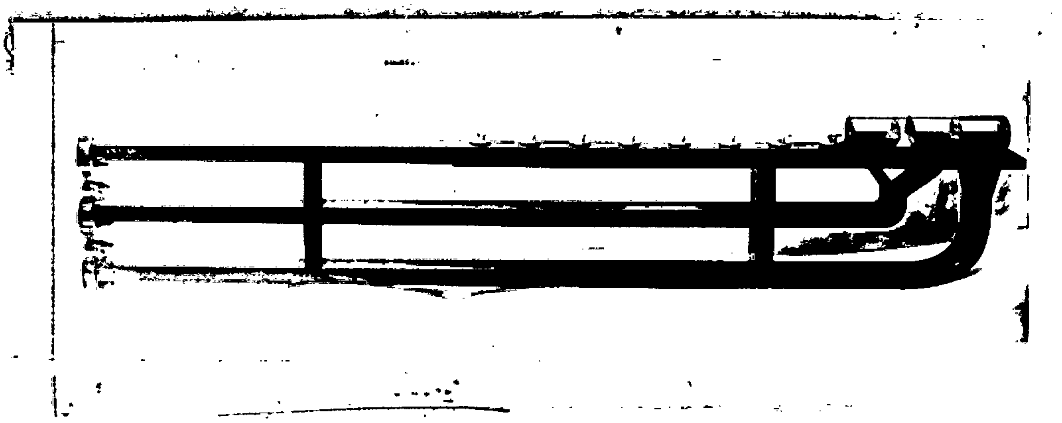

Fig 18. Radiators of the Slant-Beam Antenna (p 33)
(without protective housing and lock)

maxium directivity pattern, slants toward the optical axis of the reflector by an angle of minus two degrees. Below the second channel radiator is the third channel nine-dipole radiator, which forms an iso-altitudinal directivity pattern, the maximum of which is at an angle of plus 6.5 degrees to the horizontal.

The horns are designed so that nearly all of their radiated energy will fall on the surface of the reflector. This is accomplished by an appropriate choice of the flare angle of the horns and by special cylindrical divergent lenses installed in front of each of the horns. The horns are matched to the feeder waveguides (waveguide must operate in a traveling-wave mode) by means of diaphragms inside the horns. The dimensions and positioning of the diaphragms are determined during factory adjustment of the radiating unit.

The reflector of the third channel consists of half-wave dipoles of various types (Figure 17) installed on the wide wall of the feeder waveguide. Each dipole is fed by a short segment of a coaxial line, (p 32) the inside conductor of which is terminated in a stub which extends into the cavity of the waveguide. The distance that the coupling stub extends down into the waveguide determines what part of the power fed to the third channel radiator is diverted to the other dipole. The distribution of power to the dipoles is selected so as to provide an iso-altitudinal directivity pattern for the third channel. Most of the power is fed to the dipole closest to the focus of the reflector; for this reason the diameter of the coaxial line where the dipole is connected is larger than that of the other dipoles (Figure 15a). The coupling element of this dipole is made in the form of a cap. The coupling stubs of the second, third and fourth dipoles are rods with spheres at the end (Figure 17 g); the fifth, sixth, seventh, eighth and ninth dipoles have cap-type coupling elements (Figure 17 b, v).

The radiator of the third channel is matched by placing the shorted (grounded) wall of the waveguide above the first dipole.

All the radiators in the unit are covered with a protective penoplast housing.

3. <u>The Slant Beam Antenna for Centimeter-Wave Channels</u>

The slant beam antenna for centimeter-wave channels consists of one slant reflector and a unit of three radiators (Figure 18).

All the radiators are enclosed in a protective housing of penoplast. (p 36)

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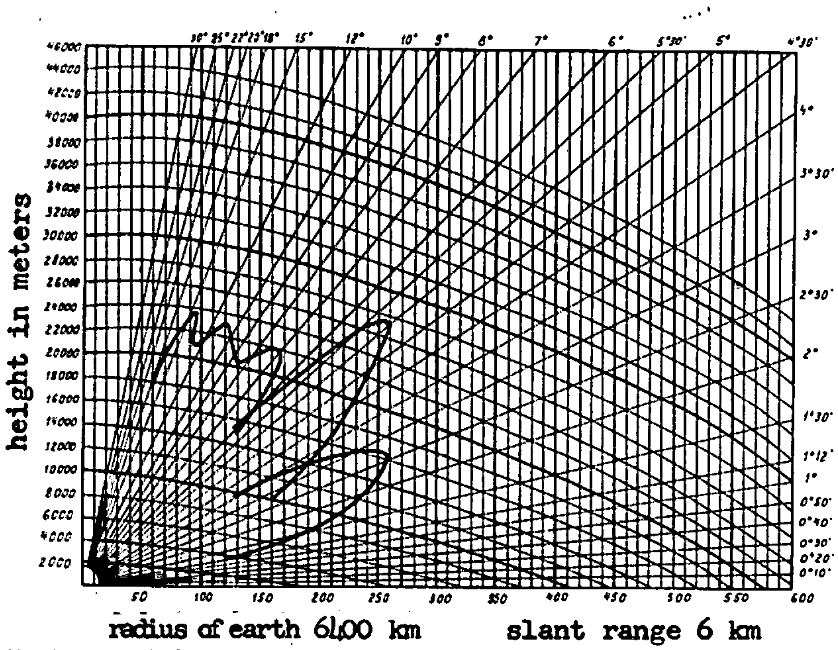

Fig 19. Directivity Pattern of the Slant-Beam Antenna in the Vertical Plane (p 35)

Fig 20. The Reflector (p 37)

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4. The Reflector

The antenna system has two reflectors (Figure 3, positions 1 and 3), each of which (Figure 20) is a truncated paraboloid of revolution.

The reflector dimensions are 9.7 x 3 meters; the focal distance is 2.5 meters.

Both reflectors are similar in design, with ridged frame reinforcement. The ridged frame is a riveted box-type design of duralumium sheets and is made up of three parts: the center part has a continuous rectangular cross section, and the peripheral sections have a variable rectangular cross section.

In order to increase the strength and rigidity of the frame construction, transverse septa are riveted along its entire length. Circular holes are cut into both sides of the frame in order to reduce the weight and wind loads.

On the frame of the reflector are eleven grating sections, which are attached to the frame by means of clips. The ends of the grating sections are attached to the frame by tubular struts. A grating section consists of a section, or structural panel, of stressed aluminum screening with a 10 x 10-mm mesh. When installed, the sections make up the working surface of the reflector.

Figures 21 and 22 show the method of fixing the reflector to the cabin. (p 38)

The horizontal reflector is attached to the horizontal frame on the front of the cabin by means of two swivel joints, which are two of the support points for the reflector. The third support point is connected to the rocking mechanism.

The reflector unit is attached by means of a bracket.

The horizontal frame is fastened to two supporting plates attached to the wall of the cabin. On one plate, the frame is attached to a pin, and on the other plate, the frame is attached by spring bolts.

The adjustment of the reflector in the horizontal position is done by rotating the frame on the pin by means of adjusting bolts. After the adjustment, the spring bolts are stressed.

One of the swivel joints of the frame on which the reflector is suspended has a special screw mechanism which moves the reflector in the horizontal plane in order to set the reflector at an angle of 10 degrees with respect to the slant reflector.

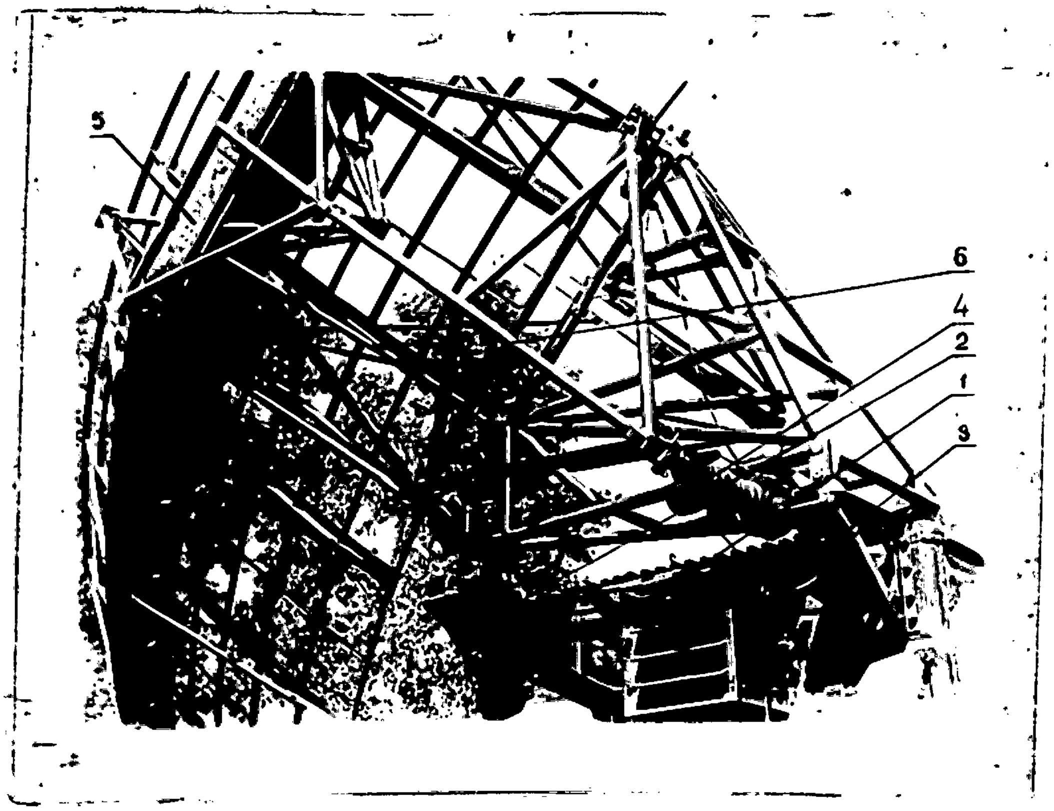

Fig 21. Attachment of the Slant Reflector to the Cabin

1. cabin
2. special bracket (left)
3. special bracket (right)
4. slant reflector
5. rocking bracket

(p 39)

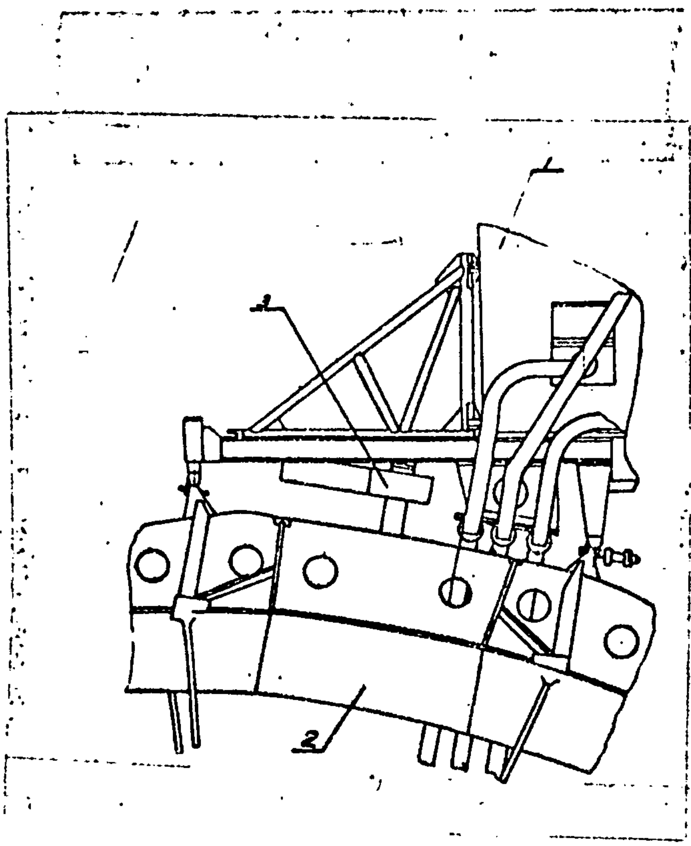

Fig 22. Attachment of the Horizontal Reflector to the Cabin

1. cabin
2. horizontal reflector
3. rocking mechanism

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The slant reflector is attached to a trihedral girder unit attached to the roof of the cabin.

On the lower edge of the reflector are two chocks with lugs that fit into the brackets of the girder unit and attach to it by means of pins.

At the three support points on the back of the reflector are the connections of the frame of the rocking mechanism, the rear end of which is connected to the rod of the rocking mechanism. (p 41)

5. The Reflector Rocking Mechanism

The rocking mechanism changes the angle of inclination of the reflector and correspondingly changes the directivity pattern in the vertical plane: from -2^{o} to $+8^{o}$ for the horizontal reflector, and from -2^{o} to $+8^{o}$ for the slant reflector, both in relation to the original positions.

Remarks: To guarantee the adjustment of the reflectors, the following ranges of adjustment are possible with the rocking mechanisms:

$+8^{o}$ ($\pm 0.3^{o}$) to -7^{o} ($\pm 0.3^{o}$) for the slant reflector in the vertical plane; and

$+8^{o}$ ($\pm 0.3^{o}$) to -5^{o} ($\pm 0.3^{o}$) for the horizontal reflector in the vertical plane.

The rocking mechanism for the horizontal reflector is attached at one end to the strut of the horizontal frame, and at the other end to the three-point reflector attachment. (p 42)

The rocking mechanism of the slant reflector is attached at one end to the bracket on the cover of the cabin, and at the other end to the rear end of the frame of the rocking mechanism of the slant reflector.

The rocking mechanism (Figure 23) consists of an electric motor 1 attached to reduction-gear housing 2 by a flange. Inside the reduction-gear housing is the worm gear and its worm wheel.

The worm wheel is connected to the nut of the drive screw. On the drive screw are two collars which disconnect the drive-screw nut from the worm wheel, thereby disengaging the mechanism, when the screw moves to the end position. The final position of the mechanism is set during factory adjustment by shifting the collars. On the housing of the rocking mechanism and on the drive screw are swivel joints 3 and 4, which attach the rocking mechanism to the cabin and to the reflector.

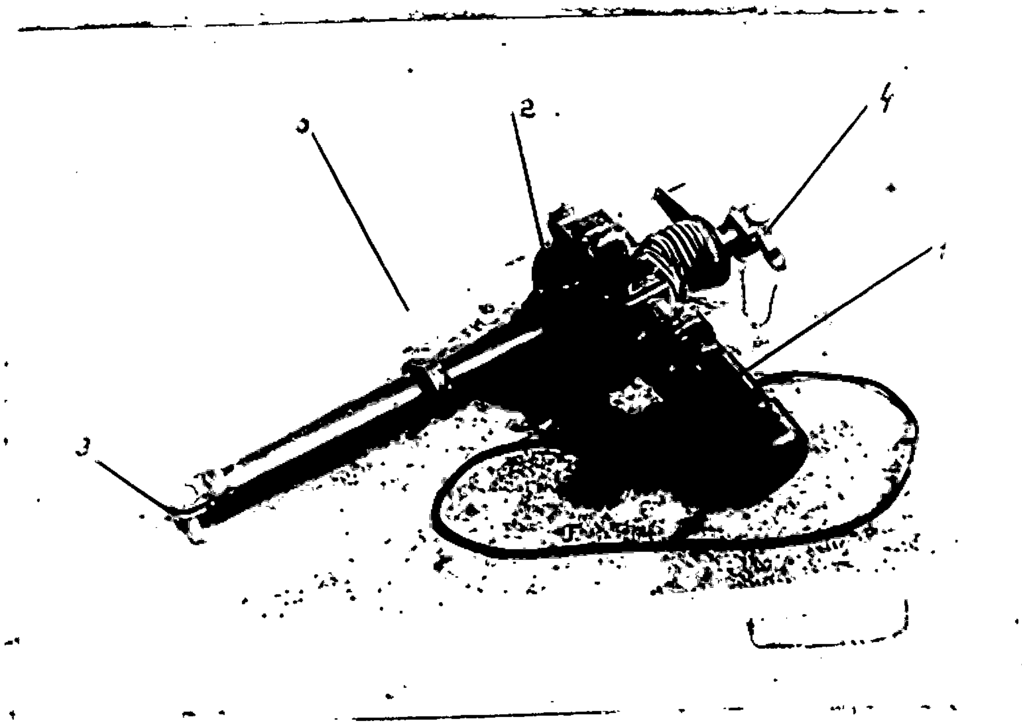

Fig 23. The Rocking Mechanism (p 43)

1. electric motor
2. reduction-gear housing
3,4. swivels for attaching the mechanism
5. dial

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The reduction gear has a device which is used to shut off the motor and to adjust the rocking mechanism manually with a wrench. Dial 5, which indicates the angle setting of the reflector when it is adjusted manually, is attached to the drive screw.

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CHAPTER THREE (p 44)

HIGH-FREQUENCY CHANNELS

1. High-Frequency Channels of the Centimeter Range

Block Diagram of the Channel

The station has six high-frequency channels all similar in construction. The block diagram of one of the high-frequency channels is shown on Figure 24.

The following basic components comprise the centimeter-wave channel:

- magnetron coupling element SMS
- rigid waveguide VZhs
- antenna switch APS-1 with a mixer of the AFC channel
- waveguide coupling VPS for coupling of the antenna switch with the high-frequency amplifier incorporating a traveling-wave tube
- flexible coupling SGS-1
- waveguide channel terminating in a radiator.

Magnetron Coupling Element

The magnetron coupling element SMS (Figure 25) serves as a non-reflecting coupling between the magnetron coaxial output and the waveguide. Two types of magnetrons with different outputs of high-frequency energy are used in the centimeter-wave transmitters. In conjunction with this, two types of magnetron coupling elements are used. (p 47)

The first type of magnetron coupling element is in the form of a T-shape coupling between the coaxial line and the waveguide.

It consists of a waveguide section 1 having a 38 x 88.5 mm cross section which gradually changes to a section 34 x 72 mm. The latter waveguide section is rigidly connected through an opening in its wide wall to a cylindrical brass section (bushing 2) which serves as an external conduit to the coaxial transmission line.

This section is connected with the aid of lock nut 3 to the external conductor of the coaxial output of the magnetron.

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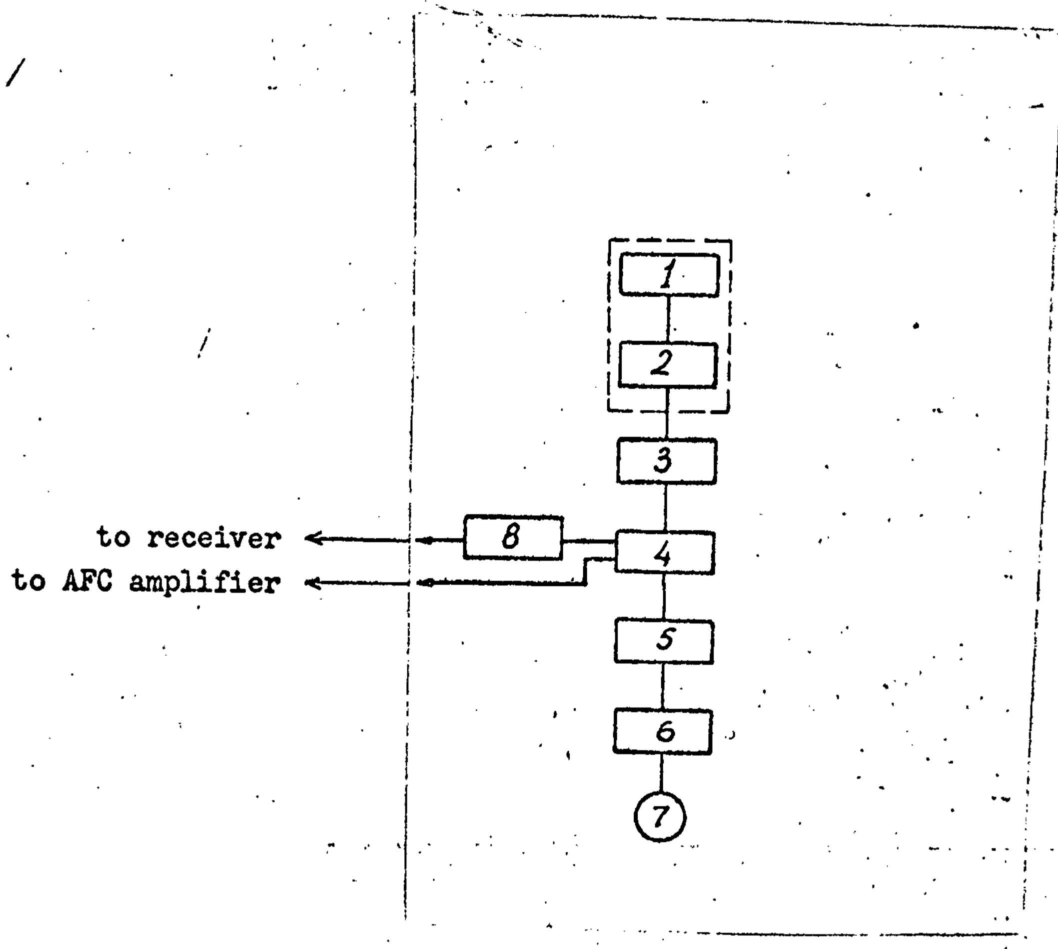

Fig 24. Block Diagram of One of the Centimeter-Range Channels of the High-Frequency System (p 45)

1. reflector
2. radiating element
3. waveguide channel with SGS
4. antenna switch
5. rigid waveguide
6. magnetron coupling element
7. magnetron
8. waveguide coupling

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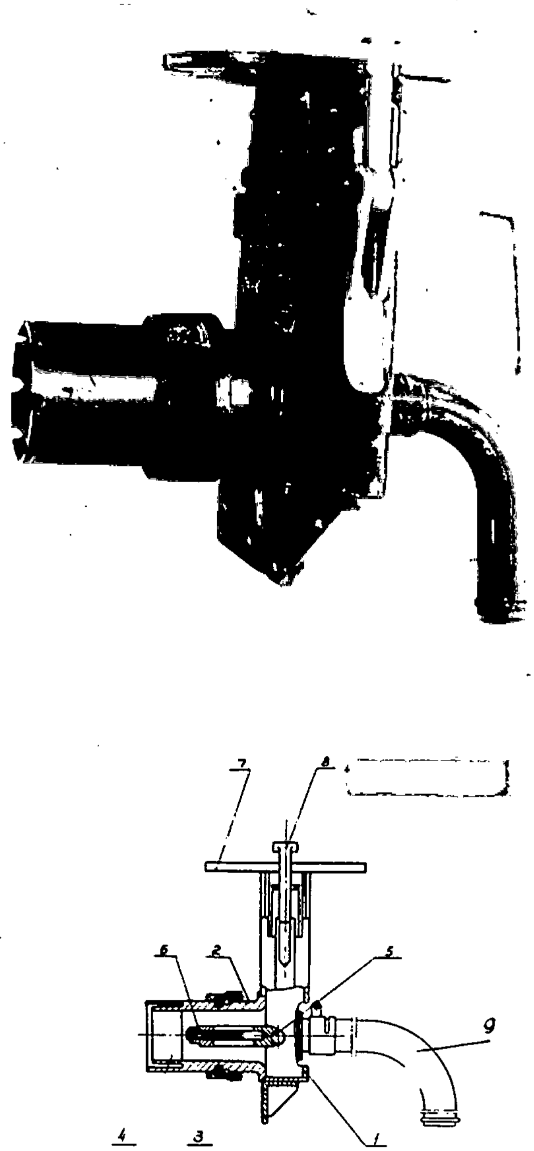

Fig 25. Magnetron Coupling Element SMS (p 46)

1. rectangular waveguide
2. bushing
3. lock nut
4. quarter-wave cavity
5. exciter
6. tip
7. flange
8. throw lock
9. air pipe

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A reliable contact at the junction is formed by a quarter-wave shorted cavity 4. A cylindrical stub with exciter 5 is connected to the middle part of the side wall of the waveguide. The stub axis coincides with the axis of the external conductor of the coaxial cable. The exciter has a hole for connection with the internal conductor of the coaxial cable. The internal conductor of the coaxial cable is in a form of a split brass cylinder (tip 6) which is connected at one end with the exciter and at the other end with the extension of the magnetron loop. The coupling loop extension forms the internal conductor of the magnetron coaxial outlet.

The waveguide part of the magnetron coupling element has, at the smaller cross section, flange 7 for connection to rigid waveguide VZhS with the aid of throw locks 8; on the other side it is closed. The high-frequency energy is transmitted from the magnetron through the coaxial cable to the exciter, which, in turn, excites a type H_{01} wave in the waveguide. (p 48)

The horizontal part of the T-shape coupling, on which the exciter is mounted, can be looked upon as an inner conductor of a short-circuited coaxial cable connected to the end of an exciter. The waveguide wall serves in this case as an outer conductor. The dimensions of the magnetron coupling-element components and their mutual positions are selected in such a manner, that within the range of the centimeter waves used, the transfer of energy from the magnetron to the waveguide takes place without appreciable reflection. On the narrow side walls of the SMS element are four slots for the exit of hot air.

Air if forced by a blower through tube 9 to cool the magnetron outlet.

The second type of the magnetron coupling element SMS-B (Figure 26) consists of a 34 x 72 mm waveguide chamber 1, which is closed at one end.

At the coupling of unit SMS-B with the magnetron, a coaxial line is formed in which the inside surface of bushing 2 serves as the outer conductor, and the magnetron stub 3 serves as the inner conductor. For better matching, the inside surface of the bushing is tapered. (p 50)

The waveguide is thus excited by a dipole which is a continuation of the stub. To ensure dielectric strength at the coupling, the magnetron stub is enclosed in an evacuated glass envelope 4. A blower supplies air through tube 5 for cooling the magnetron outlet and the glass envelope; this air escapes through the louvers cut in the side walls of the chamber.

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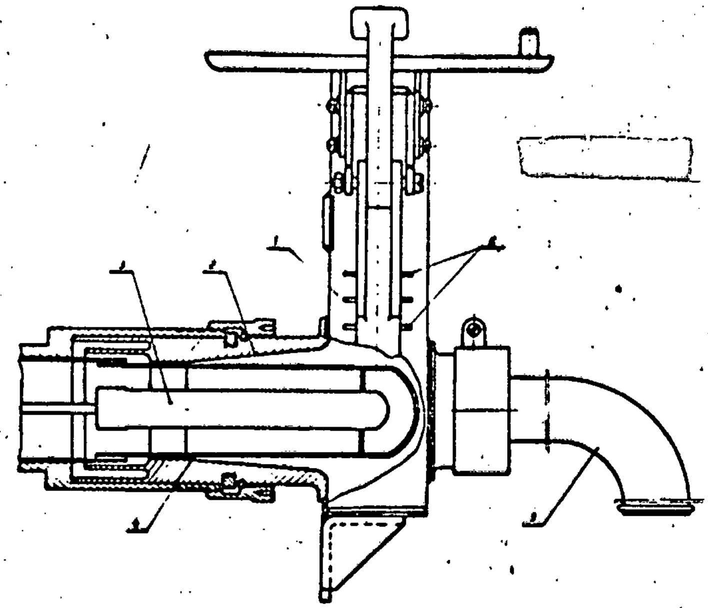

Fig 26. Magnetron Coupling Element SMS-B (p 49)

1. waveguide chamber
2. bushing
3. magnetron stub
4. glass envelope
5. air pipe
6. louvers

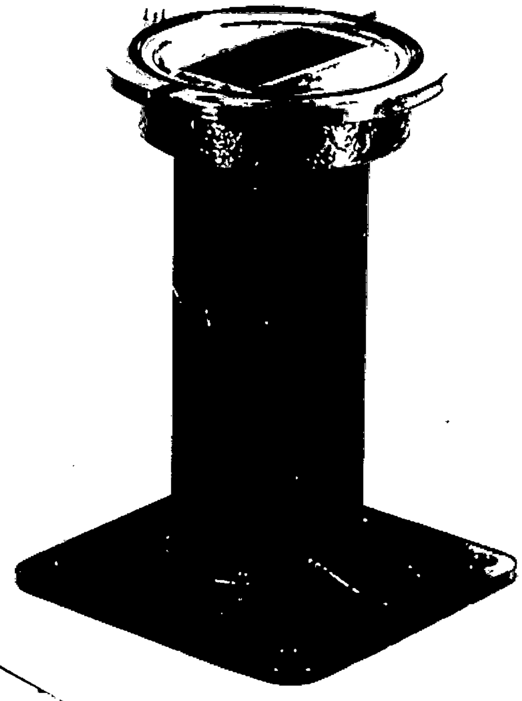

Fig 27. Rigid Waveguide

(p 51)

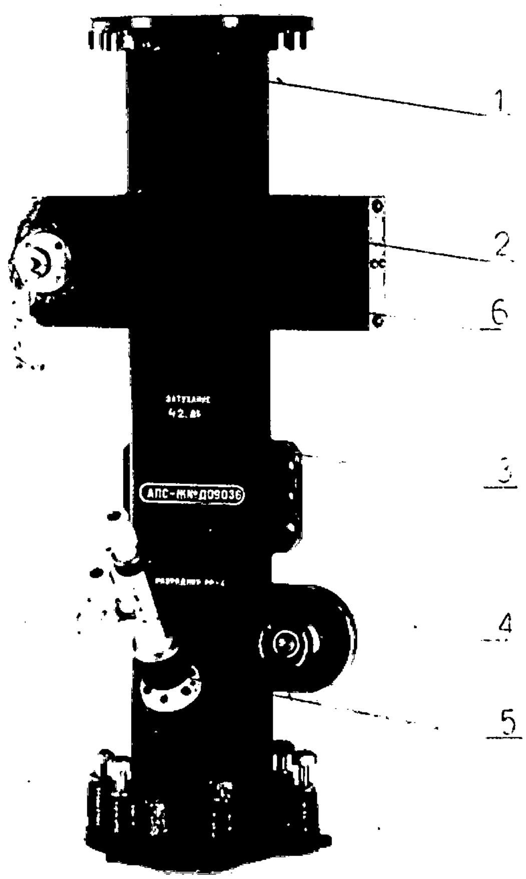

Fig 28. General View of the Antenna Switch (p 53)

1. rectangular waveguide
2. directional coupler
3. flange for connection of the rectangular discharge gap
4. ATR-chamber with round discharge gap
5. AFC mixer
6. connection for measurements

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The shape of the flange and its connection to the next element of the channel is similar to that of the first type SMS.

The magnetron coupling element is located in the transmitter unit cabinet PS, is rigidly connected to the magnetron bracket, and serves to support the magnetron.

Rigid Waveguide

The rigid waveguide VZhS connects (Figure 27) element SMS to the antenna switch.

It is in the form of a section of rectangular rigid waveguide. Flanges, soldered to both ends of the rigid waveguide, connect to element SMS and the antenna switch. A choke flange is used to connect element SMS, and a plain flange is used to connect the antenna switch.

Antenna Switch

(p 52)

During the transmission period the antenna switch ensures conduction of high-frequency energy from the magnetron to the antenna, and protects the receiver from overvoltage. During the reception period it ensures conduction of high-frequency energy from antenna to receiver without excessive losses.

The antenna switch consists of a section of rectangular waveguide on which are mounted two gas-welded discharge gaps, a directional coupler and AFC channel mixer (description of the latter is given in chapter VII).

A general view of the antenna switch is shown in Figure 28, and the block diagram in Figure 29.

The lower discharge gap type RR-7 (Figure 30) is placed in a cavity resonator which is coupled with the waveguide by a slot in the narrow wall. The resonator with the discharge gap is called the anti-transmit-receive switch (ATR).

At a distance of $1/2\,\lambda$ from the ATR-switch (λ is the wavelength) on the wide wall of the rectangular waveguide is mounted a rectangular discharge gap (Figure 30).

When the channel is assembled, the gap is mounted between the antenna switch and the flange of the waveguide coupling. A branch consisting of a half-wave section and a rectangular discharge gap is called the TR switch.

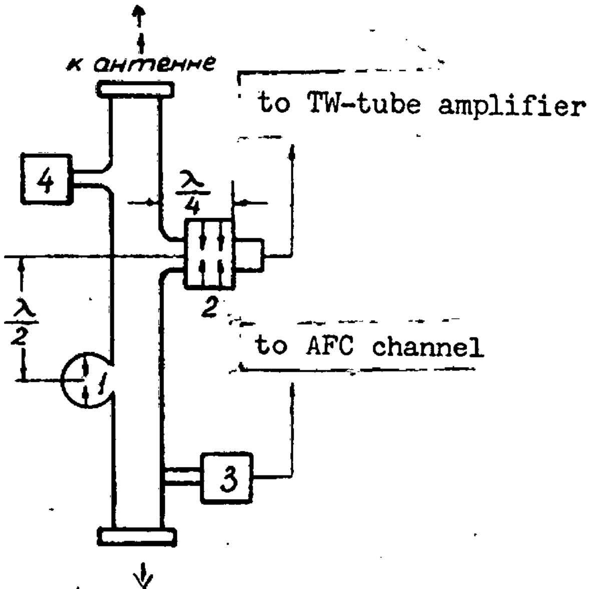

Fig 29. Block Diagram of the Antenna Switch (p 54)

1. ATR switch
2. TR switch
3. AFC mixer
4. directional coupler

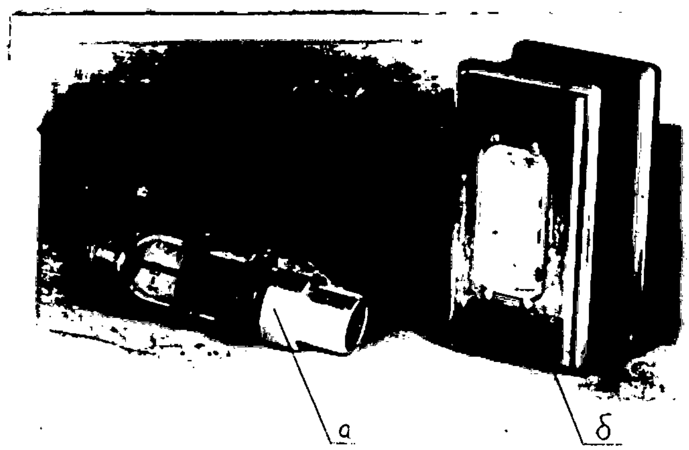

Fig 30. Gas Dischargers (p 54)

a. RR-7 discharger

b. rectangular discharger

The rectangular discharge gap serves as a preliminary protection. (p 55)

The discharger RR-7 consists of a glass envelope filled with argon. In the envelope are placed two brass diaphragms on which are mounted hollow tapering stubs with a small gap between them; this gap can be regulated by a screw placed in the end wall of the discharger. When placed in the chamber, the discharger forms a toroidal resonator, the resonance frequency of which is controlled by the magnitude of the gap between the tapering stubs.

The preliminary-protection discharger consists of a quarter-wave waveguide section. The ends of the section are closed by diaphragms in form of metal sheets with rectangular openings. The glass envelope is filled with argon and an admixture of water vapors; the envelope has a rectangular shape and is placed inside the waveguide section. The intensity of the electric field close to the diaphragm is greater than in the adjacent waveguide, which facilitates the firing of the discharger gap. Since the resonance response of the diaphragm is highly selective, the size of discharger gap varies for different wave lengths. For this reason four types of discharger are used: RR-20 for the APS-1-V, RR-2 for the APS-1V and APS-1-G, RR-3 for the APS-1-D and RR-4 for the APS-1-Zh and APS-1-Ye.

Equivalent Circuit of the Antenna Switch (p 56)

At low power in the waveguide, the voltage across the gap of discharger RR-7 is low, therefore the gap is not fired and its cavity circuit is equivalent to a tuned circuit with relatively high Q-factor. When energy from the magnetron travels along the waveguide, the voltage at the spark-gap of the discharger rises, the spark gap is broken and the cavity circuit of the resonator becomes equivalent to a highly detuned circuit. Since the Q-factor of the circuit is high, the equivalent impedance of the broken and unbroken spark gap differ from each other considerably. The latter property makes the discharger capable of switching on for either receiption or transmission.

On the equivalent diagram of the antenna switch (Figure 31) the waveguide is replaced by a two-wire line. The branch from the narrow wall of the waveguide is shown as a section of the line connected in parallel to the main line. The branch from the wide wall of the waveguide is shown as a section of line connected to the main line. Such a substitution is permissible only under the assumption that oscillations of only one type exist in the waveguide. In the waveguide the energy propagates in the wave mode H_{01}.

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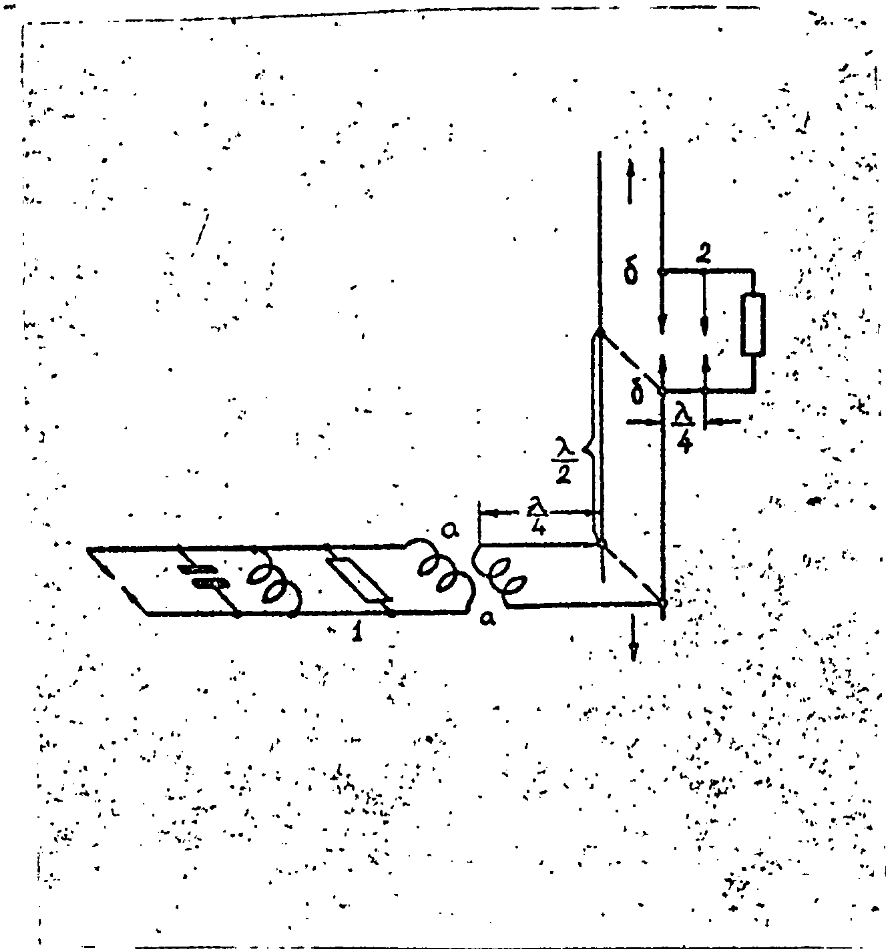

Fig 31. Equivalent Circuit of the Antenna Switch (p 57)

1. equivalent circuit of the ATR-switch

2. TR-switch

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The ATR gap, represented in the form of equivalent circuit 1, is connect in parallel with the line.

The/discharger TR-2 is inserted into the line and is shown as two spark gaps spaced at a distance of $^1/_4\ \lambda$. (p 58)

Operation of the Circuit During Reception: The ATR switch is coupled to the waveguide through a slot in the narrow wall. The ATR switch is positioned so that it corresponds to a resonance cavity equivalent to a two-wire line through a quarter-wave branch.

At points a-a the input impedance is very high when the gap is not broken.

This impedance is converted through the quarter-wave branch into a very low impedance. Therefore, the closed ATR switch shorts the equivalent two-wire line. Since the ATR switch is located at a distance of $^1/_2\ \lambda$ from the TR switch, the high-frequency energy from the antenna is not admitted to the magnetron (the input impedance of the half-wave line, shorted at the end, is equal to 0).

The TR-switch is coupled to the waveguide through an opening in the wide wall. The coupling is selected in such a manner that the input impedance of the TR-switch is matched to the waveguide, so that the energy of the reflected signals enters the receiver channel without loss.

Operation of the Circuit During Transmission: During the transmitting period the spark gaps of the ATR and TR switches are broken. The ATR-switch circuit becomes detuned, its input impedance becomes very small, (p 59) and through the quarter-wave loop it is converted into a very large impedance in parallel with the main line. Therefore, the high-frequency energy is freely transferred from the magnetron to the antenna without any reflection from the ATR-switch.

At high voltage in the main channel, the gas inside discharger 2 (TR-switch) becomes ionized and an electrodeless breakdown occurs at the imput window of the discharger.

Directional Coupler

The directional coupler serves as a connecting element during any changes of wavelength and magnetron spectrum, as well as any changes in receiver power and sensitivity.

The directional coupler consists of a short section of waveguide coupled through a special opening with the wide wall of the main waveguide. It is mounted at a certain angle to the wide wall of the waveguide, and is terminated at one end in an absorber and at the other end in a matched output for a standard 50-ohm connector. The absorber forms a traveling wave inside the directional coupler.

In the antenna switches type APS-Zh and APS-Ye, the directional coupler is mounted perpendicular to wide wall of the waveguide.

Flexible Coupling

The station has provisions for changing the angle of inclination of each of the reflectors in the antenna array.

Since the waveguide is rigidly fixed on both ends, there should be some means of changing the angle of inclination of one part of the waveguide with respect to the other. (p 60)

For this purpose the waveguide channel is provided with a flexible coupling AGA-1 (Figure 32). It consists of a corrugated waveguide section.

The size and spacing of the corrugations are selected in such a manner that they will not affect the performance of the high-frequency channel.

To provide mechanical strength and to restrict the corrugations from excessive stretching, the flexible coupling has a hinged joint.

The position of the flexible coupling is selected in such a manner that the axis of rotation of the movable flange (located closer to the antenna) coincides with the axis of rotation of the reflector.

Waveguide Line

The standard waveguide sections type RZL-72 x 34, in the form of rectangular copper tube with inner cross section of 72 x 34 mm, are used for the transmission of high-frequency energy.

Under normal atmospheric conditions, the waveguide is capable of conducting about 2 megawatts of power without breakdown. The efficiency of power transmission in the waveguide is about 95 percent.

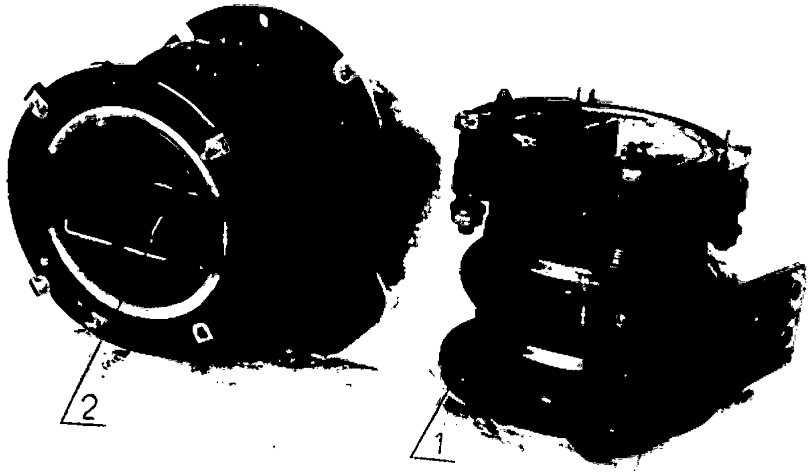

Fig 32. Flexible Coupling SGS-1 (p 61)

1. rubber casing
2. corrugated waveguide
3. corner

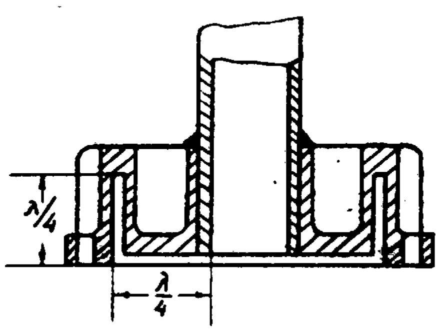

Fig 33.

choke flange

(p 64)

The internal walls of the waveguide are coated with a special lacquer to prevent corrosion.

Since it is inconvenient to transport long waveguides, they are made in individual sections which are connected during the assembly of the radar station. (p 62)

In order to prevent excessive power loss through imperfect contact at the junction of the individual sections, the section ends are provided with special choke flanges. (Figure 33).

In the choke flange is cut an annular groove $1/4\lambda$ deep. The distance from the groove to the wide wall of the waveguide is also $1/4\lambda$. Part of the flange within the groove and waveguide is somewhat depressed with respect to the peripheral part. Therefore, at the junction with a plane flange, the two parts form, together with the annular groove, a cavity equivalent to the waveguide line terminated at one end, thus the region of direct contact falls in those parts of the line which have the lowest currents (current nodes). Therefore, imperfection of the junction does not create excessive power loss.

Imperfection of the flanges often leads to sparking. This phenomenon can be eliminated by placing metal inserts into the flange groove near the narrow wall of the waveguide.

This eliminates the possibility of the formation of fields which might lead eventually to sparking at the flanges. (p 63)

At the choke-flange junctions the uniformity changes but slightly and therefore does not produce any appreciable reflection.

The choke-flange cavity is filled with foam plastic in order to prevent moisture accumulation. For drainage of moisture from the waveguides, holes are made in the lowest parts of the waveguide channel.

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CHAPTER FOUR

(p 65)

THE TRANSMITTING EQUIPMENT

The radar transmitting equipment is intended for generating short-duration, centimeter-range electromagnetic pulses which are radiated into space from the radar antenna.

The radar equipment includes six centimeter-wave transmitters PS each for a different frequency band, and a ground interrogator NRZ-1.

A schematic showing the interaction of the transmitter with other units of the radar is given as Figure 34.

The transmitters 7 - 12 are interconnected with the following units:

- antenna switches 1 - 6
- receiving equipment
- triggering unit BZ (16)
- control cabinet ShU (14) and remote control panel PDU-1 (18)
- electric station (20) and high-frequency unit VPL-30 (19) through the distributing box RK (15).

The transmitters are triggered by pulses generated in the BZ unit. From vehicle No 2 the trigger-pulse voltage is admitted to vehicle No 1, to the control cabinet ShU-1 (14) and then to the transmitters PS (7-12).

(p 67)

The trigger-pulse circuit terminates in the unit PS No 4 (11), therefore the circuit of this transmitter is provided with an equivalent load for the cable which conducts the indicated pulses. The trigger pulse is fed from unit BZ to NRZ-1.

If vehicle No 1 is not connected to vehicle No 2, or the unit BZ in vehicle No 2 is disconnected, then the transmitters can be triggered by the emergency triggering unit located in control cabinet ShU-1.

All the centimeter-wave transmitters are connected to the unit ShU-1 through the control, testing and protection circuits. All local controls of these transmitters are on the front panel of the unit ShU-1 and on transmitter control panels.

Remote control of the transmitters is carried out from the remote-control panel PDU-1 (18) located in the cabinet DUS-1 (18) on vehicle No 2.

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The 3-phase, 220-v, 50-cps and the 3-phase, 200-v, 400-cps power supply to the transmitters are fed to the terminal block of the transmiters from the distributing box RK.

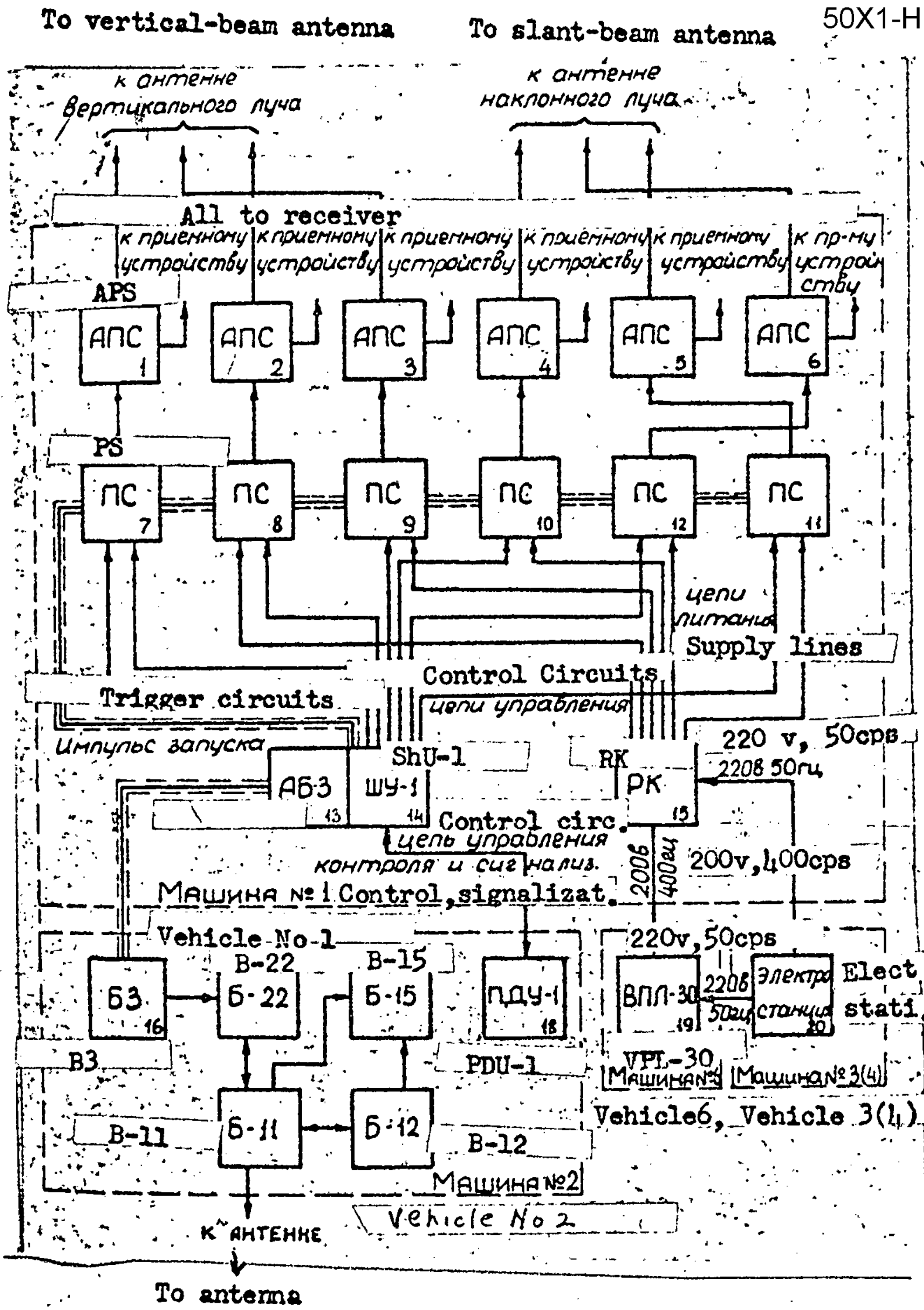

Fig. 34. Diagram Showing Interaction of the Transmitter with Other Units of the Radar Station. (p 66)

All the connections of the transmitters with other units of vehicle No 1 are made with type RPShE and PK-49 cable. (p 68)

Centimeter-Wave Transmitter (PS).

1. General Information on the Transmitter.

Each of the transmitters has the following characteristics:

Pulse power fed to the load..................	850-900 kw
Wave length of the generated oscillations....	fixed
High-frequency pulse duration................	about 2.7 microsec.
Power consumption from the 50-cps power network..................................	about 400 va
Power consumption from the 400-cps power network..................................	about 3 kva.

Each transmitter incorporates a magnetron type MI-29 operating at a specific frequency subband.

Functional Diagram of the Transmitter

The functional diagram of the transmitter is shown in Figure 35. The transmitter consists of the following units:

High-voltage rectifier 1 which generates 7-8 kv dc voltage of positive polarity.

The rectifier draws power from a 3-phase, 200-v, 400-cps network.

(p 70)

Charging Choke 2. The use of an inductive charge-storage circuit in the transmitters permits to obtain approximately a doubled voltage of the power source (high-voltage rectifier).

Energy Storing Device - Artificial Long Line 3, serves to shape the voltage modulating pulses in an approximately trapezoidal form. A pulsed thyratron acts as switching element 7. At the instant the trigger pulse is admitted to the thyratron grid, it discharges the long artificial line through the load.

Trigger-pulse amplifier 6 generates pulses which are admitted to the control grid of the thyratron in order to fire it.

Pulse transformer 4 matches the dc-current resistance of the magnetion with the characteristic impedance of the long artificial line, and increases the voltage of the modulating pulses.

Magnetron oscillator 5 consists of a pulse magnetron and a system of permanent magnets. The magnetron acts as a source of high-frequency oscillations which are radiated into space.

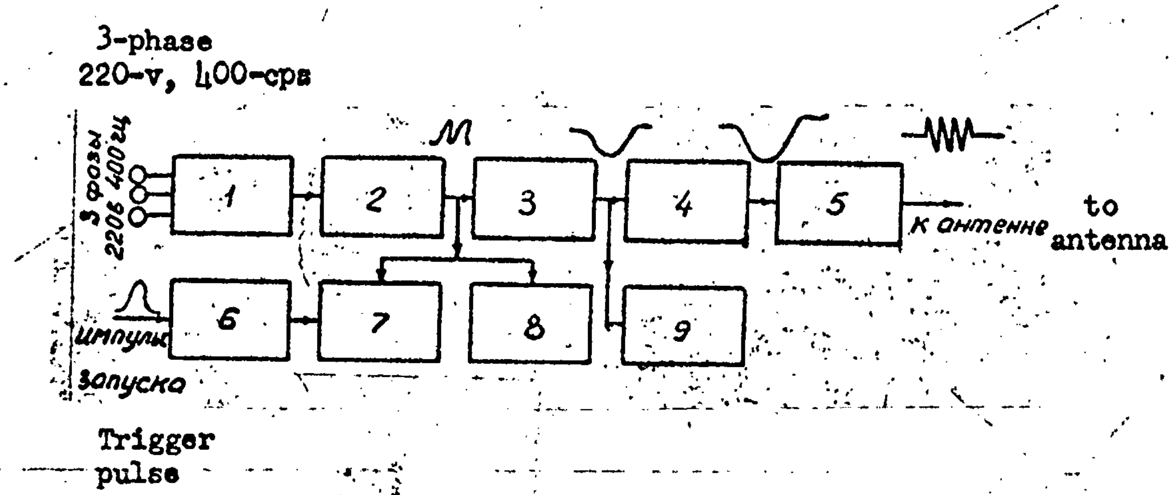

Fig 35. Functional Diagram of the Transmitter PS (p 69)

1. high-voltage rectifier
2. charging choke
3. artificial long line
4. pulse transformer
5. magnetron
6. trigger pulse amplifier
7. switching element
8. protection-diode
9. compensating circuit

The compensating circuit smoothes leading edge peaks formed at the beginning of the magnetron oscillations.

Protective diode 8 (circuit) protects the transmitter components from overvoltage during recharging of the artificial long line due to sparking or breakdowns in the magnetron. (p 71)

2. Schematic Diagram of the Transmitter

The schematic diagram of the transmitter is shown in Figure 36.

The power supply to the transmitter is drawn from a 3-phase, 220-v, 50-cps power network of the radar station and from the higher-frequency power pack VPL-30 which generates 3-phase, 200-v, 400-cps power.

The 50-cps voltage is switched on by automatic device P3 (AD-3 x 5) which provides thermal and overload protection. This voltage is applied to the primary windings ofthe anode-filament transformer Tr 2, to the windings of the protective-diode filament transformer Tr 5, and to the windings of motor Ml which drives the magnetron and TWT cooling blower.

The 400-cps voltage is used in the transmitter circuit to obtain the desired magnetron anode-voltage and is switched on by automatic device Rl (AD - 3 x 5).

The automatic device Rl is switched on 5-6 min after automatic device R3 has been switched on.

The delay is necessary for heating the cathodes of the transmitter tubes before switching on the plate voltage. The automatic device Rl is switched on by the motor-operated time relay in unit ShU-1. (p 73)

The 400-cps voltage is admitted through fuses Pr 3, Pr 5, Pr 4 to the 3-phase autotransformer Tr 4 with contact plates P 6 and then to the primary winding of the anode transformer Tr 3 of the high-voltage rectifier. The autotransformer controls the voltage within the 10% limits of the value supplied to transformer Tr 3.

Such a regulation makes it possible to set up in each transmitter the required value of the dc component of the magnetron anode current when all of the transmitters are supplied from a common 400-cps voltage source.

The high-voltage rectifier operates on the principle of a 6-phase circuit. Selenium diodes serve as the rectifying units. Capacitor C-14 serves to smoothen the rectified current.

After switching on the automatic device R 1, a reduced voltage of the order of 150-160 v is applied to the primary winding of transformer Tr 3; this voltage is then raised with the aid of a rheostat in unit

[p 72]

P 1

7	H-V swit.PRS
11	Trigger
12	"
8	12v,50cps
3	Heater
5	Emergency
6	Magnet.current
2	High-Volt.
1	" "
4	emergency
10	frame

Sh 1

No	Function
7	220v,50cps,FS
5	220v,50cps,FV
3	220v, 50cps,FA
2	H-V swit.PRS
1	H+V " PRS
8	To frame

P2

1	220v,50cps,FA
2	" " ,FV
3	" " ,FS
4	200v,400cps,
5	" "
6	" "

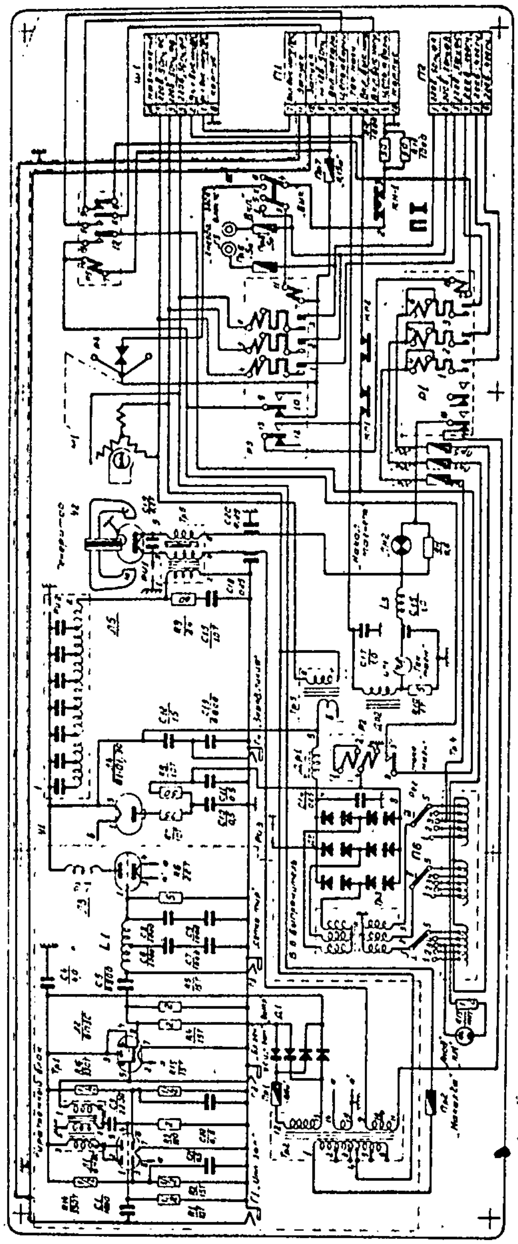

Fig. 36. Schematic Diagram of the Transmitter PS.

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ShU-1 (or TsDU-1) until a rated value of the anode current of the magnetron is reached. Sudden application of full voltage to the magnetron anode may lead to a breakdown in the magnetron, thus rendering it useless.

To understand better the operation of the charging circuit let us examine the diagram shown on Figure 37. (p 74)

The diagram represents merely a simplified schematic of the modulator charging circuit of the transmitter.

In this circuit, capacitor C discharges fully in an interval T through load R when the key K is closed for a short time.

During interval T there occurs a slow (as compared to the discharge period) process of charging of the capacitor from the dc-voltage source E through choke L.

In the actual circuit a thyratron performs the function of key K.

Since the closing of the key and discharge of the capacitor occur during a period considerably shorter than the period needed to charge it, it can be assumed that the current flowing in the choke does not change during this period, i.e., each charging cycle begins under identical initial conditions (voltage across the capacitor is $U_c = 0$, current in the choke is $i_3 = 0$.)

In a specific case, when all the energy is stored in the capacitor at the instance of discharge, current in the choke is equal to zero ($i_3 = 0$).

This case corresponds to the so-called resonance charge. The case of resonance charge is utilized in the actual modulator circuit of the transmitter, because under these conditions the efficiency of circuit charging is improved, and loading of the thyratron with the charge-circuit current is avoided.

The transient processes occuring in the charging circuit are shown on the Figure 37 a; a maximum voltage, twice that of the power source E, is obtained across the capacitor $U_{c\ max}$ when charged through choke L. When the principle of resonance charging of the capacitor is used, the natural frequency of the charging circuit should be one half the commutation frequency. (p 76)

In the previous discussions we did not take into consideration the attenuation in the charging circuit caused by the resistance of the charging choke. Since this resistance is relatively low, the nature of the charging process is but slightly effected; however, the voltage across the capacitor at the end of charging cycle will not reach 2E, but will be only 1.85 to 1.95 of E.

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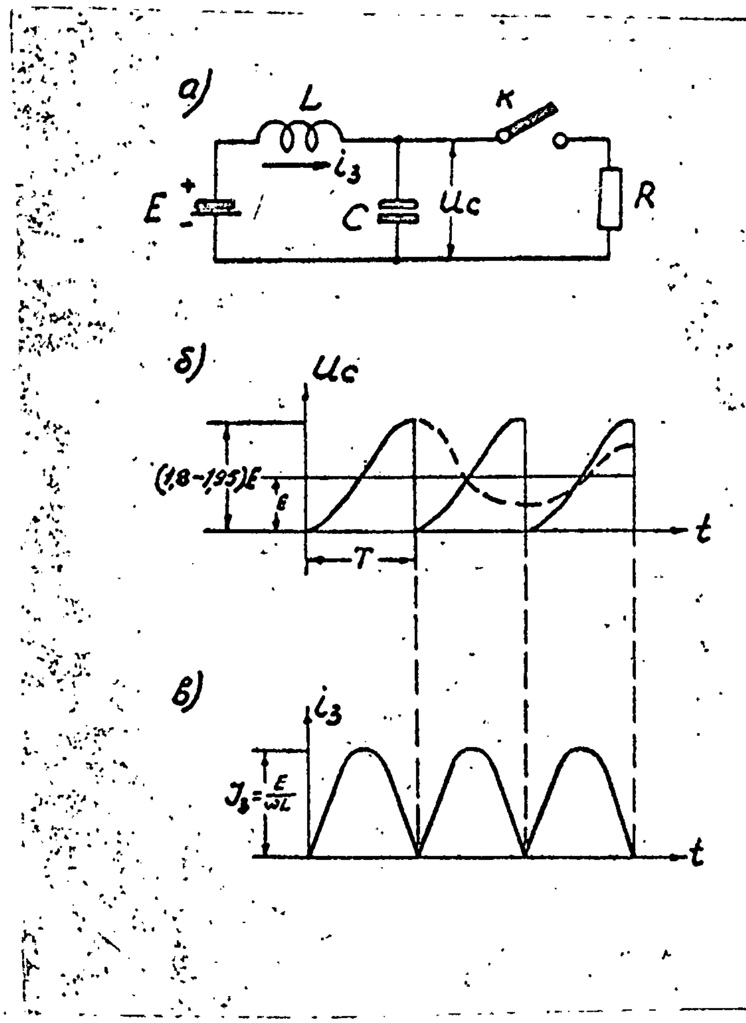

(p 75)

Fig. 37. Simplified Diagram of the Manipulator Charging Circuit.

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Graphs for changes of voltage across the capacitor U_c and current in the charging circuit i_3 are shown on Figure 37, b and c.

The dotted line indicates the voltage changes across the capacitor when periodic discharges of this capacitor are absent (under actual conditions this corresponds to discontinuation of transmitter triggering.)

Due to the effect of the choke impedance, voltage oscillations across the capacitor decay, and a voltage, equal to that of the source, is established across the capacitor.

The rectifier output voltage is of positive polarity and is equal to 7-8 kv. This voltage is admitted through the charging choke Dr 1 to the input of artificial long line U 1. As a result of the transient process, the line capacitors of the charging artificial line will be charged to a voltage of 14-15 kv, i. e., to a voltage almost double that of the rectifier. (p 77)

The artifical long line consists of eight T-shaped inductive-capacitive sections placed in an oil-filled tank. The characteristic impedance of the line is 25 ohms. The line discharges through the primary winding of impulse transformer Tr 6. The hydrogen-filled pulse thyratron V_3, type TGI 1-400/16, serves as the switching element of the circuit.

The thyratron fires at the instances when the voltage across the capacitors of the artificial long line is at its maximum. This condition is fulfilled in the transmitter circuit by the fact that the natural frequency of the charging circuit is selected in accordance with the repetition rate of the trigger pulses.

The thyratron is fired at the instant of arrival on its control grid of the triggering pulses generated in the trigger-pulse amplifier circuit which incorporates tubes V_1 (6N8S) and V_2 (6P8S). The amplifier is triggered by pulses admitted from triggering unit B3.

Prior to the arrival of the trigger pulse both halves of the tube V_1 are blocked by negative bias supplied to the control grid from resistors R 2 and R 15 of the voltage dividers R 2, R 14, R 15, and R 16. (p 78)

The triggering pulse admitted to the grid of the left half of the tube makes both halves of the tube conduct in proper sequence. The current passing through the tube forms a positive pulse in the secondary winding of the blocking transformer Tr 1.

This pulse is admitted to the control grid of the tube V_2 which functions as a cathode follower. The pulse formed at the resistors R 4 and R 5, with an amplitude of the order of 200 v, is fed through a filter consisting of capacitors C 6, C 7, C 8, C9 and choke L 1 to the thyratron grid. This filter protects the amplifier low-voltage circuits from the effect of short-duration voltage surges with amplitudes of several kilovolts originating in the thyratron grid circuit at the instant of its firing.

The amplifier-tube power is drawn from a rectifier D 1 assembled with selenium piles type AVS-18-306 or AVS-16-306 on the principle of a full-wave bridge rectifier. The plate voltage of the amplifier tubes is equal to 300 v.

The discharge period of the artificial long line is 2.8-3.2 microsec. Choke L_2 is connected to the anode circuit of the thyratron and limits the initial current surge through the thyratron caused by the discharge of parasitic capacitances of the circuit; such a surge is harmful to the thyratron. (p 79)

A negative voltage pulse with an amplitude of 7-8 kv is formed across the primary winding of the pulse transformer during the discharge of the line. The transformation coefficient of the pulse transformer is 1 : 4.25. Therefore negative-polarity voltage pulses with an amplitude of the order of 26 - 30 kv are formed on the secondary.

These pulses are fed to the magnetron cathode.

A pulse magnetron V_5 type MI-29, of one of the subbands B, V, G, D, Zh, is in operation at the transmitter depending on the frequency used.

The filament voltage is supplied to the magnetron cathode from anode-heater transformer Tr_2 through two parallel secondary windings of a pulse transformer. With this type of filament supply, the necessity of using a filament transformer with high-voltage insulation is eliminated.

The lamp LN2 with a resistor R 11 connected in parallel signals the condition of the filament circuit.

Capacitor C 19 balances the potential of the high-voltage terminals of the pulse-transformer secondary windings. The anode ac current component of the magnetron is shorted to the frame through blocking capacitors C 18 and C 20.

The air-discharge gap RI 1 fires at substantial increase of voltage across the secondary windings, thus protecting the pulse transformer and magnetron from overvoltage.

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The dc-component of the magnetron anode current is admitted through filter L 3, C 16 to the measuring milliammeter IP 1. Filter L 3, Dr 2, C 16, C 17 prevents mutual interferences from the radar transmitters. Resistor R 10 forms a bypass for the dc-component when the transmitter is disconnected from the remote-control circuit TsDU-1. (p 80)

A compensating circuit consists of resistor R 9 and capacitor C 15, and is connected in parallel with the primary winding of the pulse transformer. Resistor R 9 (24 ohm) is approximately equal to the wave impedance of the artificial long line (25 ohm), and the capacitance of C 15 is equal to 0.01 microfarad.

At the start of the line discharge, when the voltage at the magnetron is low and it does not oscillate, the resistance of the line to dc-current is relatively high. Therefore, during this period (about 0.2 microsec) the line is charging through a resistance which is considerably greater than the wave impedance.

On the leading edge of the modulating pulse may originate peaks which would upset the normal performance of the magnetron. In the presence of the compensating circuit, the line becomes loaded at the initial instance of discharge with a resistance equal to that of the wave impedance, whereas, after a certain time,when the capacitor becomes fully charged, the circuit loses its effect on the process of discharge. The time constant of the compensating circuit is selected to be approximately equal to the leading-edge duration of the modulating pulse.

Sparking and breakdowns sometimes occur in the magnetron during its operation. The load of the artificial long line is shorted during the breakdown of the magnetron, because under those conditions the magnetron offers but very low resistance. Now the line recharges,and a reverse-polarity voltage is impressed on it. During a few cycles of such a recharge, the voltage in the line may reach such a value as to become dangerous to the electric insulation of the charging choke and the thyratron. For the protection of the transmitter circuit elements from a breakdown, a protective diode circuit is provide consisting of kenotron V 4 type V1-0.1/30, resistors R 7 and R 8, and capacitors C 10 and C 11. (p 81)

The time constant for the circuit resistance and for the artificial long-line capacitance is such, that the charging of the line through the circuit takes place considerably faster that the charging of the line from the power source.

The excitation winding of the protection relay R 2 type RKMP-1 is connected in series with the circuit resistors.

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During frequent sparking and breakdowns in the magnetron, current in the protective diode circuit rises to a value sufficient to operate relay R 2. Closing of the contacts of this relay disconnects the automatic device R 1 and removes the supply voltage from the transmitter circuit.

The dc-component of the recifier current passes also through the relay R 2 winding. In case of sparking in the thyratron or breakdowns in the charging circuit of the artificial long line, the rectifier current rises sharply and actuates the protective relay. (p 82)

Capacitors C 10 and C 11 form a path to the frame for the ac-current component flowing in the protective diode circuit; this current creates a certain hindrance to the relay operation.

A centrifugal disconnector R 4 type TsR-1 protects the blower motor. If the speed of rotation drops or the motor stops completely, the disconnector operates and switches off the automatic devices R 1 and R 3.

The transmitter cabinet is provided with a safety door. When the cabinet door is opened during the operation of the transmitter, the contactors of the door safety devices KP1 and KP 2 open. As a result, the automatic device R 1 is disconnected, and high-voltage is removed from the transmitter circuit. The lamp LN 1 indicates the presence of the 400-cps voltage.

To remove the residual electric charge from the charging-circuit components of the transmitter, a protective discharger is provided, which is mounted on the high-voltage rectifier unit. When the cabinet door is opened, the movable contact of the discharger connects the high-voltage outlet of this rectifier to the frame.

Switch Va disconnects the transmitter while the rest of the vehicle No 1 equipment continues to operate. Receptacle G 5, with 220-v supply, is provided for the measuring instruments, portable lamps, soldering equipment, etc. (p 83)

The transmitter performance is monitored with the aid of milliammeter IP 1 which measures the dc-component of the magnetron anode current and of the oscillograph.

Control receptacles G 1, G 2, G 3 and G 4 are provided for connection to the oscillograph.

To the receptacle G 4 is supplied part of the charging voltage of the artificial long line taken from capcitor C 18 of the cap 50X1-HUM voltage divider (C12, C 13). The receptacles G 1, G 2, and G 3 serve, respectively, for the control of the trigger pulses at the amplifier input, the blocking-oscillator pulses and the thyratron grid pulses.

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3. Main Components of the Transmitter High-Voltage Rectifier.

A schematic diagram of the high-voltage rectifier (VVS) is shown in Figure 38.

The 200-v, 400-cps voltage is fed from the higher-frequency generating unit VPL-30 to 3-phase transformer Tr 3.

The stepped-up voltage from this transformer is admitted to a selenium rectifier assembled on the principle of a 6-phase circuit. To each phase of the secondary winding of the 3-phase transformer are connected two arms of selenium piles having conduction in opposite directions. (p 84)

Each rectifier arm consists of ten selenium piles type AVS-25-309.

The negative poles of the three arms with foreward conduction are connected together and form the positive pole of the rectifier. The positive poles of the other arms with reverse conduction are also connected to each other and form the negative pole of the rectifier.

The positive-polarity rectified voltage is fed to a filter consisting of capacitor C 14 with capacitance of 0.25 microfarads. After the filter this voltage is admitted through a charging choke Dr 1 to the transmitter circuit.

The filament transformer Tr 5 is fed from a 220-v, 50-cps power circuit. The 5-v secondary voltage of this transformer is fed through the high-voltage bushing I-5, having two insulated outlets, to the filament of the protective diode located in the transmitter.

All components of the high-voltage rectifier (plate transformer, filament transformer, selenium rectifier, charging choke) are placed in a common oil-filled tank.

The selenium rectifier is mounted on a textolite plate which is fastened to the cover by stubs.

The plate also serves as an insulator between the selenium rectifier and the transformers. (p 86)

On the top of the cover are the expansion cup, moisture absorber, capacitor, protective discharger, two high-voltage and six low-voltage insulators. The expansion cup has a hole covered with a plug, which is used to measure the oil level.

During operation the moisture absorber is screwed into a hole on the side wall of the expansion cup. During transportation this hole is closed with a plug and the moisture absorber is screwed into a blind hole on the tank cover.

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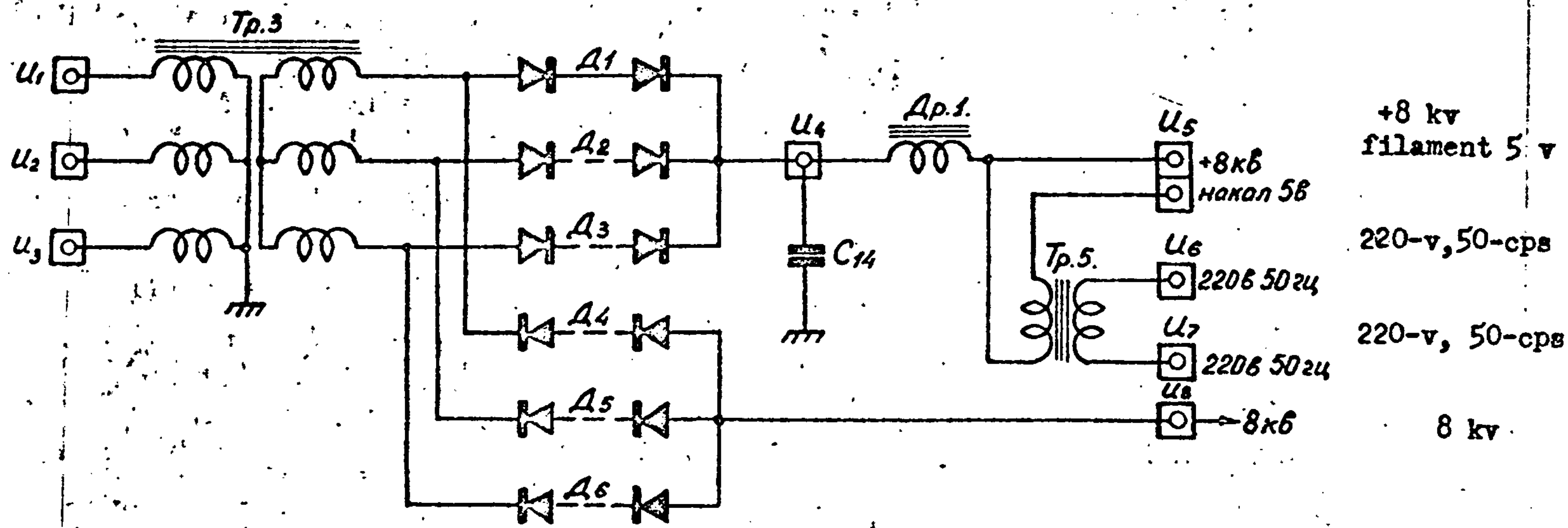

Fig 38. Schematic Diagram of the High-Voltage Rectifier (p 85)

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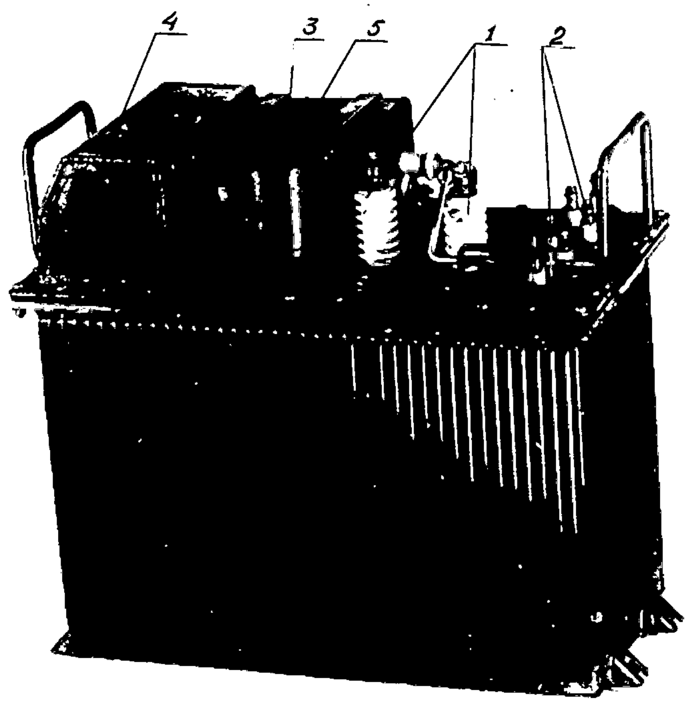

Fig 39. High-Voltage Rectifier

(p 87)

1. high-voltage insulators
2. low-voltage insulators
3. filter capacitor
4. expansion cup
5. moisture absorber

A general view of the high-voltage rectifier is shown in Figure 39.

The fundamental specifications of the rectifier are:

- rectified voltage is +7 kv at 300-ma load;
- filament voltage is 5 v at a 5-a load;
- rectified voltage ripple at the output does not exceed 1.5%;
- inductance of the charging choke is 18 henries with bias current 0.3 a;
- the unit is 500 mm long, 260 mm wide and 440 mm high with the bushings.

Artificial Long line

The artifical long line forms almost trapezoidal modulating pulses. An artifical long line of type D is used in the circuit of transmitter PS.

The line has the following specifications: (p 88)

- amplitude of the charging voltage is 16 kv;
- wave impedance is 25 ohms;
- inductance of a single section is 3.75 micro-henry;
- capacitance of each section is 6,000 micromicrofarad;
- number of sections is 8;
- voltage-pulse duration formed by the line with 25-ohm load is 2.8 to 3.2 microsec;
- total capacitance is 0.048 microfarad.

The schematic diagram of the artificial long line is shown in Figure 40. The line unit in assembled form is shown is Figure 41.

All other components are mounted on the inside of the cover. The coils are wound on textolite forms. The winding is of single-layer type using bare silvered wires. Individual sections of the induction coil are placed at such a distance from each other as to ensure a minimum of mutual inductance, which effects the shape of the modulating pulse. The section capacitors have mica insulation and are joined into individual packages.

On the outer side of cover are mounted: insulators, air-gap dischargers, over-voltage protection elements of the line, oil-level indicator and carrying handles.

The dimensions of the line unit are: length is 260 mm, width is 280 mm, the total height with the insulators is 260 mm and it weighs 56 kg with oil.

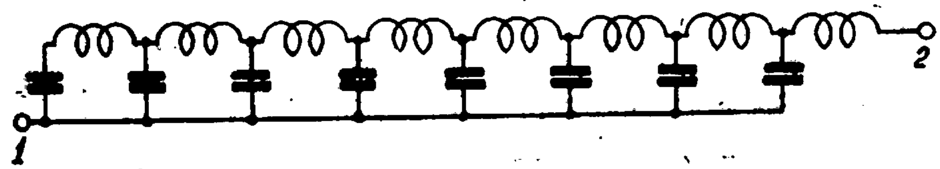

Fig 40. Schematic Diagram of the Artificial Long Line (p 89)

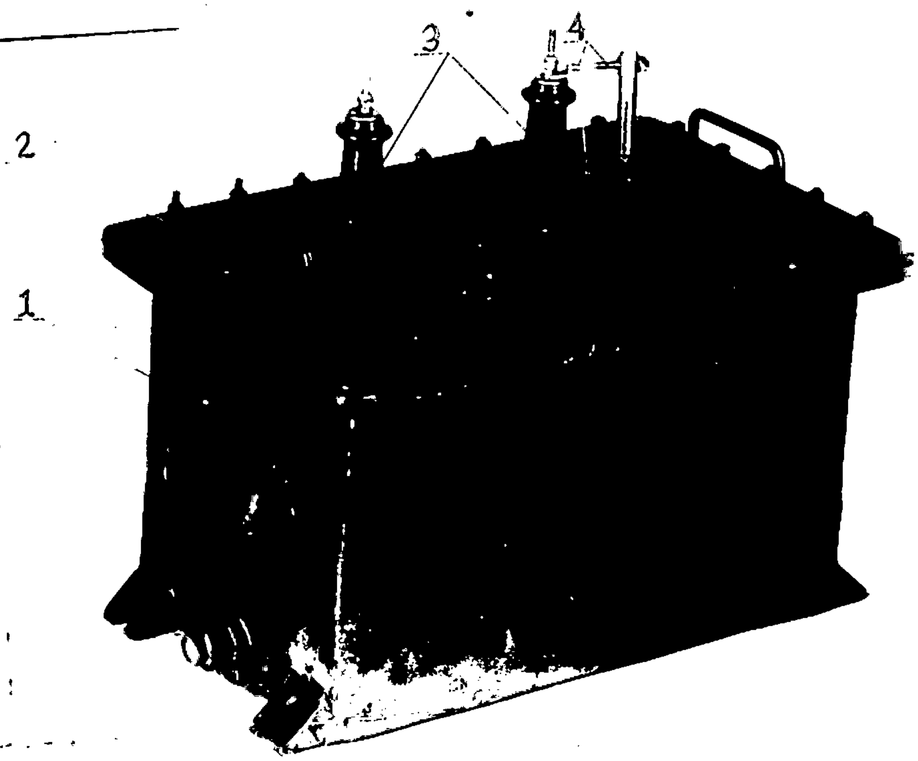

Fig 41. Artificial Long Line, Type D (p 90)

1. tank
2. covers
3. high-voltage insulators
4. air-gap discharger

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Thyratron Unit

(p 91)

The thyratron unit consists of the following components:

- trigger pulse amplifier with its rectifier;
- switching element (pulsed thyratron); and
- anode-heater transformer.

The schematic diagram of the thyratron unit is shown in Figure 42.

Trigger Pulse Amplifier

The trigger pulse amplifier consists of a two-stage circuit which generates the thyratron firing pulses. The amplifier is triggered by pulses admitted from trigger unit BS.

Prior to the arrival of the trigger pulse, both halves of tube V 1 are cut off by the negative bias supplied to the control grids of the tube from resistors R 2 and R 15 of voltage dividers R 2, R 14, and R 15, R 16. The triggering pulse admitted to the grid of the left half of tube V 1 causes both halves of the tube to conduct in sequence. The current flowing through tube V 1 forms on the secondary winding of blocking-transformer Tr 1 a pulse of positive polarity.

The positive pulse from the blocking-oscillator is admitted to the control grid of tube V 2 (6N3S) of the output amplifier assembled on the principle of a cathode follower.

The cathode follower acts as a power amplifier. The plate current, originating in tube V 2 when it is opened by the blocking-oscillator pulse, is much greater than the grid current, therefore the pulse formed on the cathode load of the tube is considerably amplified in power. The amplitude of this signal is somewhat smaller that the amplitude of the blocking-oscillator pulse which causes the tube to conduct, because the amplification factor of the cathode follower is less than unity. The amplitude of the pulse voltage at the output of the cathode follower is about 200 v. (p 93)

Rectifier D 1 with selenium piles type AVS-18-306, assembled on the principle of a full-wave bridge circuit, supplies power to the plate circuits of the amplifier tubes. Voltage to the selenium piles is supplied from the step-up winding of anode-heater transformer Tr 2. The two heater windings of this transformer supply power to the magnetron heater and to the thyratron.

The 4-microfarad capacitor C 4 filters the rectified current.

The output voltage of the rectifier is +300 v.

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The anode-heater transformer has four windings [one primary, three secondary] and is of a semi-closed type.

The primary winding is connected to the power network.

The second winding (outlets 12, 13) supplies voltage to the selenium rectifier.

The third winding (outlets 14, 15) supplies power to the thyratron heater. In order to maintain the thyratron heater voltage within permissible limits during power-line voltage fluctuation, the transformer primary winding is provided with taps.

The fourth winding (outlets 9, 10, 11) supplies power to the magnetron heater. (p 94)

Switching Element

Hydrogen-filled pulse thyratron V 3 (TGI-400-16) serves as the switching element in the modulator circuit of the transmitter.

The thyratron has the following fundamental parameters:

- heater voltage . . . . 6.3 v ± 5%
- heater current . . . . 9.5 to 11.6 a
- maximum forward anode voltage . . . . 16 kv
- maximum reverse anode voltage. . . . . 16 kv
- maximum anode current in pulse . . . . . . 400 a
- maximum mean value of anode current. . . . 500 milliamp
- maximum pulse repetition rate . . . . 500 cps
- time spread of the leading edge of anode current . . . . not greater than 0.04 microsec
- cathode heating time . . . . 6 min

Grid Firing Pulse:

- amplitude . . . . not less than 200 v
- duration . . . . not less than 2.5 microsec
- service life. . . . . 200 hours

The firing process of the thyratron proceeds in the following manner. Positive polarity pulses with an amplitude of about 200 v and a front edge rise rate of 400-500 v/microsec are admitted to the control grid of the thyratron from the trigger-pulse amplifier. The triggering pulse breaks the grid-cathode gap in the thyratron. Thus the grid acquires a potential close to that of the cathode, which, in turn, causes a breakdown of the anode-grid gap. Now the charging current of the artificial long line begins to flow through the thyratron, while its anode voltage falls to a value determined by the internal resistance of the thyratron. (p 95)

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During the instant of breakdown of the thyratron anode-grid gap, the grid acquires for a few hundredths of a microsecond a potential close to that of the anode, i.e., of the order of several kilovolts. This may be accompanied by a sudden surge of grid current, which would result in considerable overvoltage in the grid circuit of the thyratron. To protect the output circuits of the trigger-pulse amplifier from the effect of the thyratron grid-current surges, a filter consisting of choke L 1 and capacitors C 6, C 7, C 8 and C 9 is connected to the grid circuit. The choke has two sections, each having an inductance of 32 microhenries. The capacitance of each capacitor is 1,000 micromicrofarad.

After the thyratron is fired, a discharge of parasitic capacitances of the modulator circuit takes place, which is followed by the discharge of the artificial long line. The discharge of the parasitic capacitances is a very rapid process and is accompanied by a rapid rise of current in the thyratron. Any very rapid rise of current is dangerous to the thyratron, and for this reason a 7-microhenry choke L 2 is connected to the thyratron anode circuit which limits the current rise. This choke coil is wound on a ceramic form. (p 96)

Construction of the Thyratron Unit.

The thyratron unit consists of a dismountable frame on which are mounted the components of the trigger-pulse amplifier, thyratron and anode-heater transformer.

A general view of the thyratron unit is shown in Figure 43.

In the right part of the frame are tubes 6N8S and 6P8S of the trigger-pulse amplifier and blocking transformer.

In the left front part of the frame, on a special panel mounted on a rack is thyratron TGI-100/16. The special panel is designed to permit a free access of cooling air to the thyratron base. Behind the thyratron is its anode choke.

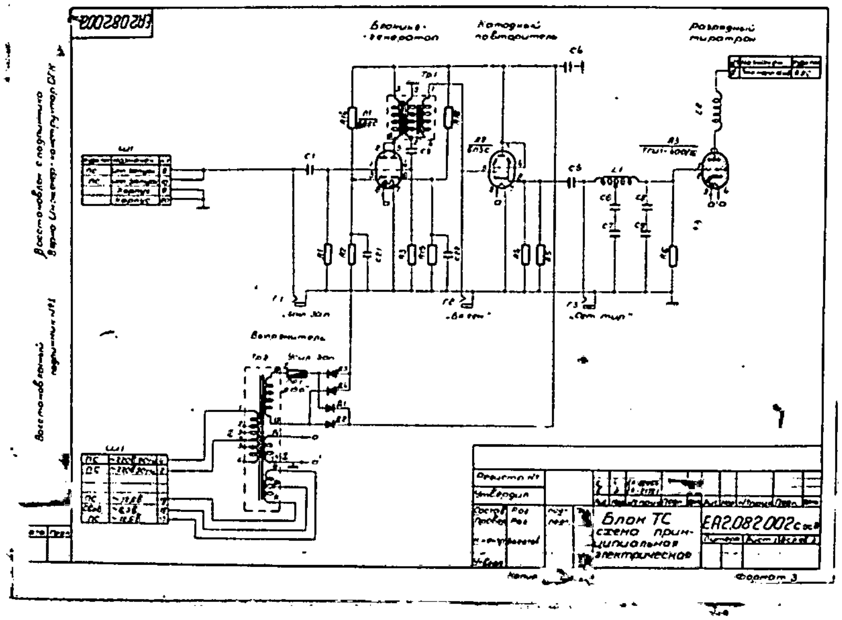
In the back part of the frame are mounted the anode-heater transformer and the filter capacitor of the rectifier. (p 98)

On the inner side of the frame are mounted the components of the trigger-pulse amplifier, the rectifier selenium piles and the filter elements of the thyratron-grid circuit.

The thyratron unit is connected to the transmitter circuit by contact disconnector 20 which is mounted on the inside of the front wall of the frame. On the outside of the same wall are located control jacks which are marked: IMP. ZAP. (TRIGGER PULSE), BL, GEN. (BLOCKING OSCILLATOR), SET.TIR. (GRID THYRATRON); these jacks are used for monitoring the performance of the thyratron unit. On the same wall is mounted a fuse for the trigger-pulse amplifier.

Fig 42. (p 92)

Schematic Diagram of the Thyratron Unit



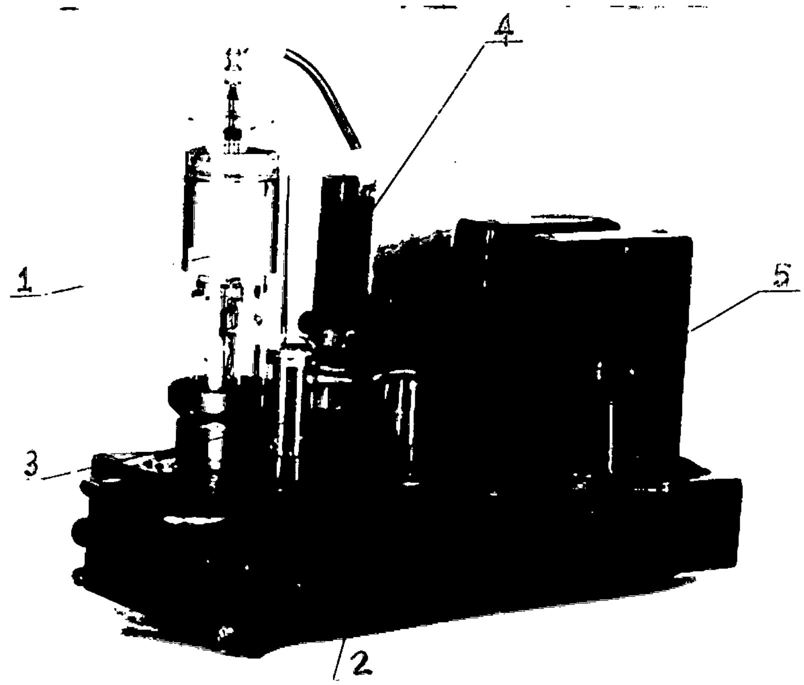


Fig 43. (p 97)

Thyratron Unit

1. thyratron TGI-1-400/16
2. 6N8S tube
3. 6P3S tube
4. plate choke
5. plate heater transformer

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An opening with removable cover is provided in the front wall for measuring voltages at the contacts of the connector.

The dimensions of the unit are: length - 427 mm, width - 190 mm, height - 272 mm, weight - 7 kg.

Pulse Transformer

The pulse transformer matches the load impedance of the transmitter manipulator with the characteristic impedance of the artifical long line and increases the amplitude of the modulating pulses.

Magnetron MI-29, with nominal resistance to dc-current (internal resistance) of the order of 450 ohms and anode voltage of 26-30 kv, serves as the modulator load.

The characteristic impedance of the artificial long line is 25 ohms. (p 99)

For the indicated value of the characteristic impedance, the transformation factor of the pulse transformer is 1 : 4.25 when the amplitude of the modulating pulses is within the limits of 26-30 kv.

The transformer has one primary and two secondary windings. Two secondary windings are essential for the selected system of power supply to the magnetron heater of the transmitter.

A diagram indicating connections of the pulse-transformer windings is shown in Figure 44.

The primary winding consists of two sections wound on both legs of the core and connected in parallel.

One end of the primary winding is connected to the bushing insulator and the other to the transformer frame.

Each of the secondary windings also consists of two sections wound on two ends of the core legs and connected in series.

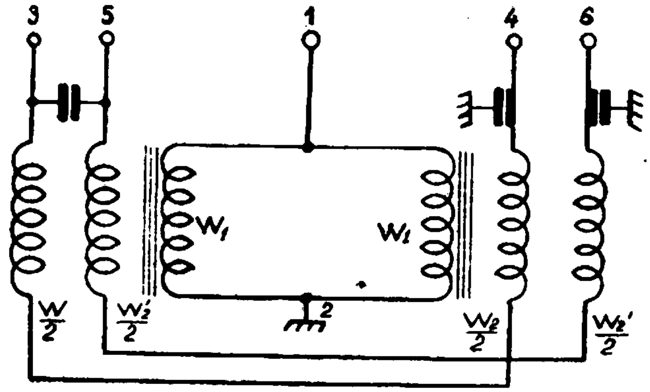
The high-voltage ends of the secondary windings leading to the magnetron cathode are connected to a bushing insulator with two insulated outlets. The low-voltage ends are also connected to bushing insulators to which the magnetron heater voltage is applied.

Figures 45 and 46 show general view of the pulse transformer and of the transformer with the tank removed. (p 101)

All the main components of the pulse transformer are mounte[redacted] of its cover. On the outside of the transformer cover are locate[redacted] insulators, air discharge gap for protection of the magnetron and transformer windings during overvoltages, dryer and blocking capacitors.

Fig 44. (p 100)

Winding Connection of the Pulse Transformer



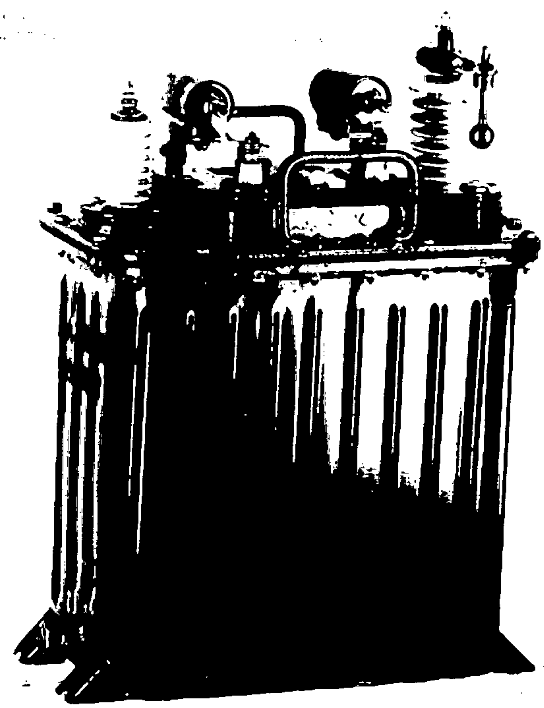


Fig 45. The Pulse Transformer

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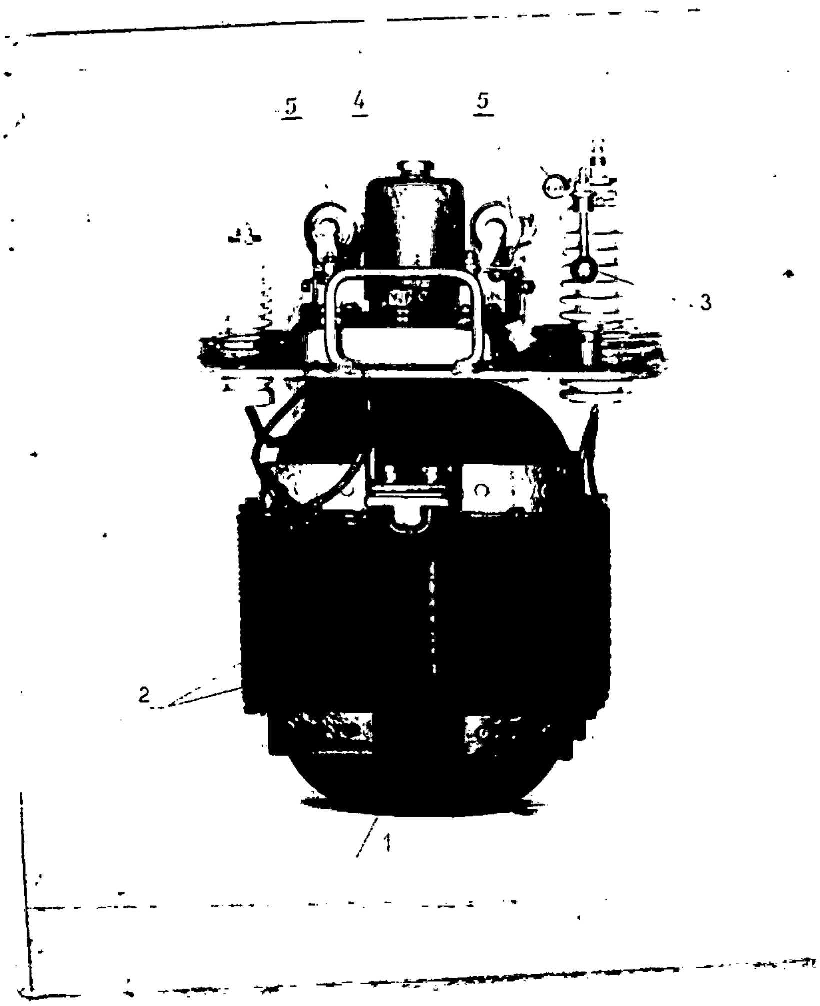

Fig 46. Pulse Transformer with Tank Removed (p 103)

1. core
2. coils of secondary winding
3. air-gap discharger
4. moisture absorber
5. blocking capacitors

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The fundamental specifications of the pulse transformer are:

- transformation factor . . . . 1 to 4.25
- dissipation factor . . . . not greater than 1.5%
- efficiency 95-90%
- pulse voltage amplitude on the secondary winding . . . . 26-30 kv
- pulse leading-front duration . . . . 0.2 -0.4 microsec
- average power . . . . about 2,000 w

Dimensions:

- length . . . . 322 mm
- width . . . . 194 mm
- total height with the insulator . . . . . 442 mm
- weight with oil . . . . 45 kg

Magnetron Oscillator

The magnetron oscillator of the transmitter consists of one of the type MI-29 magnetrons (depending on the subband used by the station) and the magnetic system.

The magnetron generates powerful, short-duration pulses of electromagnetic energy in the centimiter wave-length range and transmits them through the waveguide channel to the station antenna. (p 104)

The magnetron specifications are as follows:

- pulse power delivered by the magnetron to the waveguide during normal operation is 850-900 kw;
- efficiency of the magnetron is 50-55%
- intensity of the magnetic field in the gap between the poles of the permanent magnets is about 2,500 oersteds;
- shape of the voltage pulses fed to the magnetron anode circuit is almost trapezoidal; duration of the pulse leading edge is about 0.3 microsec and of the trailing edge about 1.5 microsec; non-uniformity of the pulse peaks as measured between points on the level of 0.9 if the amplitude does not exceed 10%;
- duration of the high-frequency pulse of the magnetron is from 2.5 to 2.8 microsec; the pulse has an almost square shape; duration of the leading and trailing edges of the pulse is about 0.2 microsec;
- the generated frequency band (width of the energy spectrum) is within the limits of 0.6 to 1.2 mc. as soon as the high voltage is supplied to the magnetron anode, the magnetron heater [redacted] is removed, and the magnetron cathode now becomes heated by the anode current. The cathode operating temperature is set by anode currents of about 40 milliamp.

Therefore the magnetron current should be set at a value above 40 milliamp. The magnetrons in the radio range-finder channels are shown in Table No 1. (p 105)

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Table No 1

Magnetrons used in the Station Channels

Channel	Magnetron
I	MI-29G
II	MI-29Zh
III	MI-29V
IV	MI-29Ye
V	MI-29B
VI	MI-29D

Magnetron Type MI-29

Magnetron MI-29 generates power pulses in the centimeter wave-length range having a power of 850-900 kw at the pulse. A general view of the magnetrons MI-29V, MI-29G, MI-29D, MI-29Ye and MI-29Zh is shown in Figure 47.

The magnetron specifications are:

Heater voltage .... 12.6 v
Heater current .... 3.0 - 3.6 a
Magnetic field intensity at the center of
the gap formed by permanet magnets.......... 2,500 oersteds
Anode voltage .... 26-30 kv
Maximum pulse duration .... 2.8 microsec
At a high-frequency pulse duration of about 2.7 microsec and normal repetition rate: (p 106)

- the dc-component of anode current is 55-60 milliamp;
- width of effective frequency spectrum is 0.6 -1.2 Mc.

The magnetron MI-29B (Figure 48) differs from the rest of the magnetrons of this series in that the inside conductor of the coaxial section passes into the vacuum exciter of the rectangular waveguide. The indicated difference is necessitated by performance peculiarities of the magnetron in the given band of the operating frequency range. For this reason the oscillation exciter is absent in the SMS block of the MI-29B magnetron.

MI-29 magnetrons have provisions for forced cooling of the anode unit.

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Magnetic System

The magnetic system (Figure 49) consists of two L-shaped permanent magnets type MP-1478 mounted on a flat plate made of armco iron. The magnetron is positioned in the air gap between the poles of the magnets. The magnets are cast from a magnico alloy with high coersive force. The pole surfaces, bases of the magnets and the part of the plate that touches the magnets are highly polished.

To ensure normal performance of the magnetron, a provision is made for the control of the magnetic field intensity by means of a magnetic shunt which can reduce the field intensity by 150-250 oersteds. Also, with the aid of this shunt it is possible to restore the rated value of field intensity which diminishes as a result of aging of the magnets. (p 107)

The main parameters of the magnetic system are:

- length of the inter-pole air gap .... 60 mm
- magnetic field intensity with the magnetic shunt in extreme lower position .. 2650 ± 50 oersteds
- range of magnetic field control .... 150-250 oersteds

Dimensions:

- width 400mm
- depth .... 225 mm
- height .... 340 mm
- weight of the assembled system, including the magnetic shunt .... 55 kg (about)

Protection Panel

On the protection panel (Figure 50) are mounted the circuit components of the protective diode and type RKMP-1 relay.

For connecting the protective panel elements to the transmitter circuit, a terminal block with four contacts is provided on the panel.

Blower for Cooling the Magnetron and TWT

The fan that cools the magnetron and TWT is driven by an induction motor DT-75. The speed of this motor is 2,800 rpm. The motor draws its power from a 3-phase 220-v, 50-cps power line.

The blower outlet is connected to manifold air duct. Through two of such (p 112) ramifications the air is directed to the magnetron radiator from the side of the heater leads, through the third one to the side of the magnetron power output, and through the fourth to the opening in the solenoid jacket of the TWT.

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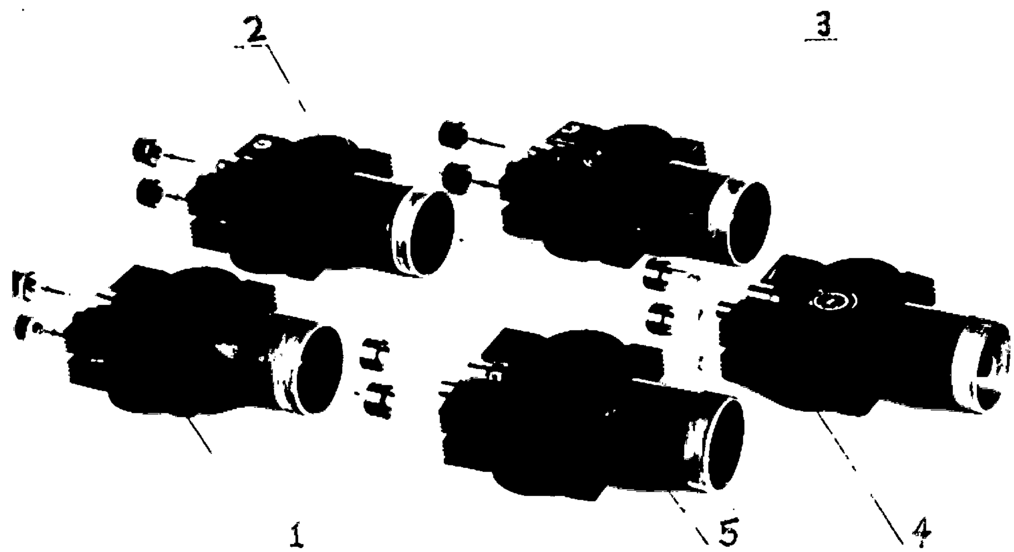

Fig 47. Magnetrons (p 109)

1. MI-29D
2. MI-29G
3. MI-29V
4. MI-29Zh
5. MI-29Ye

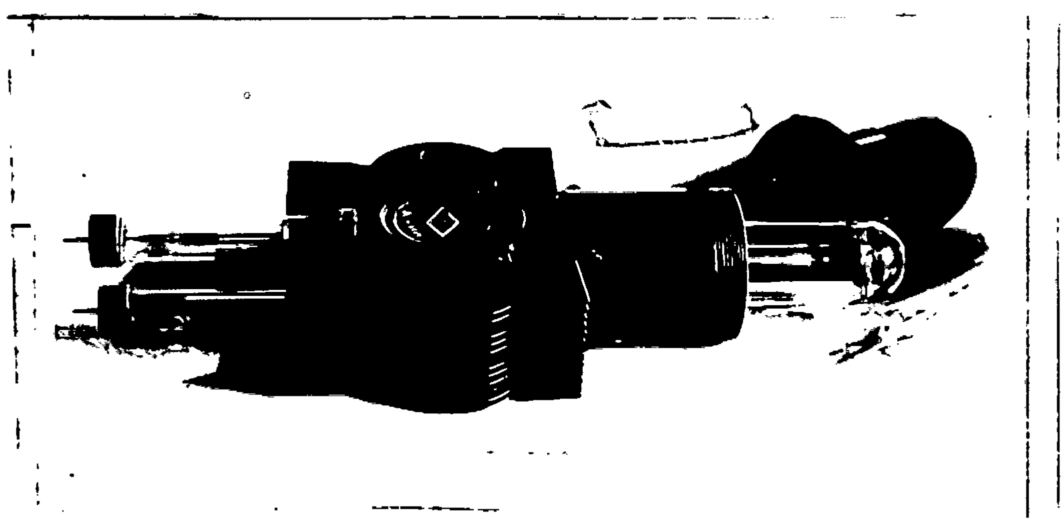

Fig 48. Magnetron MI-29B (p 109)

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Fig 49. (p 110)

The Magnetic System

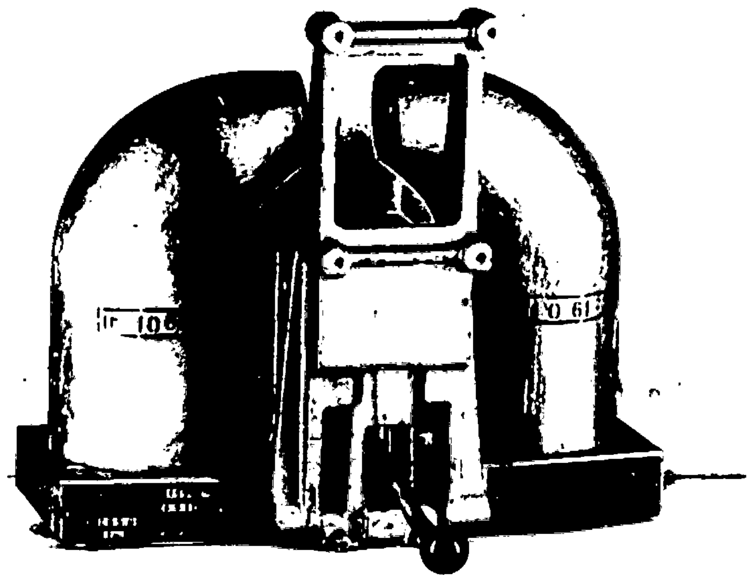
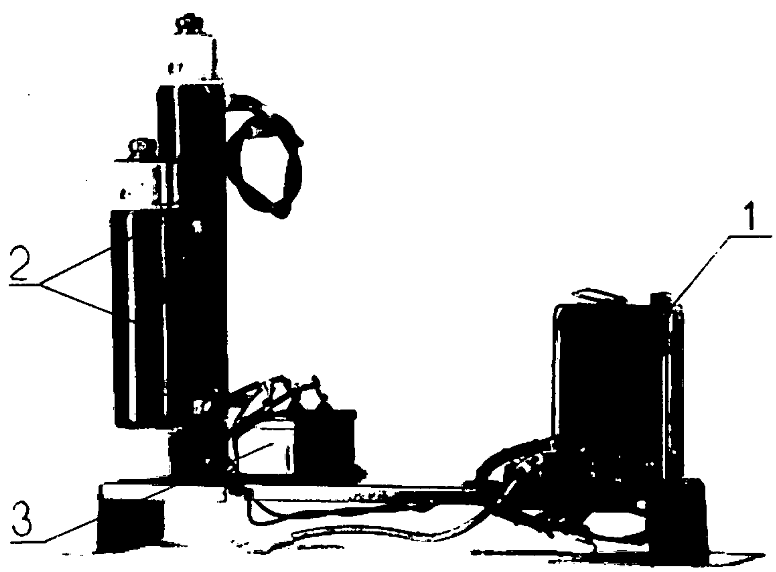


Fig 50. (p 111)

Protection Panel

1. type RKMP-1 relay
2. resistors in circuit of the protection diode
3. blocking capacitors



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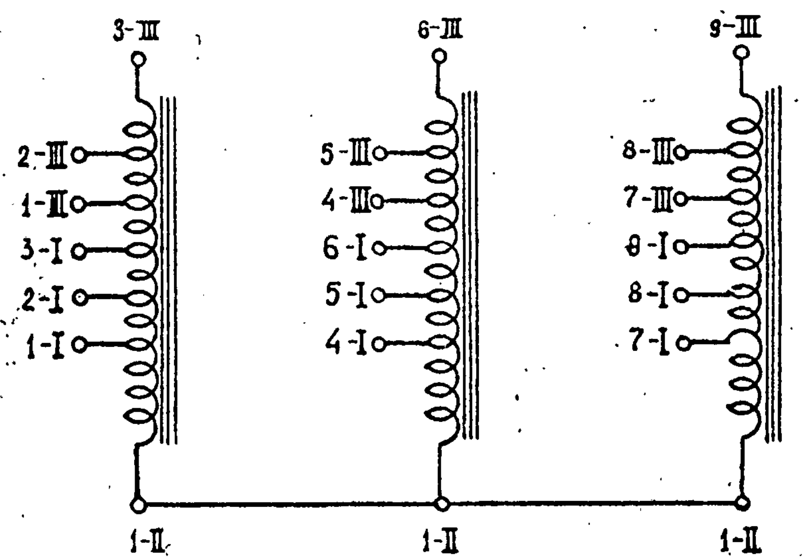

Fig 51. Connection of Windings in the Regulating Autotransformer (p 113)

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(left plate) Warning !
When the tumbler is switched,
the button must be pressed
for 2-3 seconds

(right plate) Attention !
When replacing a magnetron,
regulate the current by
moving wires 45-1, 46-1 and
47-1 to the corresponding
contacts on the same blocks
P6-I, P6-II, P6-III, with
the voltage switched off.

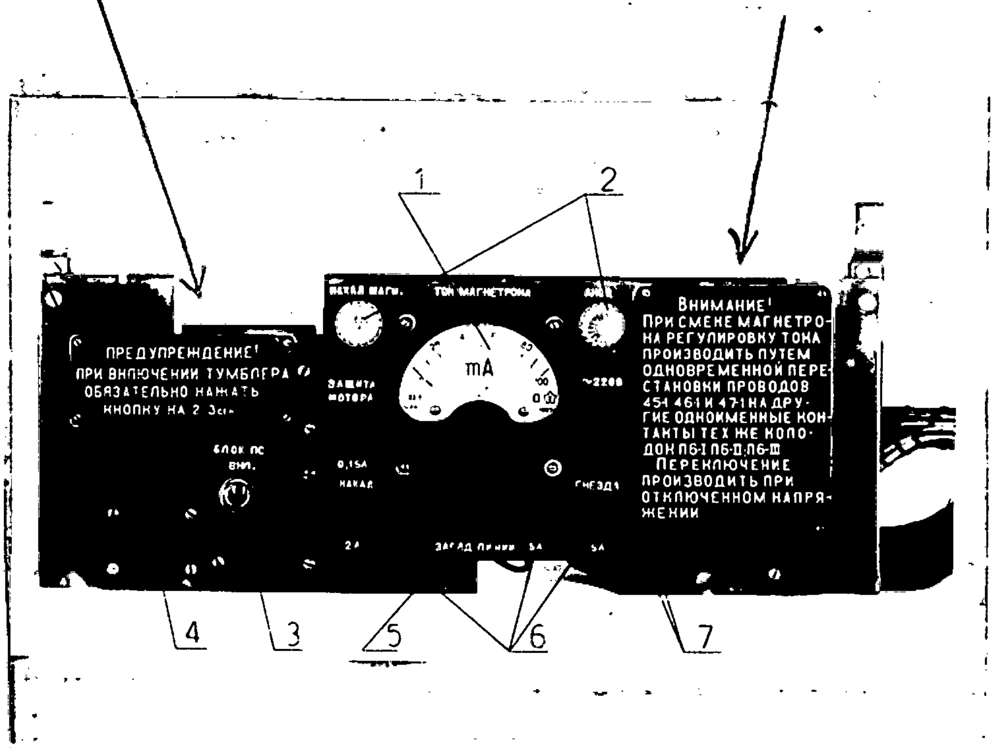

Fig 52. The Control Panel (p 114)

1. milliammeter for measuring magnetron current
2. signal lamps
3. PS-Unit toggle switch
4. button
5. test jack
6. fuses
7. 220-v jacks

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A centrifugal disconnector, type TsR-1, is mounted on the free end of the electric motor shaft.

The blower is fastened with steel clamps to an angle iron in the upper part of the cabinet.

Control Autotransformer

The control autotransformer allows up to 10% variation in the value of the 400-cps voltage which is applied to the primary winding of the step-up transformer of the high-voltage rectifier (unit VVS). Thus it is possible to adjust on each transmitter the desired value of the dc-component of the magnetron anode current when the power supply to all transmitters is drawn from a common 400-cps voltage source.

The connections of the windings in the autotransformer are illustrated in Figure 51.

Control Panel

The control panel is of a swinging type on which the control and monitoring components are mounted.

A schematic diagrm of the control panel is shown in Figure 53. (p 115)

On the panel are located:

- milliammeter IP-1 with a 0-100-milliamp dial for measuring the dc-component of the magnetron anode current;
- elements of the filter in the circuit of the dc-component of the magnetron anode current (chokes L_3, Dr_2 and capacitors C_{16}, C_{17});
- contact plates P 6 of the control autotransformer;
- signal lamp LN 2, "Magnetron Heater", and its shunting wire resistor R11;
- signal lamp LN 1, "ANODE" (with resistor connected in series) which indicates the presence of 400-cps voltage at the input of the high-voltage rectifier;
- transmitter switch V 2;
- capacitor C 18 of the capacitive voltage divider;
- control jack G 4, "CHARGING OF LINE";
- fuses Pr 2 and Pr 6 in the supply circuit of the anode-heater transformer is the thyratron unit and a 220-v, 50-cps jack;
- 220-v, 50-cps jacks G 5 for power supply to measuring instruments, soldering iron, portable lamps, etc.

Adapter blocks with clamps, located in the housing of the regulating autotransformer, are used to connect the components of the control panel with the transmitter circuit.

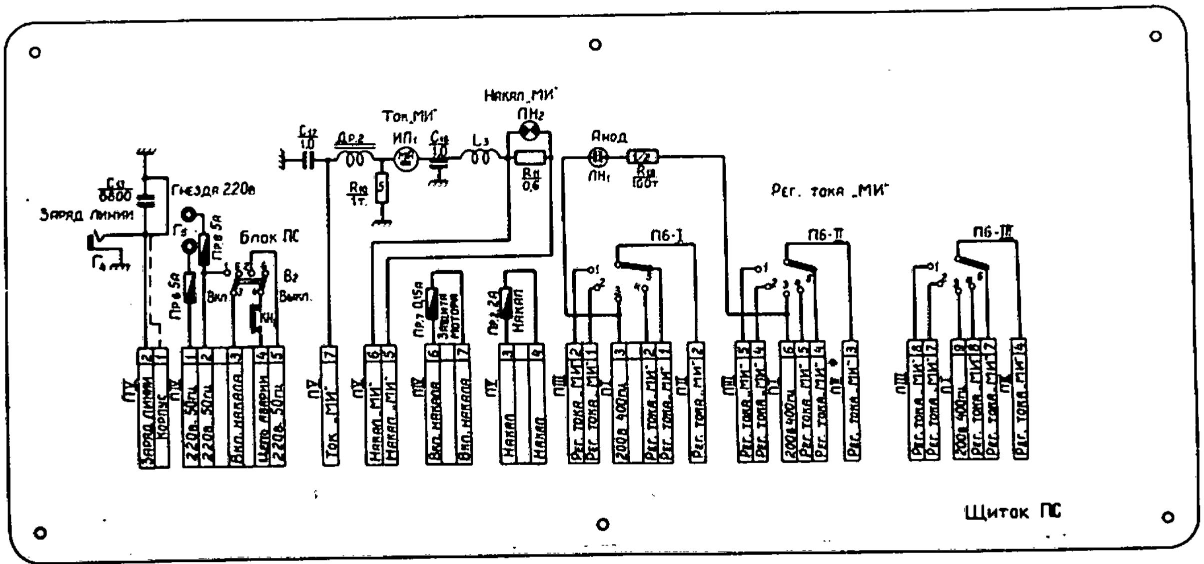
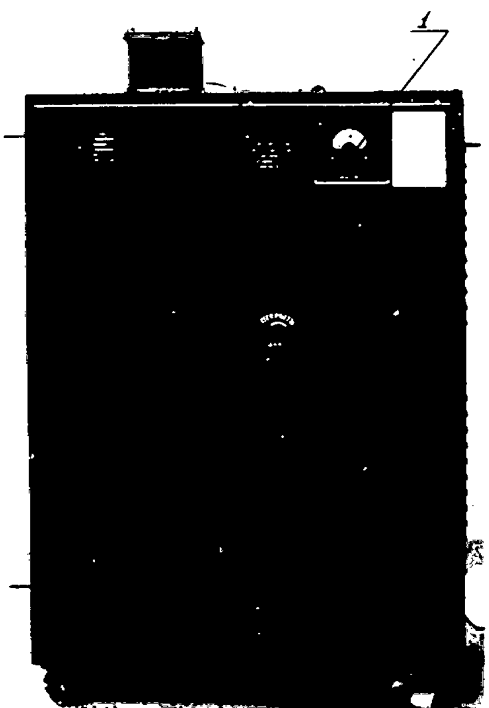


Fig 53. Schematic Diagram of the Control Panel (p 116)



1. control panel

Fig 54. Transmitter Cabinet (p 118)

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Construction of the Transmitter Cabinet (p 117)

The transmitter cabinet is shown in Figures 54 and 55.

In the lower part of the cabinet to the right is the high-voltage rectifier unit 8, next to it is the artificial long line 6, and to the left is pulse transformer 5.

The elements of the correcting circuit - capacitor and resistor 9, are mounted in front of the pulse transformer.

The protection panel 7 is mounted directly in the cover of the line unit. The protection diode is mounted on a special clamp placed over the high-voltage line insulators.

In the upper part of the cabinet are thyratron unit 2 and magnetron system 3. Over the thyratron unit and toward the front is control panel 1, behind it the control autotransformer and close to the rear wall of the cabinet is the blower.

The blower ducts are mounted behind the magnetic system.

In case of necessity the air-duct can be detached from the blower, and the blower removed from the cabinet.

Automatic devices 4, type AD-3 x 5, are mounted in the left part of the cabinet in front of the magnetic system.

The coupling element between the magnetron and the waveguide line is mounted on a bracket of the magnetic system. The unit is set on its axis in such a manner that it permits a limited movement of the SMS. This ensures an accurate coupling of the SMS magnetron coupling unit flanges with the waveguide. (p 120)

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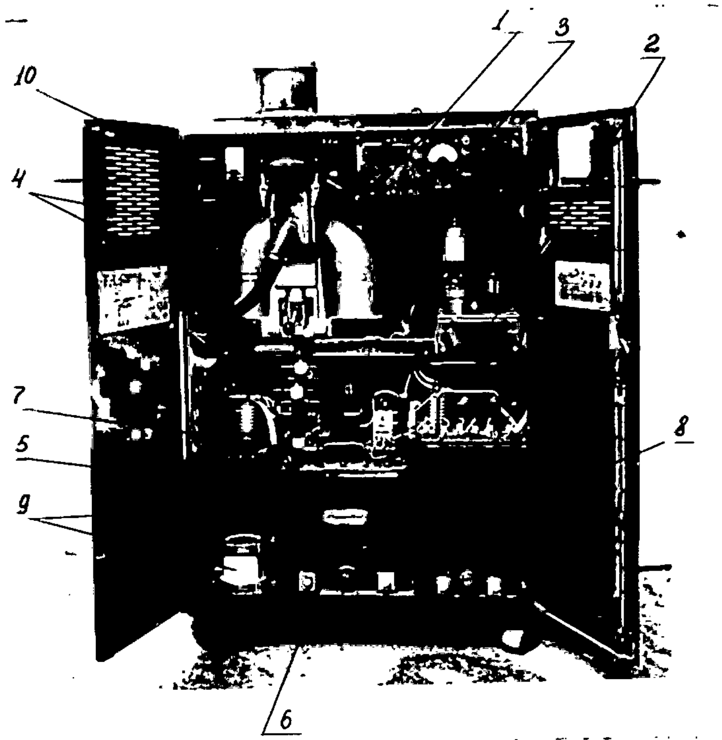

Fig 55. Transmitter Cabinet With Doors Open (p 119)

1. control panel
2. thyratron unit
3. magnetic system
4. automatic devices, type AD-3x5
5. pulse transformer
6. artificial long line
7. protection panel
8. high-voltage rectifier
9. capacitor and resistor of the correcting circuit
10. R-4P type relay

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(p 121)

CHAPTER FIVE

THE RECEIVING EQUIPMENT

The receivers, which are part of the station equipment, are designed for amplifying the high-frequency signals received by the antennas, after they have been reflected from targets, and converting them to d-c pulses.

The receiver complex includes six PRS-1 centimeter-wave receivers.

A diagram showing the interaction of the receivers with other units of the station is given in Figure 56.

The reflected signals received by the antenna are fed through the APS-1 antenna switches to the PRS-1 receivers. Part of the power of the corresponding transmitter is applied through the attenuators of the APS-1 antenna switches to the input of the automatic frequency control channel of each receiver.

The PRS-1 receivers are supplied from a 220-volt, 50-cps line, while the d-c voltages for supplying the receivers are provided in the receivers themselves.

Video signals from the output of each PRS-1 receiver are fed through slip-ring TK-03 to the input of the appropriate unit of signal mixer SS-1.

The mixed video signals are applied to units VS-3 and VS-4 of the indicators.

All receivers are controlled from remote control panel PDU-1 located in the indicator vehicle. (p 123)

The following parts are on this panel:

-- gain control potentiometers for all receivers;
-- switches for switching on and off the instantaneous AGC and differentiating circuits of all PRS-1 receivers.

The instantaneous AGC circuits of the first and fourth, second and fifth, and third and sixth centimeter-wave channels are switched on and off simultaneously by the appropriate switches. The differentiating circuits of the first and fourth, second and fifth, and third and sixth centimeter-wave channels are switched on and off simultaneously in exactly the same manner.

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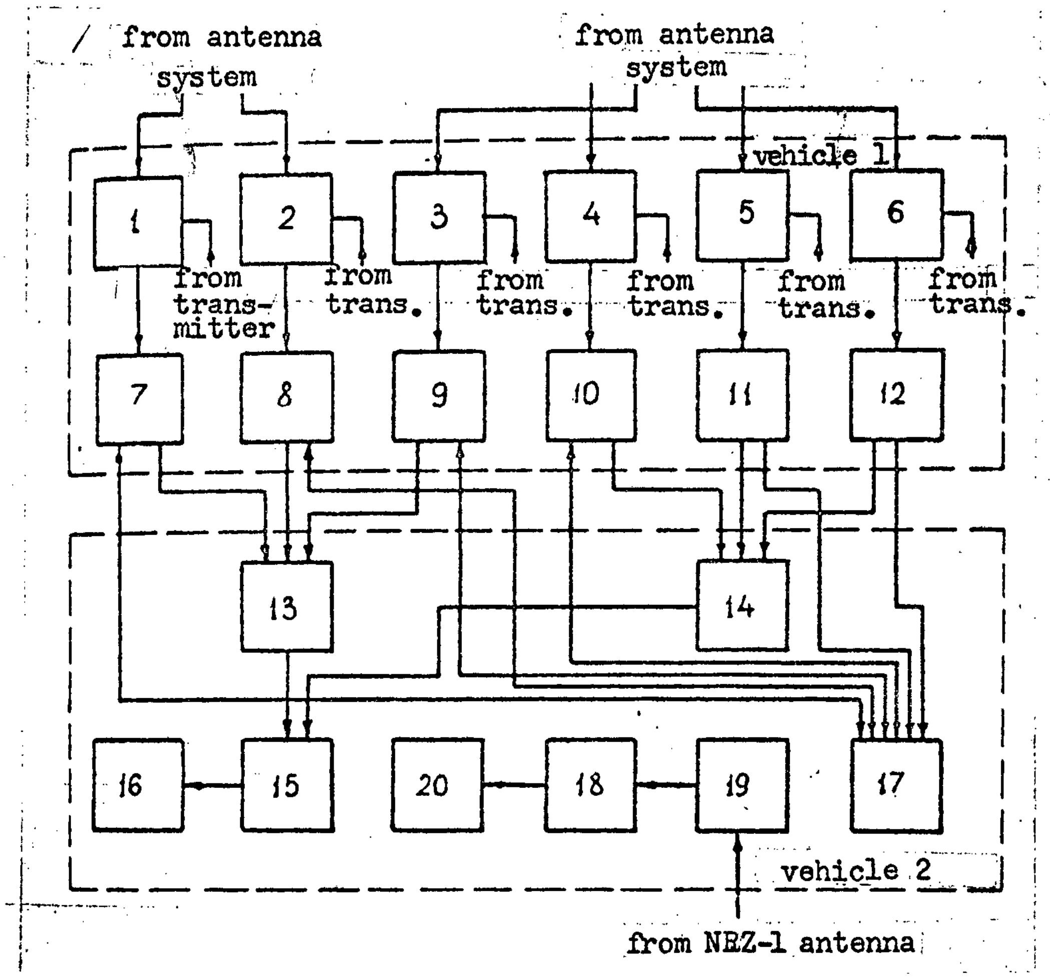

Fig 56. Receiver-Equipment Connections With Other Radar-Station Units (p 122)

1-6. APS-1 antenna switches
7-12. PRS-1 centimeter-wave receivers
13. SS-1 signal mixer (channels 1,2,3)
14. SS-1 signal mixer (channels 4,5,6)
15. VS-3 video signal unit
16. indicator
17. PDU-1 remote control panel
18. NRZ-1 ground-radar-interrogator receiver (B-15)
19. NRZ-1 ground-radar-interrogator transmitter (B-11)
20. NRZ-1 ground-radar-interrogator indicator (B-16)

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The Centimeter-Wave Receivers (PRS-1)

(p 124)

1. General Information

Basic Technical Characteristics of the Receiver

The receiver is characterized by the following basic data:

1. Operating frequency -- fixed.
2. Receiver circuit -- superheterodyne with high-frequency amplification encompassing a travelling-wave tube, with single-step frequency conversion provided by a waveguide mixer. A reflex klystron is used as the local oscillator in the receiver.

The types of APS-1 (antenna switch) units and AFC-1 blocks of the receivers are shown in Table 2.

Table 2

Types of APS-1 Units and AFC-1 Blocks of the Centimeter-wave Receivers

Channel No.	Type of APS	Frequency of Local Oscillator Relative to Signal Frequency	Type of AFC Block
I	G	below	N
II	Zh	below	N
III	V	above	V
IV	Ye	above	V
V	B	above	V
VI	D	above	V

3. The noise factor of the receiver is not worse than 11. (p 125)
4. The pass band is 0.7 $\pm$ 0.15 mc.
5. The maximum amplitude of signal pulses at the receiver output (with a load of 750 meters) is not less than 3 v.
6. With manual gain control, the amplification factor is at least 300.
7. The following auxiliary devices are encompassed in the receiver for noise protection:

-- instantaneous automatic gain control (MARU) for protection against loss of sensitivity as a result of interference in the form of high-amplitude long-duration signals;

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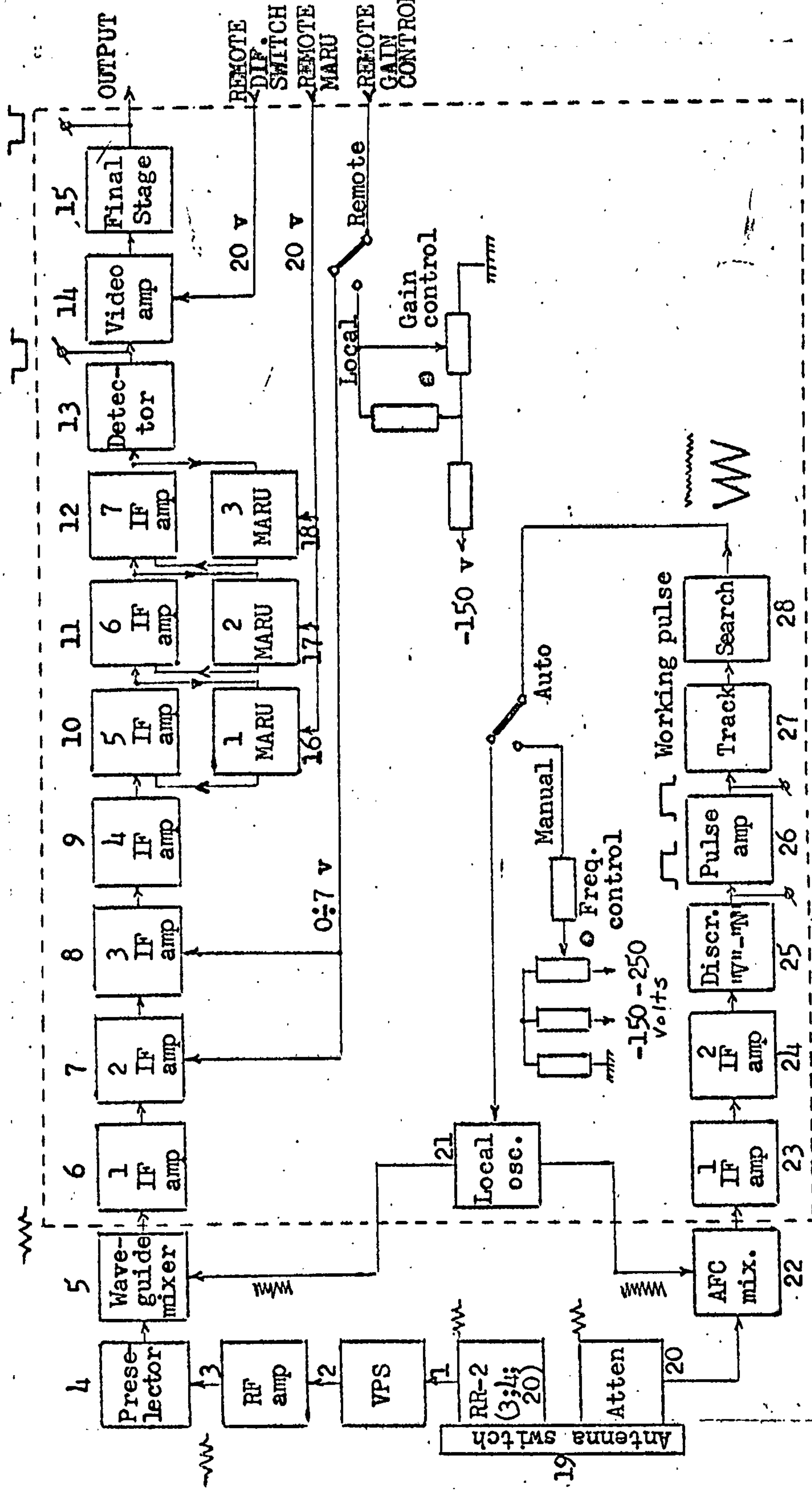

(p 126)

Fig 57. Functional Diagram of the Centimeter-Wave Receiver

-- a differentiating device for protection of the channel against a loss of sensitivity as a result of interference in the form of a long duration signal.

8. The receiver has automatic frequency control of the local oscillator; the AFC range is ± 7.5 mc.

9. The receiver is powered from a three-phase, 220-volt, 50-cps a-c network.

Functional Diagram of the Receiver

A functional diagram of the receiver, shown in Figure 57, includes a signal channel and an AFC channel.

The signal channel includes the following basic elements:

-- RF amplifier 3 with waveguide coupling 2 and antenna switch (APS) 19; (p 127)
-- signal mixer 5 with preselector 4;
-- local oscillator 21;
-- seven-stage IF amplifier 6-12
-- detector 13;
-- video amplifier 14;
-- final amplifier;
-- three stages of instantaneous AGC (MARU) 16, 17, and 18;
-- differentiating network (connected to video amplifier input) 14.

The automatic frequency control (AFC) channel includes:

-- attenuator 20;
-- AFC mixer 22;
-- two-stage IF amplifier 23 and 24;
-- discriminator 25;
-- pulse amplifier 26;
-- control tube 27;
-- search generator.

The reflector RF signal is taken from antenna switch 19 to the input of unit UVCh-1 (RF amplifier) 3 where it is amplified and sent to mixer 5 of the signal channel. A voltage from local oscillator 21 is also applied to this point.

As a result of this conversion, IF pulses are obtained which are (p 128) separated within the input circuit of IF amplifier 6 of the signal channel. These pulses are amplified in the subsequent stages 6 through 12 of the IF amplifier and are converted by detector 13 to d-c pu[lses] (video pulses), which are then amplified by the video amplifier.

Part of the energy of the RF pulses taken from the transmitter through attenuator 20 of the unit APS-1 (antenna switch) is fed to mixer 22 of the AFC channel, to which is also applied a voltage from local oscillator 21.

These pulses are first converted to IF pulses and then to d-c pulses which control the thyratron circuit regulating the frequency of the local oscillator.

Local and remote gain control are provided by the application of a negative voltage to the grids of the second and third IF amplifier stages; this is dependent upon the position of the "Gain Control" switch in unit PRS-1.

The voltages for remote switching-in of the differentiating circuit and MARU relays are applied through a plug in unit PRS-1 to the appropriate network.

The differentiating circuit is connected in the grid circuit of the video amplifier. The three MARU stages are connected to the last three stages of the IF amplifier.

Power for the receiver is taken from transformers and germanium rectifiers mounted in unit PRS-1, while the voltage stabilization circuit is also located here in an independent subassembly -- the stabilization block. (p 129)

Schematic diagrams of the control panel and the power supply unit (PRS-1) for the IF amplifier and AFC blocks and the supply voltage stabilization block are given in a separate album.

2. The Signal Channel

Waveguide Coupling From APS-1 to UVCh-1 (VPS)

The waveguide coupling (Figure 58) serves as a link between the antenna switch (APS-1) and the microwave amplifier (UVCh-1).

It is a waveguide of complex configuration with different cross-sections at either end. One end of the coupling has a special flange which is joined to the rectangular ATR tube of unit APS-1. The other end of the coupling is terminated with a flange for connection to unit UVCh-1.

The cross-section of the coupling on the UVCh end is 72 x 10 mm and corresponds to the cross-section of the UVCh waveguide. The cross-section of the other end of the coupling is determined by the dimensions of the rectangular ATR tube.

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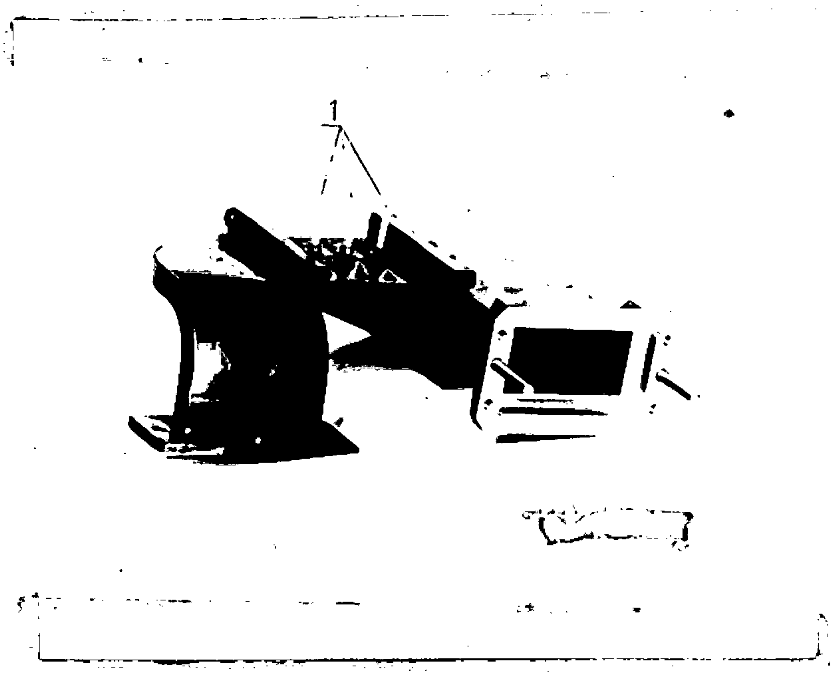

Fig 58. Waveguide Junction (p 130)

1. tuning screws

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The transition from one cross-section to the other is accomplished (p 131) smoothly in the middle section of the waveguide.

Three tuning stubs are located in the wide wall of the waveguide to eliminate reflections caused by bends and by the change in cross-section, as well as for the purpose of matching the input of UVCh with unit APCh-1. The position of these stubs is fixed after tuning by means of lock nuts.

Travelling-Wave Tube Microwave Amplifier

The microwave amplifier (UVCh-1) is connected between the rectangular ATR tube of the receiving arm of the antenna switch and the preselector of the signal mixer.

Use of the microwave amplifier reduces the demands on the quality of the crystal detector and on the circuit of the IF amplifier input stages.

In addition, introduction of the microwave amplifier increases the protection of the crystal mixer against the action of strong RF pulses.

The UVCh-1 unit includes:

-- travelling-wave tube, type UV-1B;
-- focusing system (solenoid) which produces a longitudinal magnetic field;
-- a matching device which matches the input and output of the amplifier;
-- a centering system for the UV-1B tube. (p 132)

A schematic diagram of unit UVCh-1 is given in Figure 59.

Power Supply for Unit UVCh-1

All supply voltages to unit UVCh-1 come through a cable from unit PRS-1.

Design of Unit UVCh-1

An over-all view of unit UVCh-1 is given in Figure 60, while UV-1B is shown in Figure 61. 50X1-HUM

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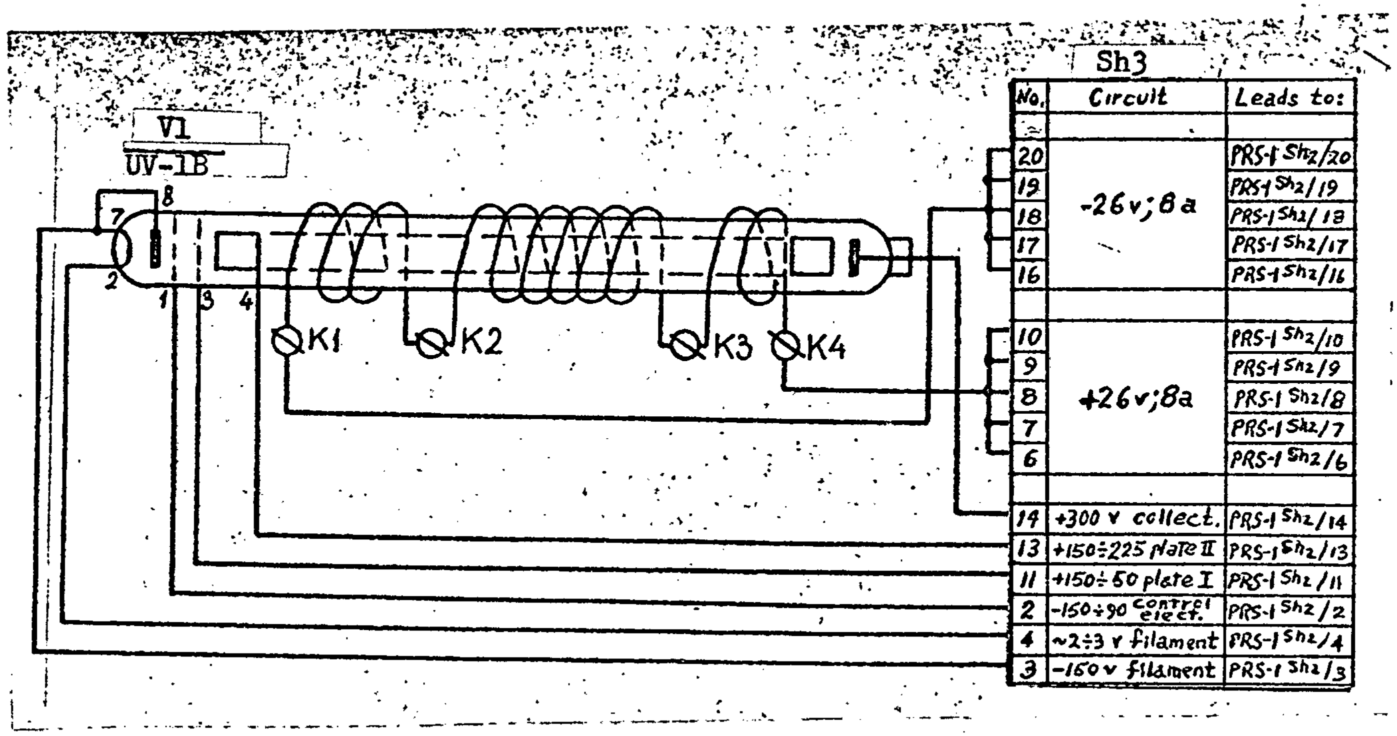

Fig 59. Schematic Diagram of the UVCh-1 Unit (TW-Tube Microwave Amplifier) (p 133)

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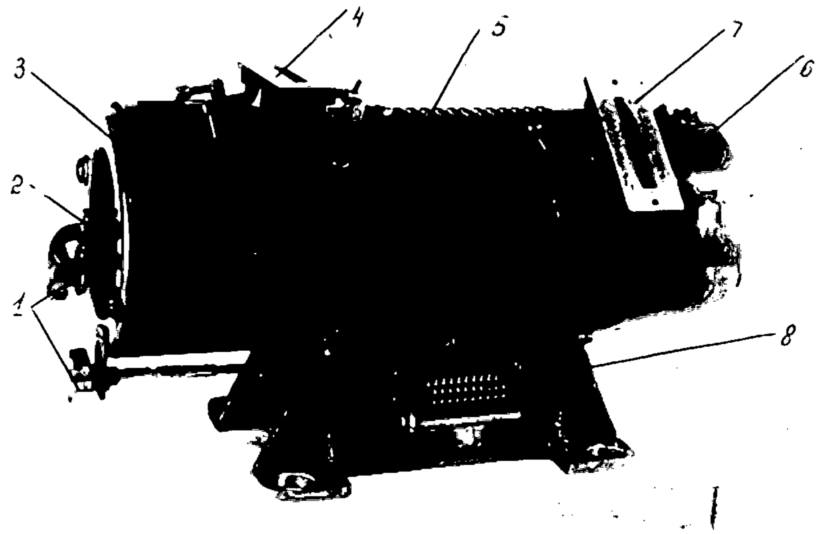

Fig 60. UVCh-1 Unit (TW-tube Microwave Amplifier) (p 134)

1. piston adjusting knobs
2. input centering device
3. side coil in housing
4. input-waveguide flange
5. center coil in housing
6. side coil in housing
7. output-waveguide flange
8. power plug-in

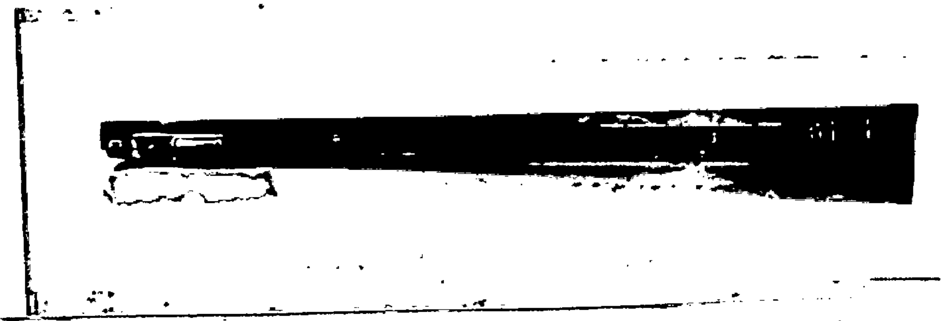

Fig 61. UV-1B Lamp (p 135)

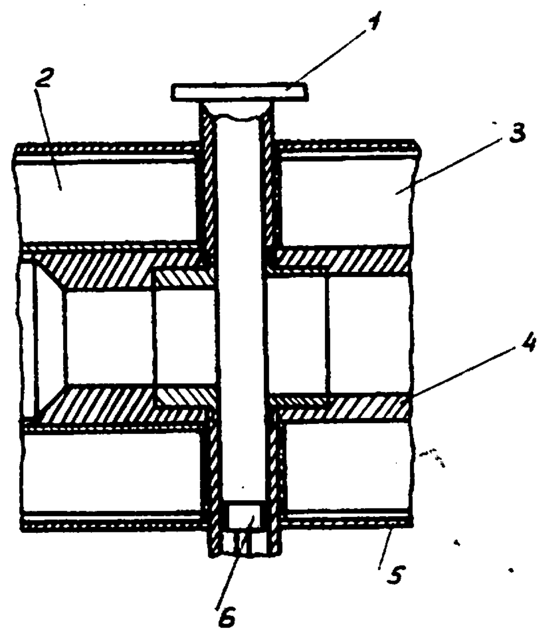

Fig 62. Cross Sectional View of the UVCh-1 (TW-tube Microwave Amplifier) at the Conjunction of Waveguide and Housing

(p 138)

1. flange
2. side coil
3. center coil
4. brass tube
5. housing
6. piston

The following voltages are required for tube UV-1B:

Filament	2-3 v
Control electrode	0-25 v relative to cathode
Plate I	0-100 v " " "
Plate II	150-225 v " " ground
	300-375 v " " cathode
Collector	450 v " " "
	300 v " " "

These voltages are controllable, since the operating mode of the tube is selected for each individual tube within limits close to its rating.

In order to simplify the rectifier of unit PRS-1 and to use common voltages of +300 and -150 v for the receiver, the cathode of the tube is not grounded, and a voltage of -150 v is applied to it.

The stabilized voltages of -150 and +300 v and the filament voltage (p 136) are taken from unit PRS-1 through the control panel located in this unit and pass through the power cable to the electrodes of tube UV-1B.

Of particular importance is the stability of the voltage at the helix (plate II) which controls the interaction of the electrons with the electromagnetic wave (interaction voltage). The amplification of the travelling-wave tube is very critical with respect to this voltage.

A d-c voltage is applied to the solenoid, and the initial current of the solenoid is equal to 8 ± 0.3 a. When the solenoid heats up, this current drops to 6 ÷ 7 a at which the required strength of the magnetic field is achieved.

The design characteristics and basic dimensions of the amplifier unit are determined by the position which the unit occupies in the RF tract of the receiver and by the dimensions of the tube (TW) and the solenoid.

The amplifier unit consists mainly of three parts: solenoid, waveguides with tuning elements, and the system used to center the tube in the magnetic field.

In order to avoid undue distortion and attenuation of the magnetic field in those places where the tube is linked to the input and output waveguides, the solenoid is made in the form of three individual coils and has a total length somewhat greater than that of the helix of the tube.

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The solenoid consists of three coils whose total resistance at a temperature t = 20°C is 2.80 ÷ 3.3 ohms. (p 137)

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The coils are wound on brass tubes (Figure 62). These tubes serve as the outer shell of the coaxial helical line in the center coil and as RF filter plates in the side coils. The tubes are connected as a single piece by bushings extending from the side walls of the waveguides.

The cross-section of the waveguide channels of the amplifier are selected at 72 x 10 mm. The width of the narrow wall of the waveguides is determined by the length of the exciter stubs of the UV-1B tube. Flat flanges 1 are fitted to one side of the waveguides to permit attachment of the amplifier to the waveguide coupling at the input end and attachment to the preselector cavity of the signal mixer at the output end. On the other side, each waveguide is shorted by a piston 6 which, by means of a special drive, can be moved along the waveguide to provide tuning to maximum signal transmission.

The ends of the outer coils are covered by two metal plates to which the tube and the device used to center it in the magnetic field are attached. The tube is held by an ordinary 8-pin tube socket and a cap holder with segmented lobes. The position of the tube along the axis of the unit is adjusted by changing spacers during factory adjustment. Incorrect adjustment of the tube causes a deterioration in its sensitivity.

Each centering device consists of a system of two eccentrics. (p 139) One eccentric is formed by a cylinder, to which the tube socket (or cap holder) is fixed, fastened to a metal disk with an eccentricity of 0.6 mm relative to the center of the disk. The other eccentric is formed by a round cylinder, the axis of the external surface of which is displaced relative to the inner surface also by 0.6 mm (Figure 63).

If one of the centering devices is kept stationary, rotation of both eccentrics of the other device will cause a movement of the center of the spiral of this end of the tube as shown at the right in Figure 63.

If both centering devices are adjusted, the axis of the tube can be made to occupy any position in space, limited by the cylinder to a diameter of 2.4 mm, relative to the axis of the focusing system.

Correct orientation of the beginning of the helix relative to the axis of the input waveguide noticeable improves the matching of the tube with the microwave channel. In view of this, the cylinder of the tube socket is held in the centering device in such a way that, once the tube has been centered in the magnetic field, the tube may be rotated around its own axis.

The armature of the solenoid is placed in a cylindrical sheath made of soft steel which screens the tube against the influence of ex[redacted] fields.

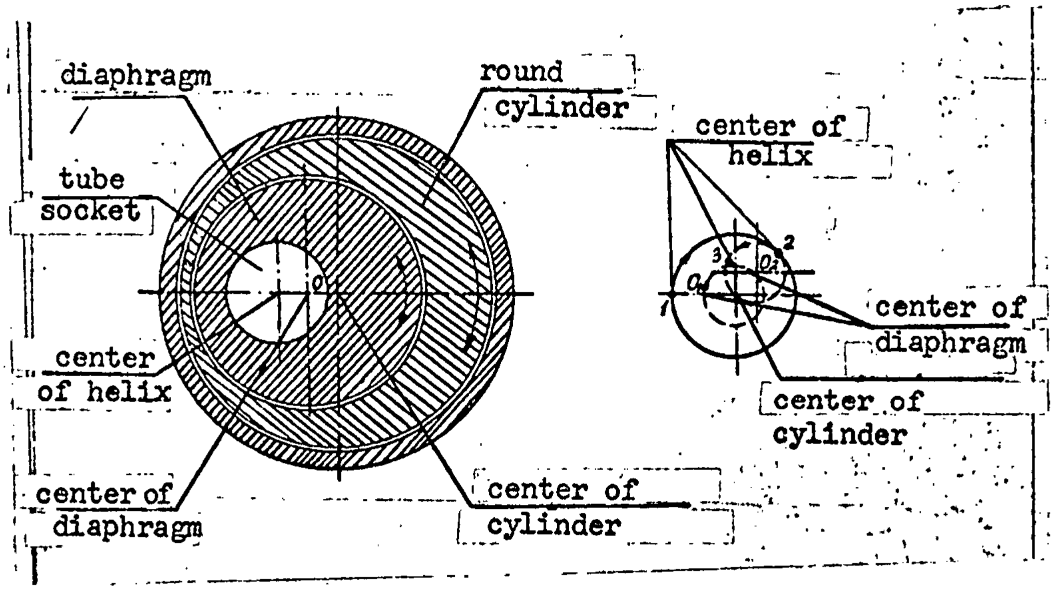
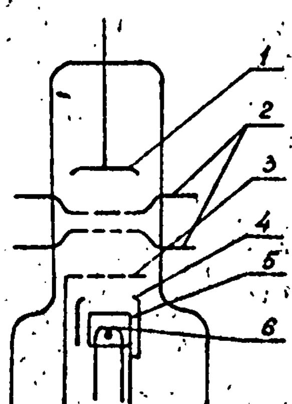


Fig 63. System of Two Eccentrics in UVCh-1 Amplifier Unit (p 140)

Fig 64. Main Elements in the Reflex Klystron (p 142)

1. repeller (reflecting electrode)
2. resonator grids
3. accelerating electrode
4. focusing cylinder
5. cathode
6. heater



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The solenoid heats up during its operation and is therefore cooled by a fan in the transmitter unit from which an air duct runs to an opening in the base of unit UVCh-1 (travelling-wave tube amplifier). (p 141)

The need for cooling arises because of the fact that, without cooling and at the high temperatures within the body of the vehicle, the solenoid may become overheated.

The weight of unit UVCh-1 is approximately 40 kg.

The Local Oscillator

A 10-centimeter reflex klystron of the K-11 type with an external cavity resonator circuit is used as the oscillator tube.

The basic elements of the reflex klystron are shown in Figure 64.

When the supply voltages are applied to the klystron, oscillations are set up in the local oscillator circuit which may be maintained under certain conditions.

The mechanism by which these oscillations are maintained in the klystron circuit may be explained as follows. Electrons escaping from the cathode enter the electrical field of the resonator circuit as a result of the action of the voltage of the accelerating electrode and the grids of the resonator (approximately 250 v). This beam, whose electrons are homogeneous with respect to velocity and distribution, enters the space between the grids of the resonator and is velocity-modulated as a result of the action of the high-frequency electrical field.

When the electrons escape from the grid area they have different velocities, whereupon they are bunched during the time that they move in the area of the reflector plate (the drift space). Bunching occurs in (p 143) the beam around those electrons which pass the gap between the grids at that moment when the a-c voltage in the resonator passes through zero and the electrical field in the gap between the grids changes from retarding to accelerating. Thus, the distribution of charges in the beam is not homogeneous and, consequently, the beam contains an alternating current component.

When the electrons return due to the action of the repelling field of the reflector, the current maximums of the beam must pass the grids of the resonator at those moments when there is voltage in the resonator, which creates a retarding field for the electrons.

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Only in this manner will the electron beam impart energy to the local oscillator circuit and sustain oscillations in the circuit. If this did not occur, the electron beam itself would remove energy from the circuit, and oscillations would cease.

The characteristic feature of any reflex klystron is the possibility of changing the frequency of generated oscillations by changing the voltage at the reflector. In any reflex klystron there are several voltage regions at the reflector at which conditions of generation are maintained.

Figure 65 shows approximately the regions of generation for the K-11 klystron for a voltage of -250 v at the resonator. The regions of generation are numbered in order. The first (I) is the region of generation with the highest negative voltage of -250 v, the second (II) has a voltage of approximately -140 v, etc. (p 144)

The local oscillator which we have considered uses the second region of generation, at which klystron K-11, as a rule, provides maximum power.

Figure 65 also shows the relationships of changes in power and frequency of the klystron to changes in voltage at the reflector within the limits of the region of generation. The frequency increases when the voltage at the reflector is increased. The change in klystron frequency caused by changing the voltage at the reflector between the points of half power is called the electron tuning range.

The electron tuning range of the K-11 klystron local oscillator is approximately 7.5 mc.

An over-all view of the K-11 klystron is shown in Figure 66.

High-frequency energy is taken from the klystron circuit by means of a coupling loop. The coupling joint is connected to a T-joint from which the local oscillator voltage is led to both mixers by means of two high-frequency cables.

Stable operation of the local oscillator requires that all fastening screws be fully tightened and the tuning stubs be securely locked.

Power for the local oscillator is taken from the same rectifier which feeds the entire receiver. A voltage of +300 v is applied through voltage-dropping resistor R26 to the accelerating electrode and the klystron resonator. (p 147)

A negative voltage from potentiometer R34 is applied to the repeller electrode of the klystron during manual adjustment of the frequency. This voltage may be varied from -55 to -220 v. With automatic frequency control, voltage is applied to the repeller electrode from the plate of the search generator tube of the APCh-1 (AFC) network.

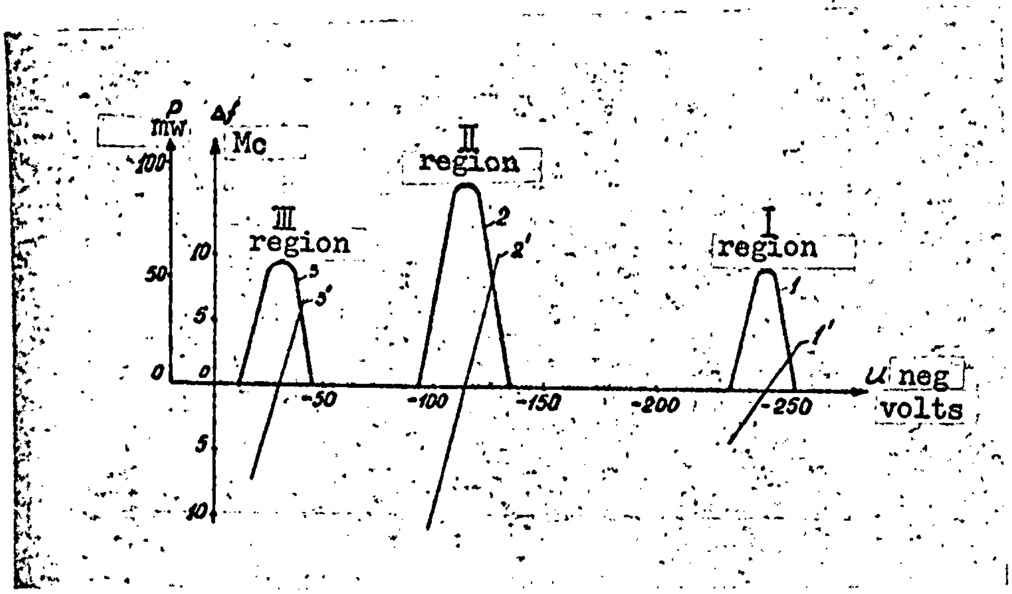


Fig 65. K-11 Klystron Oscillation Regions (p 145)

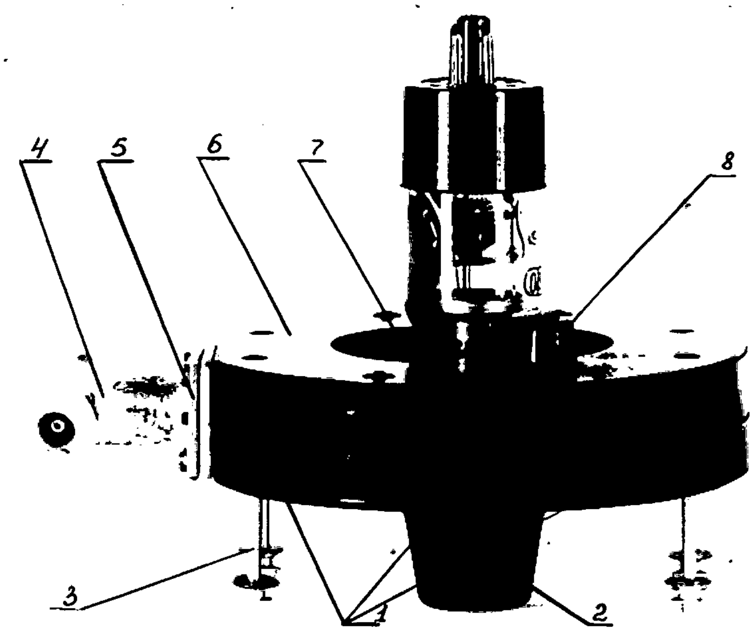
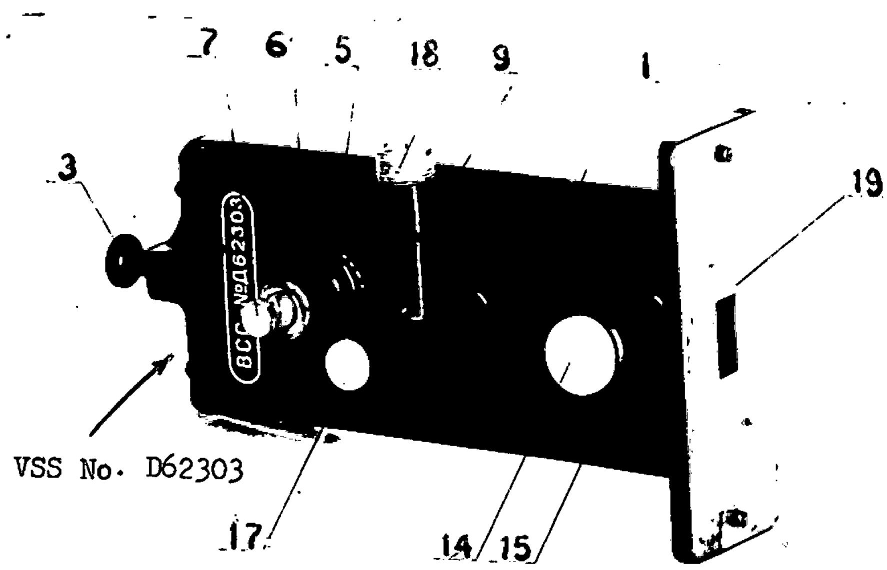


Fig 66. Local Oscillator with K-11 Klystron (p 146)

1. openings for tuning plungers
2. output for feeding voltage to the repeller
3. safety-lock bolt for attachment to PRS-1 unit
4. high-frequency Tee
5. flange with coupling loop
6. demountable housing
7. local-oscillator resonator
8. output for voltage supply to resonator



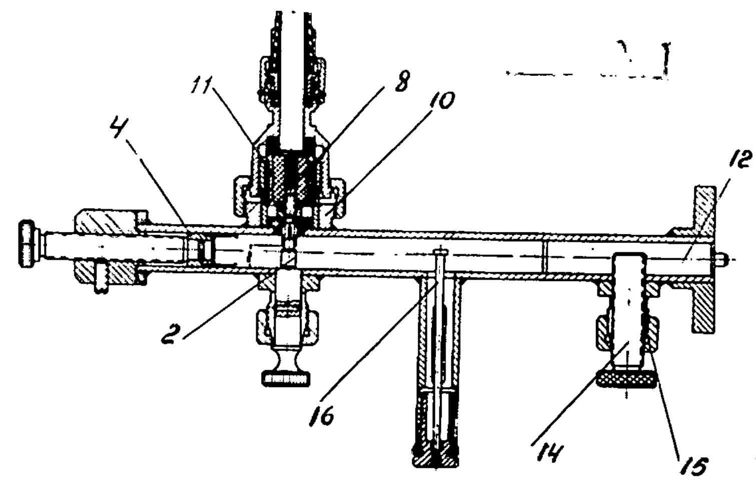


Fig 67. Signal Mixer (p 148)

1. waveguide of mixer
2. crystal detector
3. plunger-adjusting screw
4. plunger
5. split bushing
6. clamp nut
7. crystal holder
8. special plug
9. local oscillator coupling device
10. collar
11. $\frac{1}{4}$-wave filter
12. preselector cavity
14. preselector tuning plunger
15. plunger clamp nut
16. capacitive probe for coupling to the local oscillator
17. screw for adjusting coupling to local oscillator
18. connection for local-oscillator cable
19. flange for attaching to microwave-waveguide output

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Signal Mixer With Preselector Cavity

The signal mixer is used to convert the pulses of the microwave signal to intermediate-frequency pulses. The signal mixer is shown in Figure 67. The mixer consists of waveguide section 1 with a cross-section of 72 x 10 mm across which is placed a type DGS crystal detector 2. One end of the waveguide is closed by plunger 4, which is moved by means of screw 3, whose position is fixed upon tuning. At the other end are two diaphragms, which are separated from each other by a distance of half a wavelength and form the resonance cavity of the preselector; the end of the cavity is fitted with a rectangular flange for attachment to UVCh-1. On the wide wall of the waveguide mixer is guide bushing 5 of the crystal holder with lock nut 6. Crystal 2 is (p 149) screwed into crystal holder 7 and is placed in the waveguide so that its other terminal is connected to the center lead of special plug 8 of a cable leading to unit UPCh-1.

On this wall also is a device for connection to local oscillator 9. This device is described in the description of the AFC mixer. An externally threaded bushing 10 for connection to special plug 8 is located on the opposite wall.

A special box contains quarter-wave filter 11, which passes RF energy to the input of UPCh-1 (IF amplifier). The converted frequency is sent to UPCh-1 by means of a section of coaxial cable. The resonance cavity of the preselector is a section of rectangular waveguide with a cross-section of 72 x 10 mm with two coupling windows at the ends.

A tuning screw (plunger) is placed in the waveguide of the preselector cavity so that the gap between its end and the waveguide wall forms a lumped capacitance for the resonance cavity circuit. The resonance cavity represents a tunable selector device since it is equivalent to a circuit connected between the microwave amplifier and the signal mixer.

IF Amplifier and Detector (UPCh-1)

The voltage taken from the signal mixer is fed through high-frequency (p 150) cable RK-47 and the input plug to input winding L1 of the circuit (see schematic diagram). In order that the cable does not introduce a reaction in the input circuit, the geometric length of the cable is selected so that its electrical length is equal to half the wavelength of the intermediate frequency oscillations. An equivalent diagram of the input circuit of UPCh (IF amplifier) is given in Figure 68.

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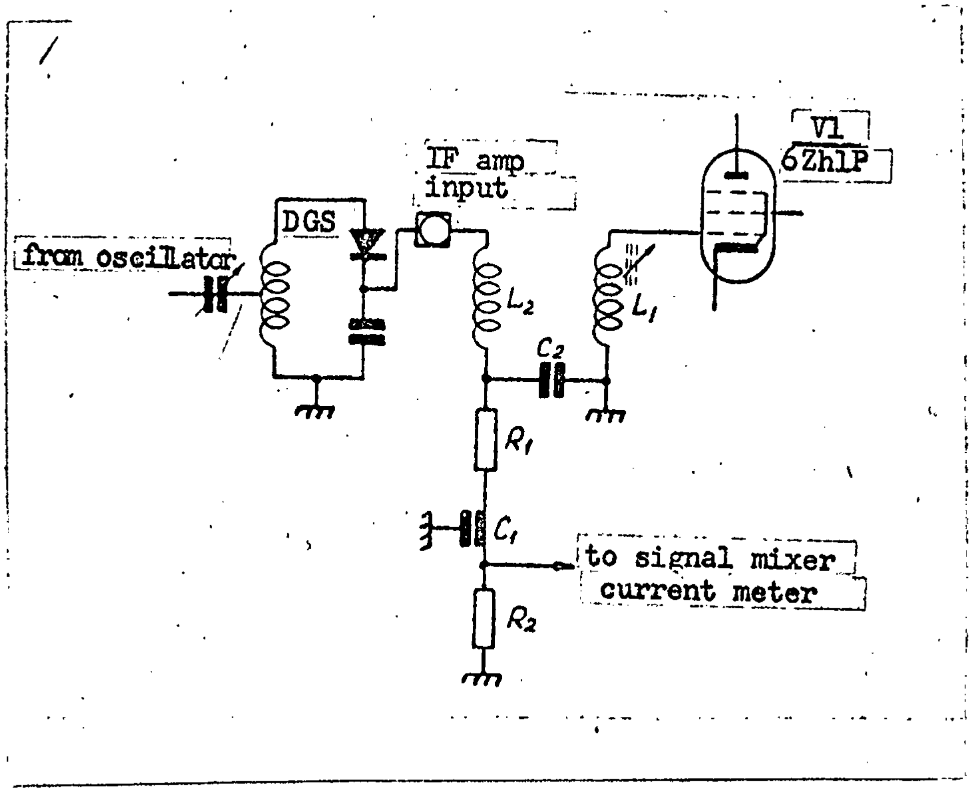

Fig 68. Equivalent Circuit Diagram of the Input Circuit of the UPCh-1 (p 151)

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The current from the signal mixer, formed as a result of the detection of the local oscillator voltage, passes through resistors R1 and R2.

Resistor R2 serves as a shunt for the measuring instrument of unit PRS-1 (when measuring the mixer current with this instrument); resistor R1 and capacitors C1 and C2 are intended as a by-pass.

The IF amplifier uses seven amplification stages with identical circuits which are resonance tuned to a frequency of 30 mc. The first six stages use 6Zh1P tubes and the last stage uses a 6Zh5P tube.

All circuits are formed by inductance coils, auxiliary capacitors connected in parallel with them, the capacitance of the tubes, and the capacitance of the wiring. The input circuit is tuned with a carbonyl iron core and all other circuits with brass cores.

The passband of each circuit is determined by the total capacitance of the circuit and the shunting resistor connected to the plate circuit of the tube.

The IF voltage formed in the input circuit is amplified by the first and subsequent stages of the IF amplifier. A voltage from the +120-v circuit is applied to the plates and screen grids of the 6Zh1P tubes. (p 152)

In order to avoid the necessity of having large blocking capacitors between the stages, the circuit coils (with the exception of the input circuit), the auxiliary capacitors of the circuits, and the shunting resistors are connected to the plate circuits of the tubes.

Bias at the grids of the IF amplifier tubes is applied through RF chokes.

The supply voltage of +120 v is applied to the UPCh stages through a resistance network which weakens parasitic feedback in the plate circuit between stages.

RF chokes wound on ferrite rods and having high loss at high frequency are included in the filament supply circuits of the tubes. These chokes provide high attenuation of IF parasitic couplings through the filament circuits.

In addition, all supply circuits are blocked by capacitors near the input contacts of the power supply plug.

The +300 v applied to the plate of tube 6Zh5P also passes through an inductance-capacitance filter.

The circuit of one stage of UPCh (the IF amplifier) is shown in Figure 69.

Circuit L4, C9 represents the load in the plate circuit of preceding tube V2.

The inductance of the circuit is trimmed during factory adjustment by means of the brass core.

The load of the stage examined above is the circuit in the plate of V3 formed by coil L5, capacitor C14, and shunting resistor R14. (p 153)

Resistor R14 in the plate circuit of tube V3 determines the gain and the passband of the given stage. RF-choke Dr6 protects the grid of the tube against strong signal overloads by maintaining a constant bias voltage on the grid of V3. An initial automatic bias of the grid circuit is created at resistor R13 in the cathode circuit of the tube, which is blocked by capacitor C15.

The cathode of tube V3 is connected through decoupling resistor R12 to test jack K3, where the operating mode and performance of the stage is monitored.

The plate of tube V3 is connected to the grid of tube V4 of the subsequent stage by coupling capacitor C17.

Receiver gain is adjusted locally by changing the gain of the second and third tubes by applying a negative voltage to their control grids from the potentiometer located on the control panel of unit PRS-1.

Remote gain control is accomplished by applying a bias to the same stages from the potentiometer located in unit PDU-1 (remote control panel). The "Gain Control" switch on the panel of unit PRS-1 is used to change from local to remote gain control.

IF-voltages are taken from the plate circuits of the fifth, sixth, and seventh IF-amplifier stages through blocking capacitors to the MARU (instantaneous AGC) stages. A control voltage is applied through filters to the control grids fo the fifth, sixth, and seventh IF-amplifier stages from the MARU stages. (p 155)

The IF-amplifier detector is formed by a twin diode 6Kh2P.

A diagram of the output stage of the IF amplifier and the detector is given in Figure 70.

IF-voltage is applied to the cathode of the detector throu[redacted] blocking capacitor C35 from the plate of the final IF-amplifier stage, which is based on tube 6Zh5P. Choke Dr19 permits passage of the direct current component of diode 6Kh2P. The load resistance in the plate

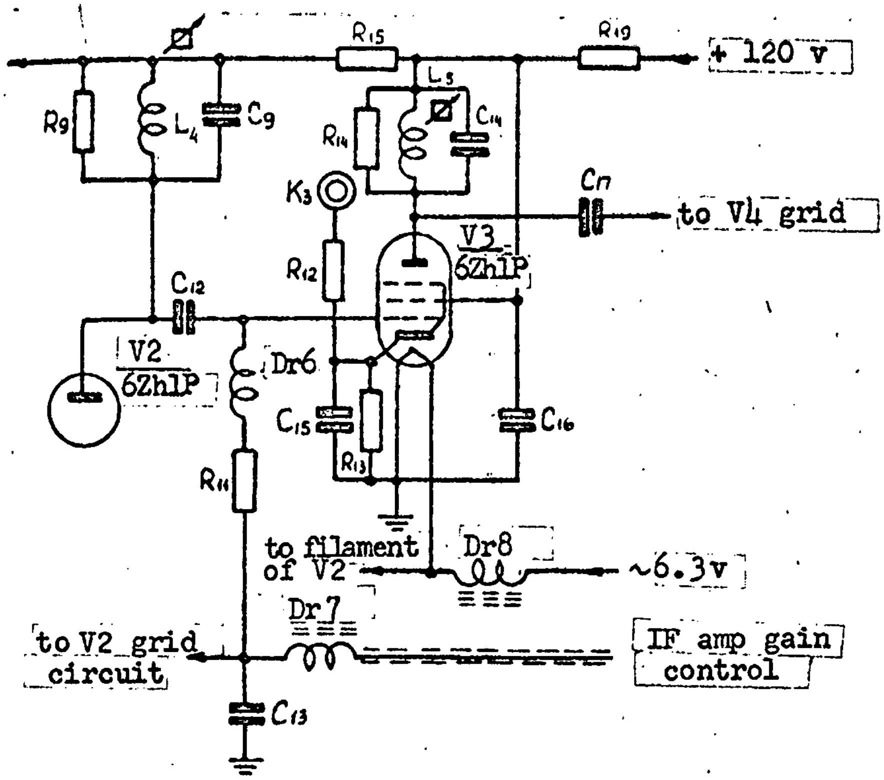

Fig 69. Diagram of a Typical UPCh (IF-Amplifier-Detector) Stage (p 154)

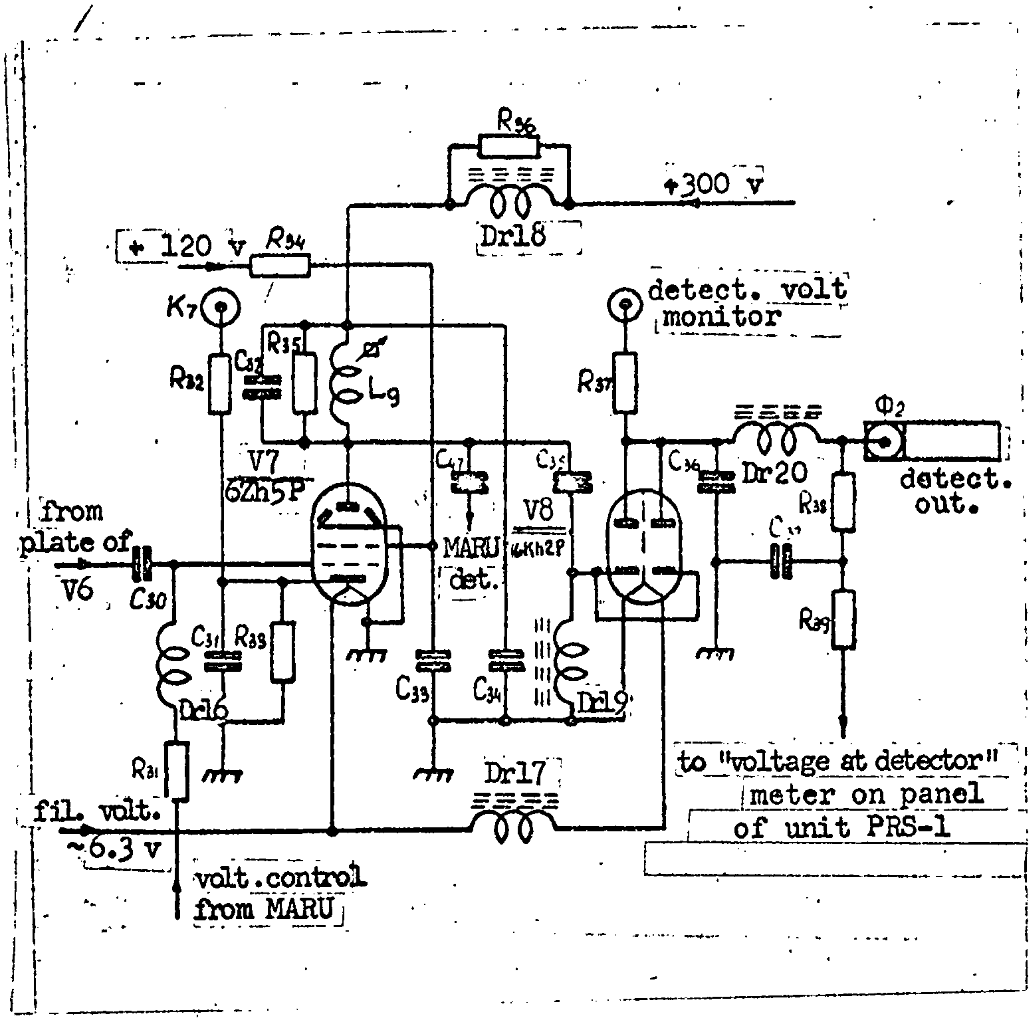

Fig 70. Diagram of the UPCh-1 Output Stage and Detector

(p 156)

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circuit of the detector, equal to 4.2 kilohms (resistors R26 and R27 in Figure 73), is located in the grid circuit of the video amplifier of the "APCh-1" block.

Two series-connected resistors R38 and R39 (Figure 70), which are multipliers for the instrument on the control panel of unit PRS-1, are connected to the plate of the detector.

The plate of the detector is also connected through decoupling resistor R37 to a test jack which is used to monitor the performance of the detector.

Capacitor C36 shunts the load of the detector against intermediate frequencies. The values of the load resistance of the detector and the capacitance which shunts it are selected so that the signal will not be noticeably distorted.

A negative d-c pulse is taken from the load of the detector. (p 157)

Choke Dr20 is connected between the detector and the output contact of plug connector F2 of the UPCh-1 block (connected by coaxial cable to the video amplifier). This choke, together with the input capacitance of the IF-amplifier tube and the capacitance of the cable, creates a filter which impedes the penetration of IF-voltages into the video a amplifier. Such a filter prevents the appearance of parasitic feedback through the video amplifier circuits.

The MARU-Circuit

The MARU (instantaneous AGC) circuit protects the radar from pulse noises with large amplitudes and durations exceeding that of the useful signal.

The MARU-circuit automatically reduces the gain of the last three stages of the IF-amplifier when interference is present at its input during operation. At the same time, the MARU-circuit does not attenuate the working pulses received immediately behind the interference.

The MARU-circuit consists of three stages built around type 6N1P and 6N2P twin triodes (see schematic diagram). The first, second, and third stages are connected between the plate and grid circuits of the fifth, sixth, and seventh IF-amplifier stages, respectively. The three MARU-stages provide sufficient depth of gain control — a reduction of the flat part of the noise pulses to the noise level.

The IF-voltage from the plate circuits of the fifth, sixth, and seventh stages of the IF-amplifier are applied through blocking capacitors to the corresponding halves of the triodes, which are connected in a diode detector circuit. A diagram of one MARU-stage is given in Figure 71.

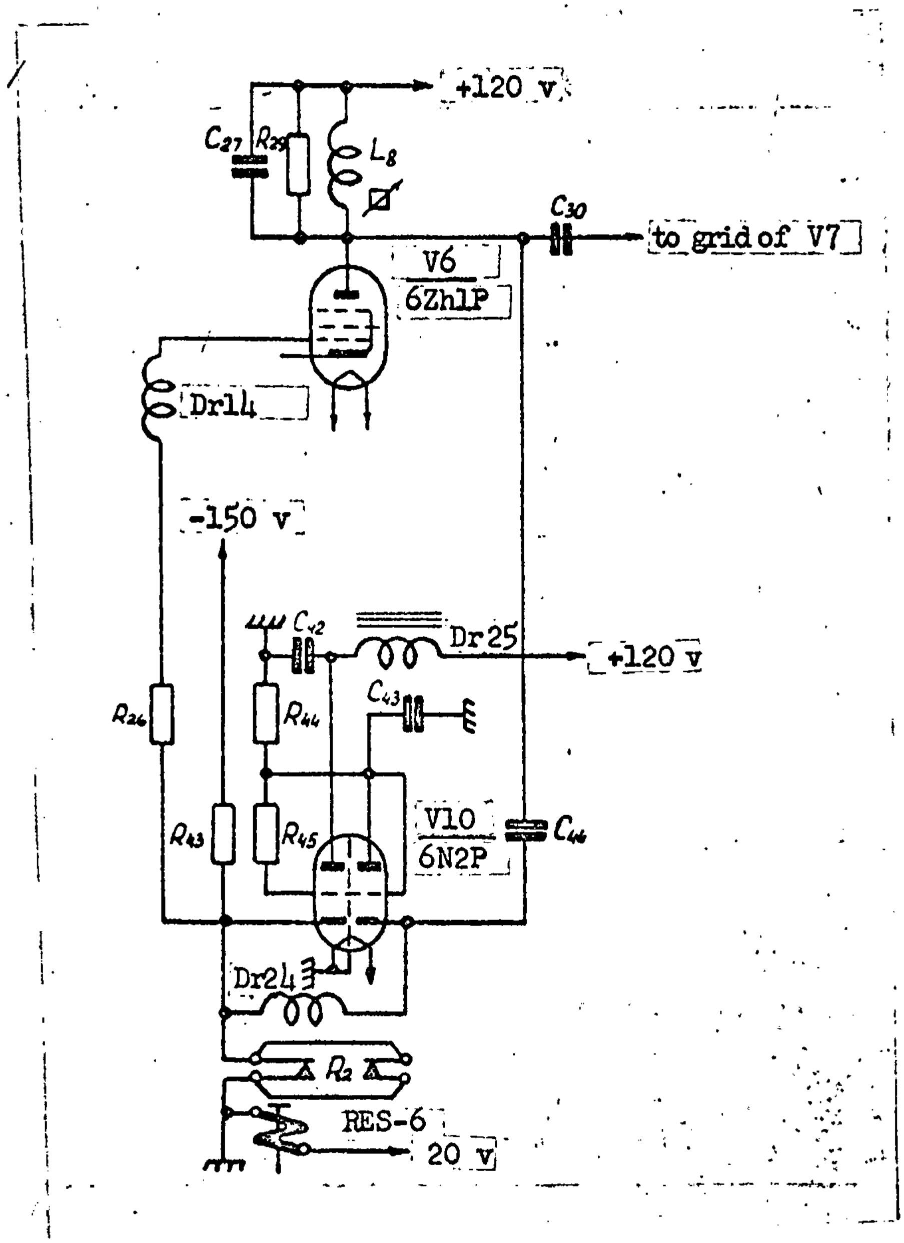
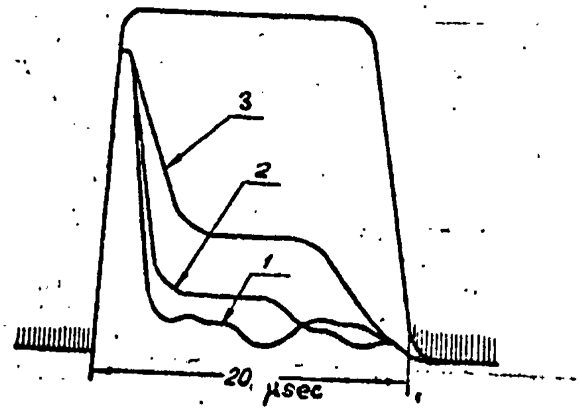


Fig 71. Diagram of One MARU Stage (p 159)

Fig 72. Oscillogram of an Output Pulse When the MARU is Operating

1. MARU stages 1,2,and 3 connected;
2. MARU stages 2 and 3 connected;
3. MARU stage 3 connected.

(p 160)



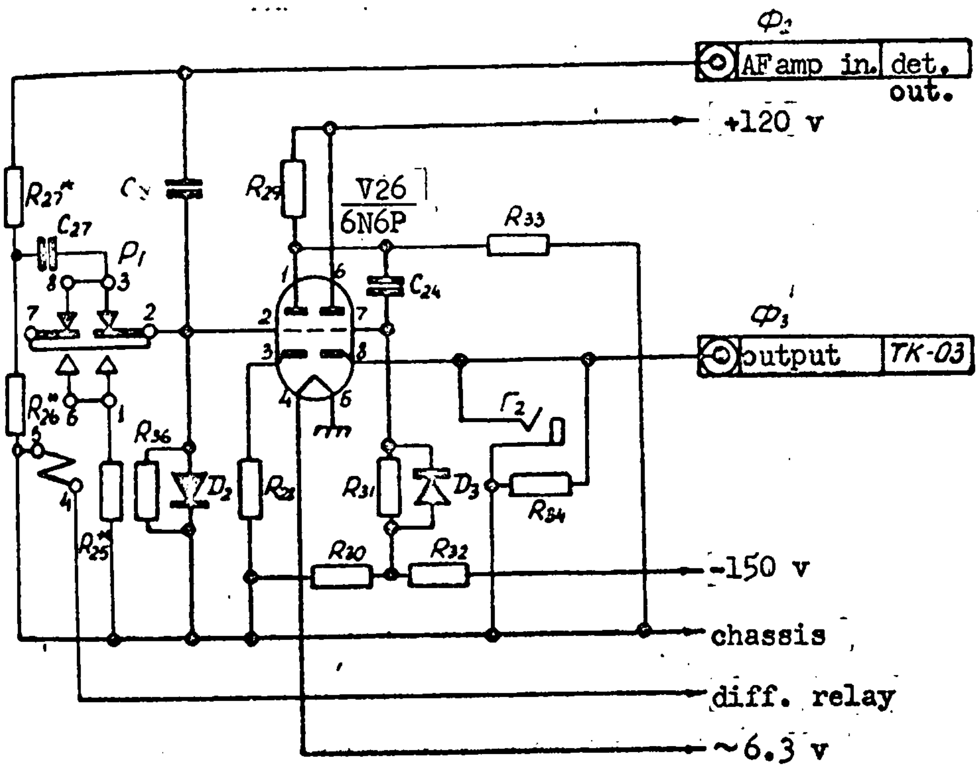


Fig 73. Schematic Diagram of the Audio-Frequency Amplifier (p 16

Resistor R44, shunted by capacitor C43, serves as the load of the detector.

A rectified voltage is applied through decoupling resistor R45 to the grid of the second half of the triode, which is connected in a cathode follower circuit. Resistor R43, which is connected to the -150-v source, serves as the load in the cathode circuit of this triode. The direct current component of the triode causes a drop in voltage across cathode resistor R43 approximately equal to 150 v. Hence, the voltage between the cathode and ground is approximately equal to ±0.2 v. This initial voltage causes a slight change in the gain of that IF-amplifier stage with which the given MARU-stage is connected.

The gain of the MARU-stage is increased by positive d-c feedback from the output of the cathode follower to the cathode of the detector through RF choke Dr24. This choke blocks the path to intermediate frequencies.

The other MARU-stages are similar to the one described.

In order to prevent the third-MARU stage from being triggered by a sufficiently high noise level at its input, the detector of this stage is blocked by a certain initial bias so that it begins operating at a certain "threshold." The triggering threshold is determined by (p 161) the magnitude of negative bias applied to the plate of the diode of this stage from divider R47 and R48 (see schematic diagram), which is connected to the -150-v network. The simultaneous application of a bias to the grid of the triode of this stage is compensated by the choice of a resistance in the cathode circuit of the triode.

The triggering threshold of the third MARU-stage is selected so as to prevent suppression of pulses of nominal amplitude.

Resistors R41, R44, and R49 and the wiring capacitance and input capacitances of the tubes in all the MARU-stages create a delay in the triggering of the circuit for a period of time greater than the duration of the signal reflected from a single target.

An oscillogram of the pulse at the output of the receiver (and at the load of the IF-amplifier detector) together with a square pulse having an amplitude of up to 0.2 v at the amplifier input, is shown in Figure 72.

The Audio-Amplifier (UNCh) and Differentiating Circuit

The audio-amplifier consists of two stages: the preamplifier and the final stage of the cathode follower (Figure 73).

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Video-Preamplifier and Output Amplifiers (p 163)

The preamplifier (video amplifier) receives the required input voltage at the grid of the output stage, which is the power amplifier.

Both UNCh-stages are based on a 6N6P twin triode. The signals are fed by means of a special coaxial cable from the output of the detector located in the UPCh-1 block to the APCh-1 (AFC) block which contains the audio amplifier. Resistors R26 and R27 form the load of the audio-amplifier detector. Video pulses are taken from resistor R26 to the grid of the video amplifier.

Negative pulse signals are applied to the input of the video amplifier. The video amplifier tube is normally open and has a small negative bias between the grid and cathode as a result of the drop in voltage across resistor R28.

When large amplitude signals arrive, the video amplifier tube is blocked, and limiting occurs. The cathode resistor of the preamplifier is shunted by capacitor C25 for the purpose of decreasing negative feedback, which attenuates the gain of the pulse signals.

The grid circuit of the video amplifier is protected against negative voltage from the output of the detector (d-c) by blocking capacitor C27. Because of the presence of this capacitor, a change in noise level at the output of the IF-amplifier does not lead to a change in gain of the audio amplifier. (p 164)

Grid leakage of the video amplifier is formed by the back resistance of crystal diode D2, type D2-Ye, which simultaneously performs the role of a d-c restorer at the grid of the tube during overloading.

The limiting threshold of the video amplifier depends on the supply voltage, the plate load R29, shunting resistor R33, and on the bias at the control grid. The values of resistors R28, R29, and R33 is chosen so that the amplitude of the signal at the plate of the left triode does not exceed 6 volts.

Positive pulses pass from the plate of the left triode through blocking capacitor C24 to the grid of right triode 6N6P. Capacitor C24 blocks the control grid of the output stage against a positive voltage from the plate of the video amplifier.

In the absence of a signal, the right triode is in an almost closed state, since a large negative bias is applied to its grid through resistor R31 and crystal diode D3 of the type D2-Ye. The necessity for obtaining a sufficiently large current pulse results in selecting the operating point in the lower bend of the characteristic of the tube.

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Crystal diode D3, type D2-Ye, which is connected in the grid circuit of the output stage, prevents overloading of this stage by pulses of long duration and amplitude; that is, it plays the role of a d-c restorer. (p 165)

The load of the output stage of the audio amplifier is an end-matched coaxial cable with a wave impedance of 75 ohms. This stage is in the form of a cathode-follower circuit. To prevent discharge of the cathode of the tube to the heater (filament) when the load cable is disconnected, the cathode of the output-stage tube is shunted to ground by resistor R34.

This resistance is chosen on the basis that the true load of the stage differs little from the wave impedance of the cable (R34 - 560 ohms).

Both stages of the audio amplifier are supplied from a +120-v stabilized voltage source.

Test jack plug G2, connected to the output plug of the audio amplifier, is used to monitor the operation of the amplifier and the entire receiver in the "APCh-1" block.

Grid-bias voltage is fed to the right triode from a special voltage divider consisting of resistors R30 and R32. This divider is supplied from a -150-v circuit.

The Differentiating Circuit (p 166)

In order to prevent overloading (blocking) of the video-amplifier stage by pulse noise of long duration, it is possible to connect (by means of relay R1) a differentiating circuit comprising resistor R35 and capacitor C28 into the control-grid circuit of the tube in place of resistor R26.

A differentiating circuit is not always needed in the video-amplifier channel, since in a number of cases it is necessary to observe large groups of "overlapping" signals.

In differentiation, only the front of these signals is reproduced. Individual signals are not visible. Therefore, the differentiating circuit is connected remotely from the PDU-1 panel at the decision of the operator. Also, it is desirable to switch on this circuit simultaneously with the switching-on of the MARU-circuit.

The detected pulses are applied to the grid of tube V26 th[redacted] capacitor C28 from the full load of the detector and through capacitor C27 and the contacts of relay R1 from part of the load (from R26). When a voltage is applied to the excitation winding of the relay, resistor

R 25 is connected in parallel with R36, and capacitor C27 is disconnected from the control grid of the tube. In this case, the signal is applied to the grid only through capacitor C28 and is differentiated by circuit C28 and R25/with parallel-connected resistor R36.

The required values of C28 and R25 are determined by the duration (p 167) of the working pulse of the radar. The working pulse must not be differentiated, since this would cause a decrease in the output signal while maintaining the same noise level, that is, the sensitivity of the receiver would be reduced.

3. The Automatic Frequency Control (AFC) Channel

The purpose of the automatic frequency control is to change the frequency of the local oscillator in such a manner that the intermediate frequency will remain unchanged in the event of a drift in frequency of the transmitter or the local oscillator itself.

The AFC channel includes an AFC mixer and an AFC circuit; a schematic diagram of the APCh-1 (AFC) block is given in a separate album.

The AFC circuit consists of two IF-amplifier stages, a discriminator, a video amplifier, and track and search stages.

A. General View

B. Cross Section

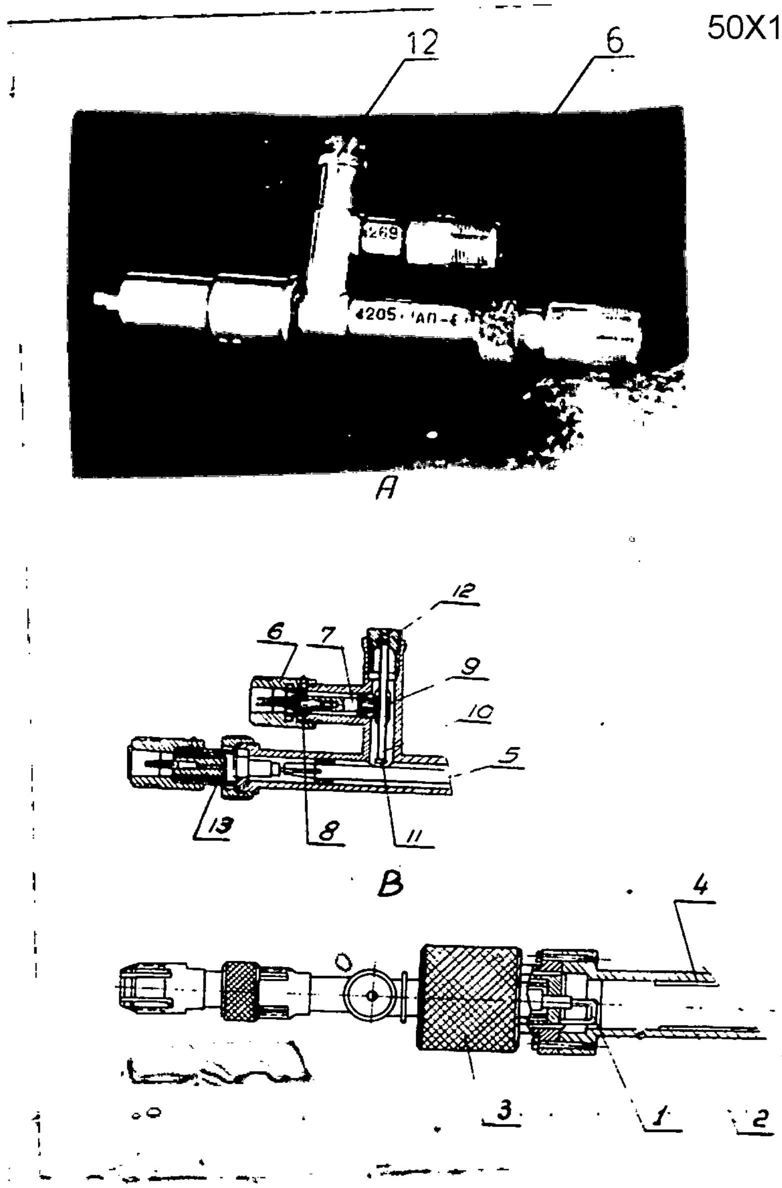

Fig 74. APCh (Automatic-Frequency-Control) Channel Mixer (p 168)

1. coupling loop
2. cylindrical tube
3. holder
4. attenuator
5. inside conductor
6. connector for voltage supply from local oscillator
7. inside plunger
8. space with absorbing layer
9. Tee
10. coupling rod
11. coupling-rod base
12. coupling-rod screw
13. $\frac{1}{4}$-wave filter

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The AFC Channel Mixer

The AFC-channel mixer (Figure 74) converts the high-frequency pulses (reaching its input from the transmitter and through an attenuator) into IF-pulses.

The AFC-mixer is a coaxial circuit containing a type DGS-detector. This circuit is linked by means of coupling loop 1 through attenuator 4 to the rectangular waveguide of the antenna switch. The attenuator is a (p 169) small cylindrical tube 2 soldered to the wide wall of the main waveguide of the antenna switch.

Optimum attenuation is achieved during complex tuning by moving the AFC-mixer and the coupling loop in an axial direction, thus increasing or decreasing signal attenuation. The position of the AFC-mixer is fixed by clamp 3 once the required attenuation is obtained.

For shorter waves corresponding to the higher harmonics (third and fifth) of the magnetron, the attenuator has less attenuation, and oscillations at these harmonics could burn out or damage the crystal upon striking it. This is prevented by the introduction of two plates 4 made of a high-loss material (pertinax with an absorbent layer) into the attenuator. The energy of the signal passing through the attenuator is picked up by the coupling loop and excites oscillations in the mixer circuit. Voltage is applied from the local oscillator through plug 6 to the coupler of the mixer.

The power applied to the AFC-mixer from the local oscillator is regulated by means of a special device. Inner rod 7 of the local-oscillator input to the mixer is connected through T-junction 9 to a movable rod 10 terminated with a cap 11. This cap, being at a great distance from inner conductor 5 of the mixer, forms a capacitive coupling. The gap between the cap and the inner conductor 5 may be adjusted by means of screw 12 (p 170) which is rigidly attached to rod 10. The position of the rod is fixed by a lock nut.

In the plug connector of the local-oscillator input of the mixer is a special gasket 8 with an absorbent layer. This gasket matches the input of the mixer to the wave impedance of the cable which brings energy from the local oscillator to the mixer.

IF-voltage is taken from the detector by a special plug connector. This connector has a quarter-wave filter 13 which does not pass high frequencies to the input of the AFC-circuit.

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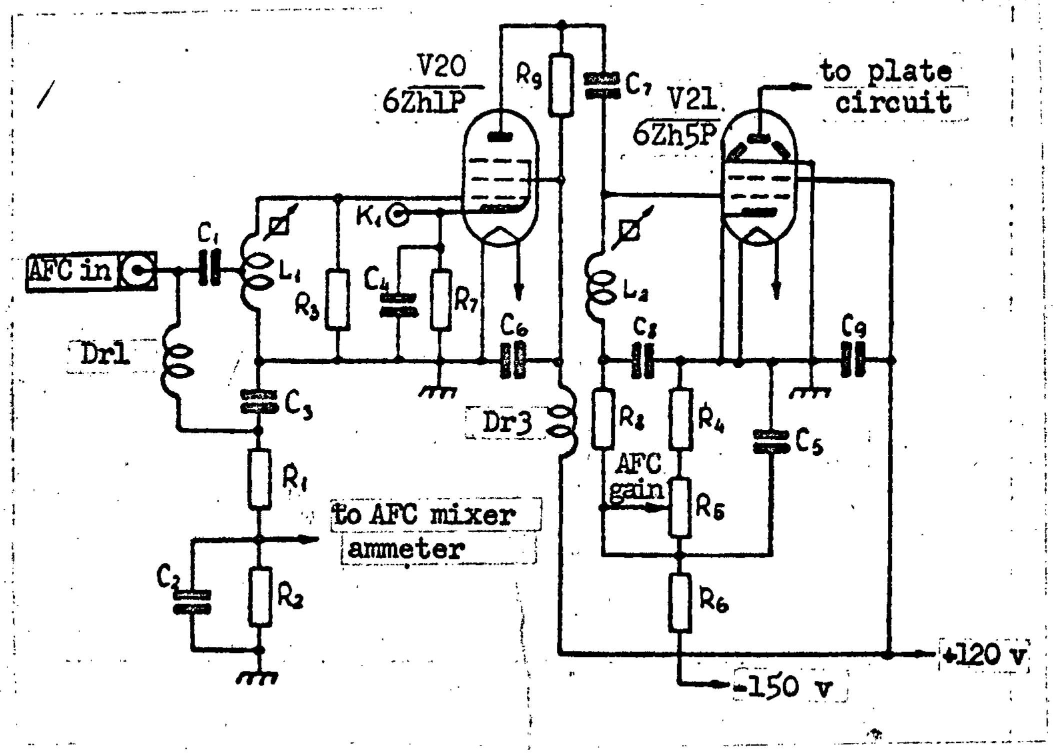

Fig 75. Diagram of Two IF-Amplifier Stages of an AFC Channel (p 171)

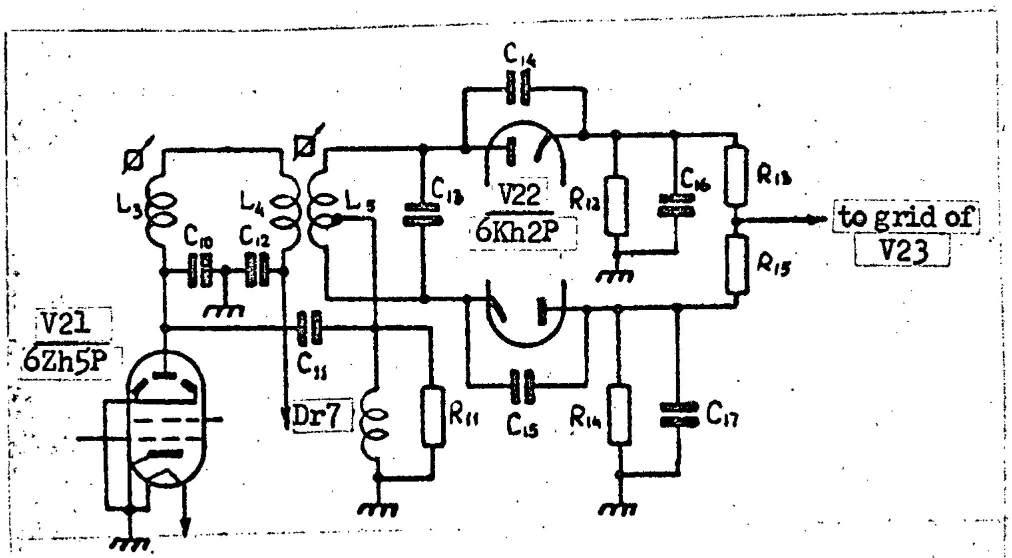

Fig 76. Diagram of the Discriminator (p 174)

IF-Amplifier of the AFC Channel

The voltage taken from the AFC mixer is sent by a short high-frequency cable RK-47 to the input plug of the AFC (Figure 75). The input circuit is in the form of an autotransformer circuit. The length of the cable and its connection to part of the coils of the input circuit are determined by the necessity for decreasing the capacity reaction of the cable to the circuit, which is necessary to permit tuning of the input circuit to the intermediate frequency.

Matching of the AFC-input circuit with the impedance of the AFC-mixer is not critical. The passband of the input circuit is widened by shunting the circuit with resistor R3.

Resistor R2 serves as a shunt for the meter in unit PRS-1 when measuring the AFC-mixer current. (p172)

The first stage of the IF-amplifier is based on a pentode circuit with tube 6Zh1P.

The second stage uses a 6Zh5P tube to provide the necessary gain.

A circuit formed by coil L2, the input and output capacitances of the tubes, and the capacitance of the wiring serves as the load for the first stage. Resistor R9 in the plate load of the first tube, which shunts this circuit, determines the gain of the stage and the frequency passband.

Bias at the control grid of the first stage is provided by a voltage drop across cathode resistor R7.

The second IF-amplification stage of the APCh-1 (AFC) block is loaded by a circuit connected to the discriminator.

A controlled negative bias is applied to the grid circuit of tube 6Zh5P to compensate aging of the tubes. The bias voltage is taken from potentiometer R5. Resistor R4 provides the necessary initial bias.

The circuits are tuned to a frequency of 30 mc. Their passband is determined by the operating characteristic of the discriminator.

The function of the remaining elements of the amplifier is the same as in the amplifiers of the UPCh-1 block.

The Discriminator

(p 173)

A circuit diagram of the discriminator is given in Figure 76. The discriminator is based on tube V22, type 6Kh2P.

The plate circuit of V21 consists of two series-connected inductance coils L3 and L4 capacitors C10 and C12, and the capacitance of 6Zh5P plus the wiring.

The discriminator circuit, consisting of coil L5 and capacitor C13, as well as of the capacitances of the diodes connected in series with it and capacitors C14, C15, C16, and C17, is inductively coupled with coil L4 of the plate circuit of 6Zh5P.

The inductance of the plate circuit is divided into two parts (L3 and L4) for the purpose of providing a sufficiently small coupling between the plate circuit and discriminator circuit. Hence, it is possible to place L4 and L5 on a single small frame.

The weak coupling between the plate circuit and the discriminator is necessary to avoid double-humped resonance curves in the coupling system.

The symmetry of the parameters of the arm of the discriminator has a particular influence on its operating quality. In order to achieve good symmetry, one half of coil L5 is wound between the turns of the other half of the winding.

Of no less influence on the operation of the discriminator is the symmetry of the diode loads and the capacitance of the diodes themselves. This is achieved in the above discriminator circuit by connecting addi- (p 175) tional capacitors C14 and C15 in parallel with the diodes of tube 6Kh2P and by individually grounding the loads of these diodes (which are also of identical value). For operation of the discriminator with both loads R12, C16 and R14, C17, which are connected to the chassis, the diodes are connected in series in the arm of the discriminator (one with the plate toward the circuit and the other with the cathode toward the circuit).

Choke Dr-7 permits passage of the d-c component of the diodes in the discriminator. Resistor R11 prevents impact excitation of the choke during pulse operation.

The middle point of the discriminator coil is connected through capacitor C11 to the plate of tube 6Zh5P.

A simplified equivalent circuit diagram of the discriminator (for high frequency operation) is given in Figure 77.

The voltage in each diode is made up of two components. One component is the voltage in the plate circuit U_I, and the second component is equal to half the voltage in the discriminator circuit. The values of load capacitors C16 and C17 are selected so that the voltage (in the operating frequency range) in the right electrodes (according to the circuit in Figure 77) of both discriminator diodes may be considered equal to zero

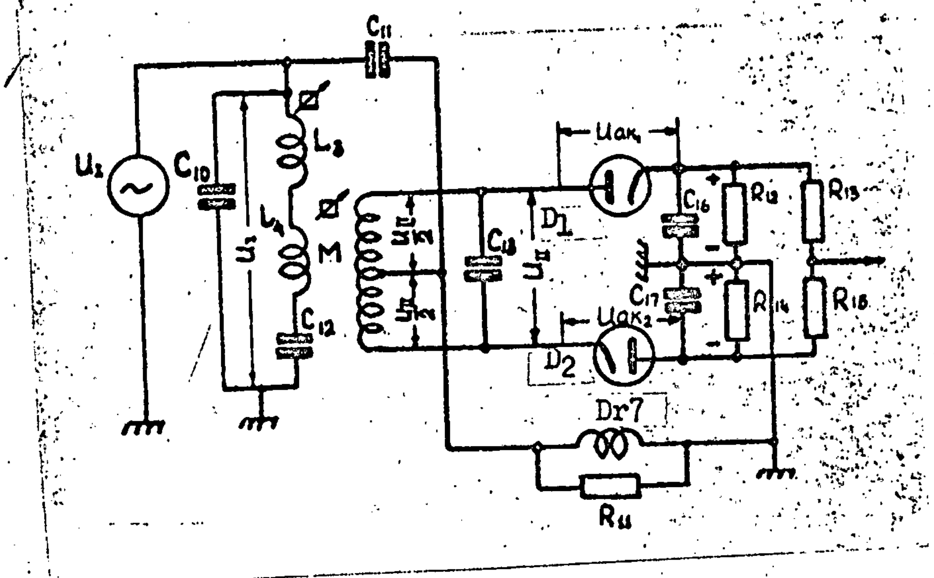

Fig 77. Equivalent Circuit Diagram of the Discriminator (for high frequency) (p 176)

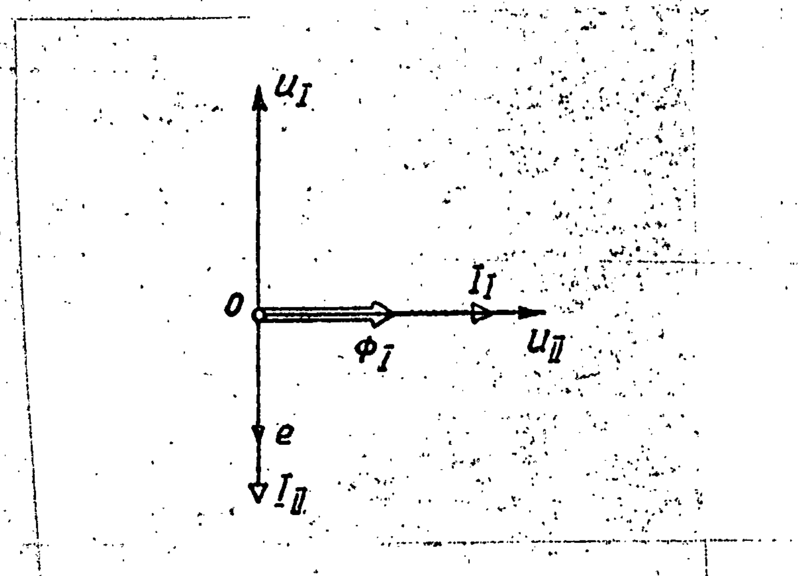

Fig 78. Vector Diagram of Currents and Voltages of a System of Two Inductively Coupled Circuits at Resonance Frequency (p 177)

In the coil of the plate circuit of 6Zh5P the phase of current I_I lags voltage U_I by approximately 90° (see the vector diagram in Figure 78). The magnetic flux vector Φ_I of the plate coil coincides in phase with current vector I_I./

The emf (e) induced in the coil of the second circuit lags the magnetic flux vector Φ_I by 90°. The current in the coil of the second circuit I_{II} coincides in phase with the induced emf. The voltage in the coil of the second circuit U_{II} leads the circuit current by 90°. and coincides in phase angle with current vector I_I. (p 178)

The vector diagram given in Figure 78 is valid only when both coupled circuits are resonance-tuned to the frequency of the signal.

It is seen from the vector diagram given in Figure 78 that the voltage induced at the resonant frequency in the discriminator circuit as a result of the inductive coupling between L4 and L5 lags the voltage in the plate circuit by 90°.

In view of the fact that voltage U_I is connected to the middle point of the coil of circuit L5, C13 and that the ends of coil L5 are connected to each of the diodes, the voltage in each diode will equal the vector which is the sum of the vectors of component voltages U_I and $\frac{U_{II}}{2}$. The vector diagram of voltages in the discriminator diodes during operation at the resonant frequency is given in Figure 79a.

Vectors Uak_1 and Uak_2 — the voltages between the plates and cathodes of the first and second diodes of the discriminator — are numerically equal when operating at the resonant frequency.

$$|\overline{U}ak_1| = |\overline{U}ak_2|$$

In this case the voltages rectified by the diodes at loads R12 and R13 are also equal in value. But, according to the circuit in which the diodes are connected, these voltages are opposite in sign. (p 180)

The output voltage of the discriminator, taken from the voltage divider consisting of two equal resistors R18 and R15, is equal to zero when the resonant frequency is applied to the discriminator.

When a signal at a frequency other than the resonant frequency is applied to the discriminator, the phase shift of vector U_{II} will change depending upon the frequency. As a result of the change inpphase shift of vectors $\frac{U_{II}}{2}$, the total voltage vectors in the diodes will also change both in direction as well as in value (see Figures 79b and 79c and Figure 80).

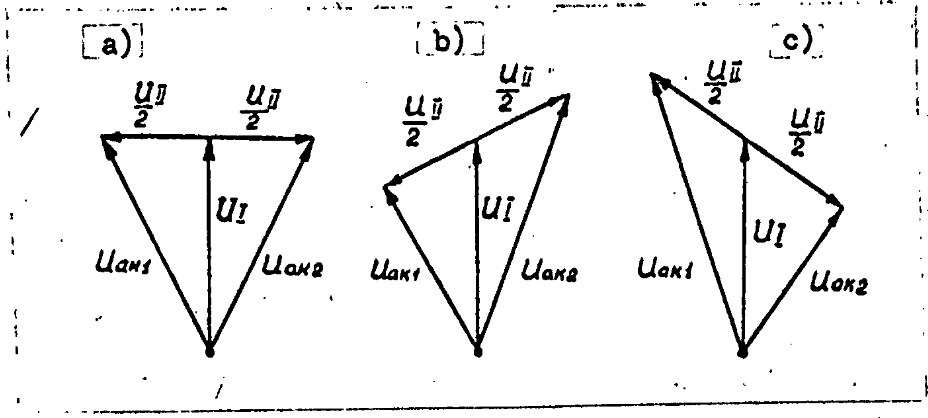

Fig 79. Vector Diagram of Discriminator Voltages (p 179)

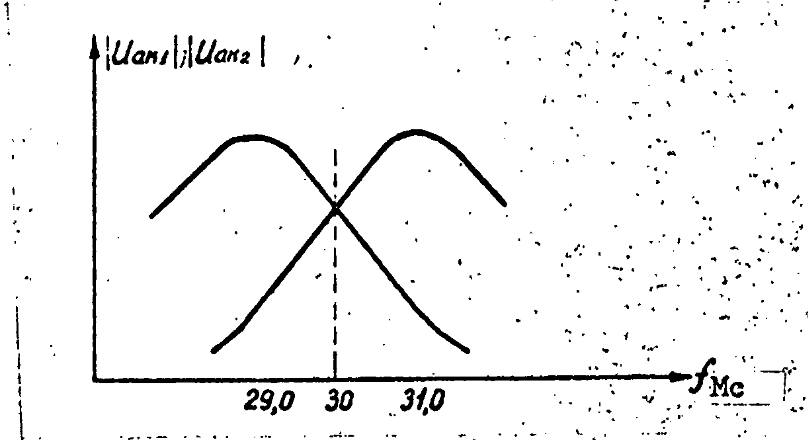

Fig 80. Voltage Variation at the Discriminator Diodes Depending on Signal Frequency (p 181)

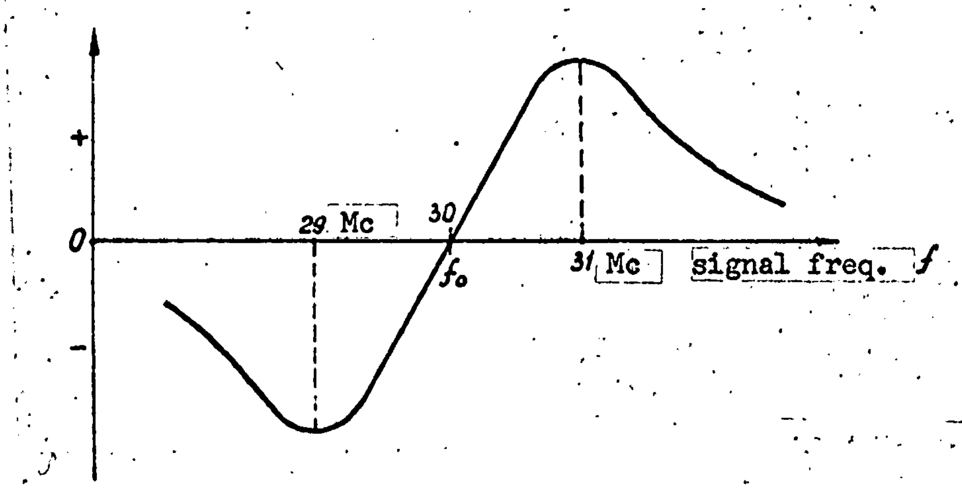

Fig 81. Frequency Characteristics of the Discriminator (p 182)

The voltages at the loads of the diodes will also change in accordance with changes in the amplitudes of vectors Uak_{I} and Uak_{II} for any departure from the resonant frequency.

The output voltage of the discriminator, which is the algebraic half-sum of the voltages at the loads of the diodes, changes in value and sign with changes in the frequency of the signal at the discriminator input, depending upon the magnitude and the side to which the frequency differs from the resonant frequency of the discriminator (usually called the "zero" point of the discriminator characteristic). The frequency characteristic of the discriminator is given in Figure 81.

As a consequence of the assymetry of the transmitter pulse and its frequency spectrum, two-polarity pulses will appear at the output of the discriminator when it operates in the pulse mode even when the discriminator (p 183) is completely balanced by precise tuning of the signal to the zero frequency of the discriminator characteristic.

The presence of two-polarity pulses at the output of the disciminator is unavoidable. The parameters of the discriminator circuit used in the network are such that they permit a sharp reduction in the amplitude of uncompensated residual pulses to a value which allows for sufficiently reliable operation of the automatic control system.

Two types of APCh-1 blocks are manufactured -- type "N" and type "V" -- which differ only in the polarity of the discriminator characteristic.

Type "V" blocks have a negative polarity hump in the discriminator characteristic at frequencies less than "zero" and a positive hump at frequencies above "zero."

The discriminator characteristic of type "N" blocks has the opposite polarity, as shown in Figure 82.

The video amplifier, which is based on 6Zh5P tube, connected after the discriminator, reverses the polarity of the pulses from the discriminator output.

The curves given in Figure 82 show the polarity and shape of the envelopes of pulses at the output of the discriminator ("discriminator pulses") and the output of the video amplifier ("AFC pulses") for type "V" and "N" blocks.

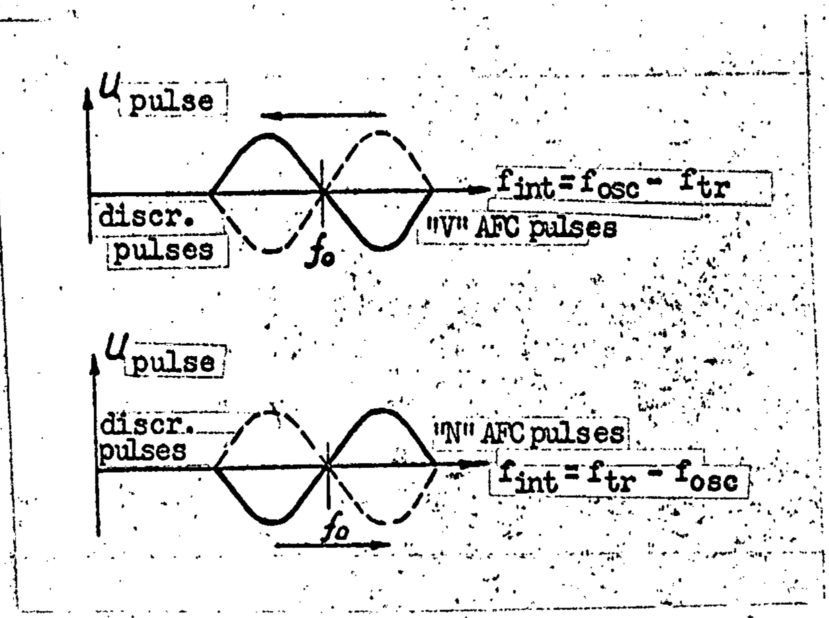

Fig 82. Discriminator Characteristics for Type "N" and "V" APCh-1 (AFC) Blocks (p 184)

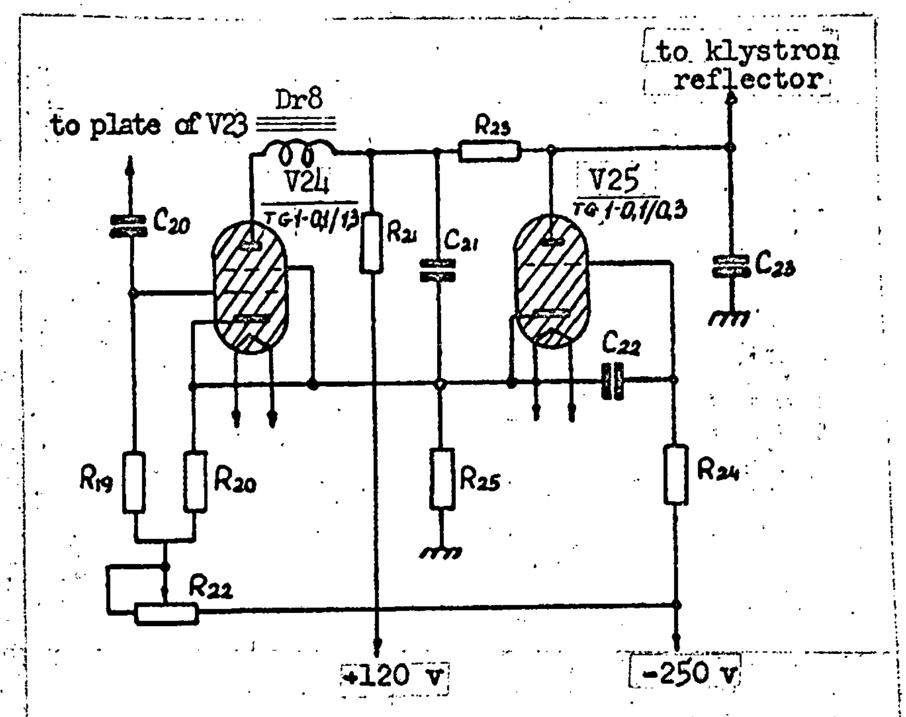

Fig 83. Thyratron Circuit (p 189)

 (p 185)

Frequency Characteristics of the Discriminator for Types "N" and "V" APCh-1 Blocks

The AFC-thyratron circuit is triggered by positive pulses at its input (the output of the video amplifier).

Therefore, the working pulses at the load of the discriminator must have negative polarity.

Normal operation of the receiver requires that the appearance of the positive AFC-pulse, when operating with the AFC-circuit, coincide with the intermediate frequency, which is near the zero point of the discriminator characteristic.

For the first and second channels, where the local-oscillator frequency f_{osc} is less than the transmitter frequency f_{tr} (see Table 2), the intermediate frequency.

$$f_{int} = f_{tr} - f_{osc} ,$$

and for the third, fourth, fifth, and sixth channels, where the local-oscillator frequency is greater than the frequency of the transmitter,

$$f_{int} = f_{osc} - f_{tr} .$$

When the search generator of the AFC-circuit is operating, the frequency of the local oscillator changes, thus changing the intermediate frequency at the same time. Figure 84 shows a graph of the voltage change at the reflector.

When the search generator is operating, the value of the negative voltage U_{ref} drops, causing a drop in the frequency of the local oscillator.

When the transmitters of the first and second channels are operating, (p 186) a drop in frequency of the local oscillator causes an increase in the intermediate frequency at the discriminator input, and when the third, fourth, fifth, and sixth channels are operating, the intermediate frequency decreases, as shown in Figure 82 by the arrows.

When the above conditions are satisfied, there should first appear negative AFC-pulses and then positive pulses. Therefore, the characteristics of discriminators for type "N" and "V" AFC blocks have the shape shown in Figure 82.

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AFC-Pulse-Circuit Amplifier

The output voltage of the discriminator is applied directly to the grid of tube V23 (see schematic diagram), so that the load of the discriminator is, at the same time, the grid leakage resistance of the amplifier. The pulse amplifier amplifies the signals to the level required for normal operation of the tracking stage and is built around a 6Zh5P tube.

Resistors R16 and R18 serve as the load of the tube. The gain provided by this stage is approximately 80. Voltage from part of the load (resistor R18) is applied through coupling capacitor C18 to the test jack "AFC-Pulse."

The initial bias of the tube is selected so as to provide undistorted amplification of the pulses of operating polarity (negative at the grid of 6Zh5P).

The Thyratron Circuit (p 187)

The thyratron circuit comprises a tracking stage using control tube TG1-0.1/1.3 and a search stage using tube TG1-0.1/0.3 (Figure 83).

A voltage of -250 v is applied to a voltage divider consisting of resistors R22, R20, and R25. The voltage drop across resistor R25 is approximately 230 v. The cathodes of both thyratrons V24 and V25 are connected to this resistor.

The voltage drop across resistor R20, equal to 9+10 v, is applied through resistor R19 to the control grid of thyratron V24 of the tracking stage and creates a negative bias at the grid with respect to the cathode which keeps the thyratron in a cutoff condition.

A bias equal to the voltage drop across resistors R20 and R22 is applied through resistor R24 to the grid of thyratron V25 of the search stage. Changing the value of resistor R22 changes the bias and, thus, the firing potential of the search-stage thyratron.

The Search Mode

The search mode is that mode of operation of the AFC-circuit in which the voltage at the reflector plate of the klystron changes periodically within wide limits and, accordingly, the frequency of the klystron changes within the range of generation.

The bias of thyratron V25 is selected so that when the voltage between the plate and cathode equals 170 v (corresponding to a plate potential of -60 v relative to ground), the thyratron fires and begins to conduct current. The thyratron remains open until the plate voltage ap[redacted] the voltage of the cathode. While the thyratron is open, almost all the plate voltage (+ 120 v) flows through resistors R21 and R23. (p 190)

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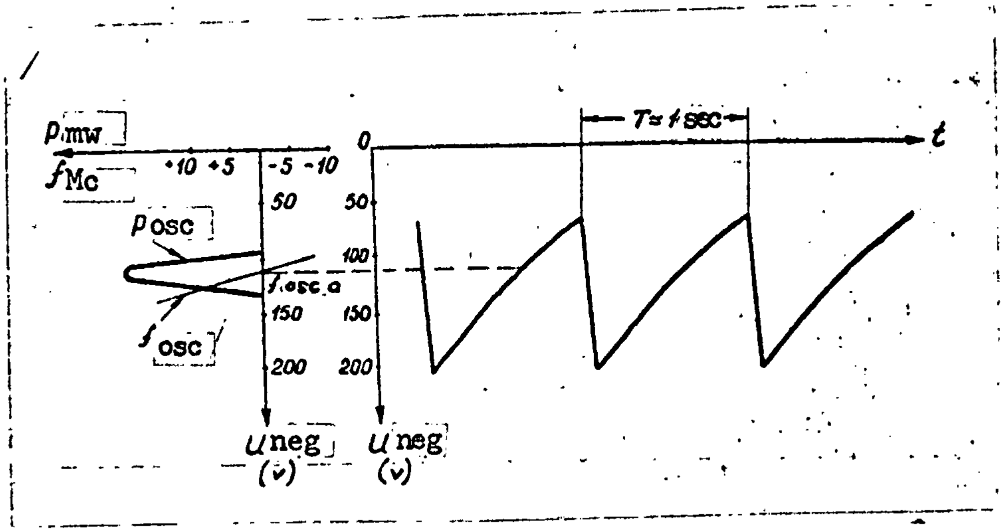

Fig 84. Search-Mode Voltage Changes at the Impeller Causing a Change of Local Oscillator Frequency (p 188)

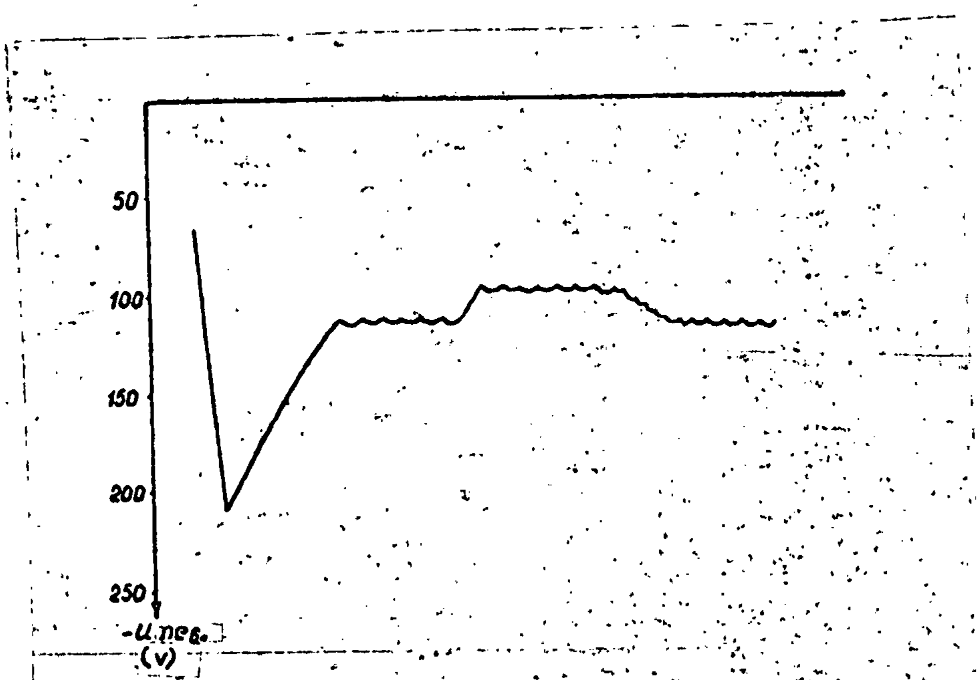

Fig 85. Voltage at AFC Output in Tracking Mode (p 194)

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The change in plate potential during the conducting period occurs as a result of the rapid recharging of capacitor C23 through the small resistance of the thyratron from the negative cathode voltage source.

Capacitor C22 is charged to a voltage of -210 v. This voltage is less than the cathode-to-ground voltage by an amount equal to the voltage drop in the thyratron (15 v). At the end of recharging, the thyratron is quenched, and capacitor C23 again begins to recharge from the +120 v source through resistors R21 and R23. The voltage at the plate begins to increase to +120 v.

Recharging continues until the voltage in capacitor C23 reaches the firing potential, at which time the entire cycle is repeated.

The time constant of the circuit consisting of resistors R21 and R23 and capacitor C23 is such that each cycle lasts approximately one second.

Thus, a sawtooth voltage which changes from -210 v to -60 v is applied to the repeller electrode of the thyratron in the search mode, as shown in Figure 84. (p 191)

This cycle of the search mode is repeated until thyratron V24 (Figure 83) opens, and operation of the AFC-circuit switches to the tracking mode.

As was noted above, it is desirable that klystron K-11 operate in the second region of generation (where it provides the greatest power).

In order to avoid the possibility of the klystron operating in a region where it provides less power, the firing potential of thyratron V25 is fixed during factory adjustment so that the voltage of the search generator does not reach those values in which this region is located.

The Tracking Mode

The tracking mode is that mode of operation of the AFC circuit in which the voltage at the reflector plate of the klystron is automatically maintained at a level where the difference between the frequencies of the transmitter and the local oscillator remain approximately equal to the intermediate frequency. A positive pulse is applied to the grid of the tracking-stage thyratron V24 as a result of the operation of the search generator and the discriminator circuit. The thyratron opens (when the firing pulse is sufficient) and conducts current until its plate voltage reaches the potential of the cathode.

While tube V24 is open, a voltage of +120 v flows, for the most part, through resistor R21, and capacitor C21 is recharged through the tube to the potential of the cathode (-120 v). (p 192)

Thyratron V24 is quenched at the end of recharging. Since the potential in capacitor C21 after firing of V24 is more negative than in capacitor C23, the charging voltage of capacitor C23 changes.

In the beginning, capacitor C21 charges capacitor C23 with a negative charge, and the voltage in it, as well as in the reflector, will drop (will become more negative).

As capacitor C21 rapidly discharges from the +120-v source (C21, R21 having a small time constant), the decrease in voltage in capacitor C23 is delayed and, at a certain moment, begins to increase, because it is charged from the same +120 v source.

The speed of charging of capacitors C21 and C23 determines the law of change of the voltage at the reflector in the tracking mode.

The initial voltage drop in capacitor C23 results in the intermediate frequency becoming greater than 30 mc, and negative pulses again pass to the grid of tube V24.

The increase in voltage at the reflector continues until the intermediate frequency again passes through a value of 30 mc. Then tube V24 will again receive a positive pulse, fire, and repeat the process once more.

A diagram of voltage changes at the klystron reflector during operation of the thyratron circuit in the tracking mode is shown in Figure 85. (p 193) This oscillogram may be seen at the output of the AFC-circuit.

Voltage fluctuations at the reflector during tracking cause changes in the intermediate frequency within limits of ±100 kc.

This occurs after every three-four pulses of the transmitter (Figure 86) when thyratron V23 (Figure 83) is operating in a steady-state tracking mode, as may be seen at the test jack "AFC-Pulse."

If the frequency of the transmitter drops slightly, the frequency of the local oscillator must also drop in order to obtain an intermediate frequency of 30 mc; that is, it is necessary that the voltage at the reflector become more positive. This is performed automatically.

If, when the transmitter frequency drops, the intermediate frequency first becomes greater than 30 mc, a positive pulse will appear at the output of the discriminator. Consequently, negative pulses will pass to the grid of thyratron V24 (Figure 83) and it will not fire. During this time, capacitor C23 will continue to charge from the -120-v source and the voltage in it, and, hence, in the reflector, will become more positive, as seen in Figure 85 (section ab). Charging continues until the frequency of the local oscillator again reaches a value at which the intermediate frequency will pass through a value of 30 mc. Then the tracking process will proceed in the usual manner.

If the frequency of the transmitter increases, the voltage at the klystron reflector must become more negative in order that the frequency of the local oscillator also increase to produce an intermediate frequency of 30 mc. (p 196)

Since in this case the intermediate frequency at first becomes less than 30 mc, negative pulses appear at the output of the discriminator and positive pulses flow to the grid of thyratron V24 (Figure 83) and trigger it.

After each pulse, capacitor C21 recharges to a voltage of -210 v. Thus, capacitor C21 recharges capacitor C23 more often than in the normal operating mode, and the latter assumes a more negative potential (Figure 85, sector cd).

As a result, the frequency of the local oscillator increases. When the intermediate frequency slightly exceeds a value of 30 mc, negative pulses flow to the grid of the tracking thyratron and the process proceeds as usual.

Manual Frequency Control

Tuning the klystron and checking the operation of the AFC-circuit require that the voltage at the reflector of the klystron be changed slowly. This adjustment is accomplished with a potentiometer located on the control panel of unit PRS-1 at the position of the "Manual" frequency-adjustment switch.

With the transmitter on, the pulses observed at the output of the video amplifier of the AFC-circuit ("AFC-Pulse" jack) will first be negative and then positive if the shaft of the potentiometer is (p 197) turned in a clockwise direction (Figure 87). The law of voltage change at the reflector in this case will be the same as when operating the AFC-circuit in the search mode.

4. Common Circuits of the Receiver

The control and monitoring circuits and the power supply circuit are the common circuits of the receiver.

Control and Monitoring Panel

The control and monitoring panel (see schematic diagram) is used to establish and monitor the operating mode of tube UV-1 [UVCh-1 ?], as well as to monitor the crystal-mixer currents, the voltage at the detector, and the supply voltages of the receiver.

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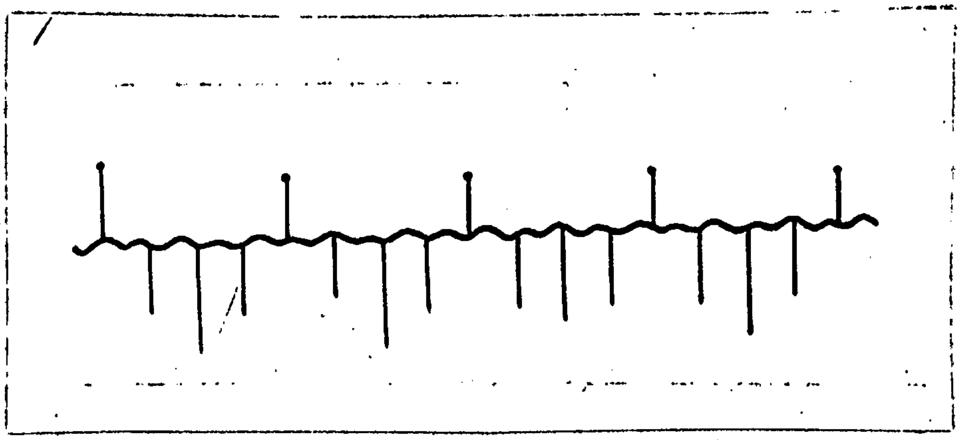

Fig 86. AFC Pulses in the Tracking Mode (p 195)

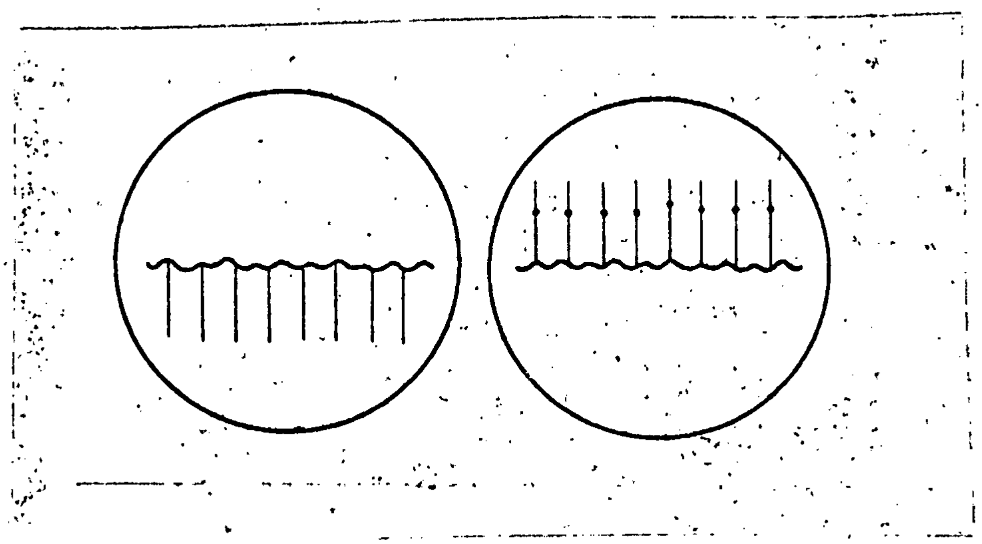

Fig 87. AFC Pulses During Manual Adjustment of the Local Oscillator Frequency (p 198)

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The operating mode of the traveling-wave tube is adjusted by potentiometers R8, R13, R15, and R63.

The current in the solenoid of the tube is adjusted with resistor R5, located in unit PRS-1 near relay RA-1. The solenoid current is adjusted at the factory and when UVCh-1 or the diodes which supply the solenoid are replaced.

Resistors R73, R74, and R75 in the -250-v circuit are used to apply a manual-frequency-control voltage from -250 to -50 v to the klystron reflector, at the same time maintaining operation of the klystron within the limits of one region of generation. (p 199)

Resistor R72, connected between the klystron resonator and the + 300 v circuit, is a voltage-dropping resistor. The voltage drop across this resistor is equal to approximately 50 v as a result of the klystron current flowing through it.

The manual-gain-control voltage is taken from potentiometer R77, which is connected through resistor R78 to the -150-v circuit. Resistor R79 improves the smoothness of adjustment.

The monitoring circuit uses a 100-microamp instrument IP1, type M-484, which has been reconnected for 125 microamps, 100 mv. The instrument is connected to different circuits by means of two three-wafer switches (V2 and V3) with 10 and 7 positions, respectively. The designations of the positions of each switch are shown in the schematic diagram and on the control panel of unit PRS-1.

Dividers consisting of range multipliers and wire shunts are used in the +300, +120, and -250 v measuring circuits to drop the voltage at the contacts of switch V5. The range multipliers limit the current through the measurement circuits. The shunt resistances provide the necessary limits and measurement accuracy for the instrument.

Measuring transformer Tr5, used for measurements of the traveling-wave tube filament circuit and the filament circuits of the remaining tubes, permits the presence of up to 35 v at the input of the tube voltmeter (with resistors R54 and R55), which is sufficient for operating the voltmeter under linear conditions and providing high measurement accuracy (p 200) of the filaments.

The tube-voltmeter circuit for the filament circuits includes a type 8Kh2P twin diode which rectifies the a-c voltage.

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Parameters Measured With Instrument IP1

Parameter	Position of switch V2 "Receiver Mode Monitor"	Position of Switch V3 "TW Tube Mode Monitor"	Rated Value	Scale	Measure. accuracy
1	2	3	4	5	6
Voltage -250v	3	any	250v	red sector	10%
Voltage +120v	4	any	120v	"	10%
Voltage +300v	5	any	300v	500v(IV)	100%
Filament volt. of tubes	6	any except 2 (TW filament)	6.3	red line	±5%
Volt. at output of detect.	7	any	0÷5v	5v (IV-100)	10%
Signal mixer current	8	any	0.2ma	blue sector	10%
AFC mixer current	9	any	0.6ma	"	10%
TW tube solenoid current	11 (TW circuit monitor)	5	6÷8a	10a(V)	5%
TW tube filament voltage	"	6	2.1÷2.9	3V(I)	0.05v
Voltage at TW control elect.	"	7	0÷25v	25v(II)	3%
Voltage at 1st plate TW tube	"	8	0÷100v	125v (III)	3%
Current at 2nd plate TW tube	"	9	0÷10μa	500μa (IV)	3%
Collec. current TW tube	"	10	to 500μa	500μa (IV)	3%
Voltage at 2nd plate (TW helix)	"	11	to 300v	500v (IV)	3%

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The d-c components of the initial diode current are mutually equalized by connecting the diodes in opposition.

Depending upon the position of the switches, instrument IP1 is used as a d-c or a-c voltmeter, milliammeter, microammeter, and ammeter.

Measurement accuracy in the circuit is determined by the accuracy of instrument IP1 as well as the precision of the range multipliers and shunts.

Table 3 gives the parameters measured with instrument IP1.

In order to avoid disturbing the parameters of the voltmeter when taking measurements in the circuits of the tube and traveling-wave tube filaments, two potentiometers R52 and R54 are connected into the circuit with which the readings of instrument IP-1 (at 6.3 and 2.6-volt points) are factory set according to a standard meter.

Switches V2 and V3 make it possible to use instrument IP-1 for all necessary measurements of the receiver operating modes. (p 202)

Switch V9 switches the operating mode from local gain control of the IF amplifier to remote control.

The neon lamps located near the safety fuses light when the fuses burn out.

Lamps NL4 and NL5 are used to monitor switching-on of the traveling-wave tube circuits and the common receiver circuits.

Incandescent lamp LN-1 ("Solenoid Supply") signals the burning out of 10-amp fuse Pr5 in the solenoid power supply circuit of UVCh-1.

Only lamps NL4 and NL5 should be on when the receiver is operating normally.

Glowing of the remaining lamps is an indication of faulty operation of the corresponding power supply circuits.

Switch V1 ("V.N. [rectified voltage] Common") switches on the +300, +120, -250, -150, and +26-v rectifiers, while switch V5 ("V.N. TW Tube") applies rectified voltages of +300 and -150 v to the operating-mode control circuit of the traveling-wave tube.

The tube filaments are turned on simultaneously with the application of the line voltage to the power plug of unit PRS-1, while the filament voltage is somewhat reduced before switch V1 (V.N. Common) is switched on.

On the control desk is a test jack to which a portable instrument, similar to the one located in unit PRS-1, may be connected. The portable instrument is used to monitor the power supply in the event of a malfunction of the main instrument, as well as when it is necessary to observe these conditions at a distance from the receiver. (p 203)

Power-Supply Circuit

Technical Data

The power-supply circuit provides the following voltages:

a) a stabilized voltage of -250 v at a load current of 15 ma; voltage stability is within 1% at load drops from 15 ma to zero and network voltage fluctuations of ± 5%; voltage fluctuations not more than 0.03%; internal resistance is not more than 10 ohms;

b) a stabilized voltage of +300 v at a load current of 80 ma; voltage stability (with load drops from 80 ma to zero and network voltage fluctuations of ±5%) is not worse than 1.6%; voltage fluctuations are not more then 0.02%; internal resistance is not more than 5 ohms.

c) a stabilized voltage of +120 v at a load current of 95 ma; voltage stability (with load drops from 95 to 40 ma and network voltage fluctuations of ± 5%) is not worse than 2%; voltage fluctuations not more than 0.02%; internal resistance is not more than 15 ohms;

d) a stabilized voltage of -150 v at a load current of 20 ma; voltage stability with network voltage fluctuations of ±5% is not worse than 0.5%; voltage fluctuations do not exceed 0.01% (p 204)

e) three stabilized filament voltages:

-- 6.5 v at a load current of 6 a;
-- 6.3 v at a load current of 1.3 a;
-- 4.2 v at a load current of 1.0 a.

f) stability of the filament voltage with a rated load and network voltage fluctuations of ± 5% is not worse than 1%.

A functional diagram of the receiver power supply is give[n in] Figure 88.

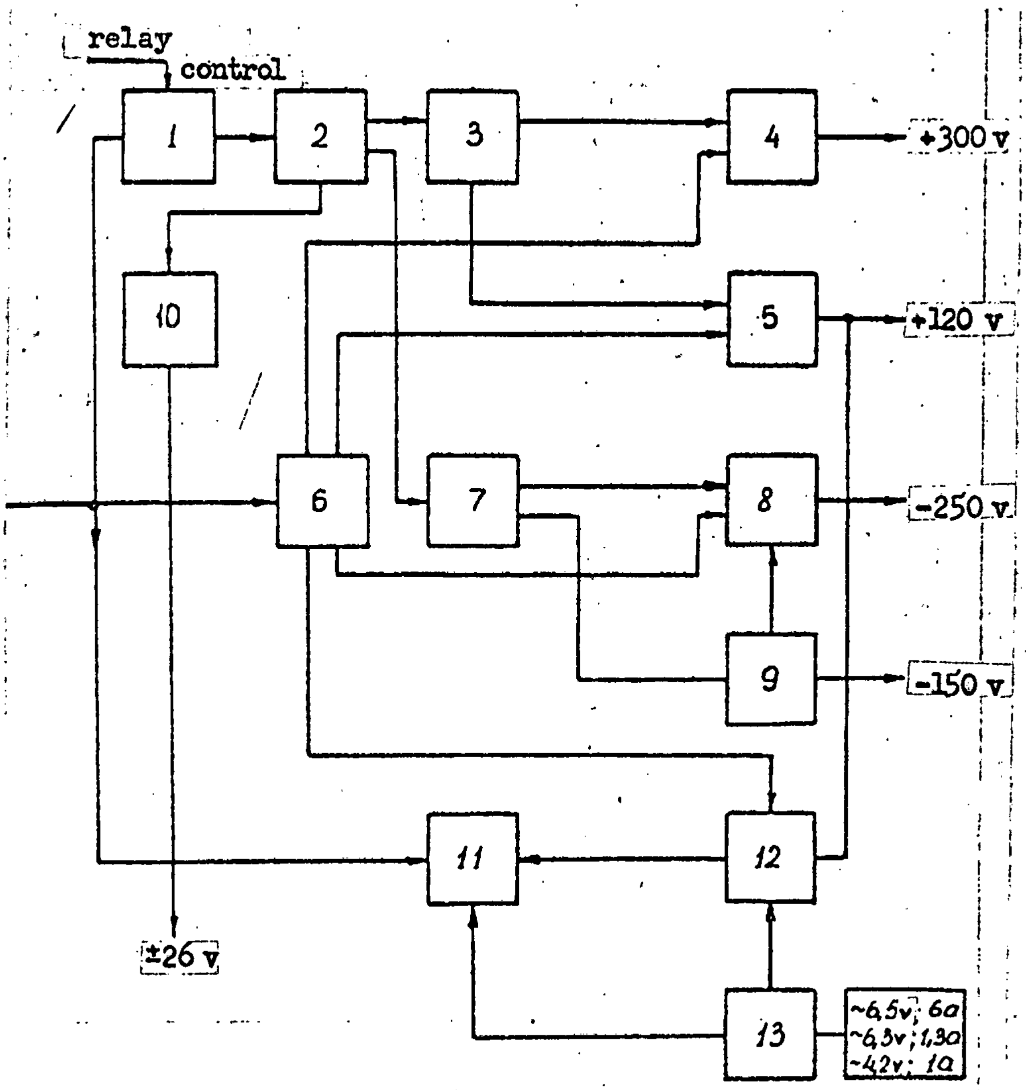

Fig 88. Functional Diagram of Receiver Power Supply (p 205)

1. AC relay, type RA-1
2. transformer for rectifiers
3. +300-v and --120-v rectifier
4. +300-v electronic stabilizer
5. +120-v electronic stabilizer
6. filament transformer for electronic stabilizers
7. -250 and -150-v rectifier
8. -250-v electronic stabilizer
9. source of reference voltage of the -250-v circuit and of the output voltage of the -150-v circuit
10. plus-minus-26-v rectifier
11. saturable coil
12. electronic filament stabilizer
13. stabilized-filament transformer

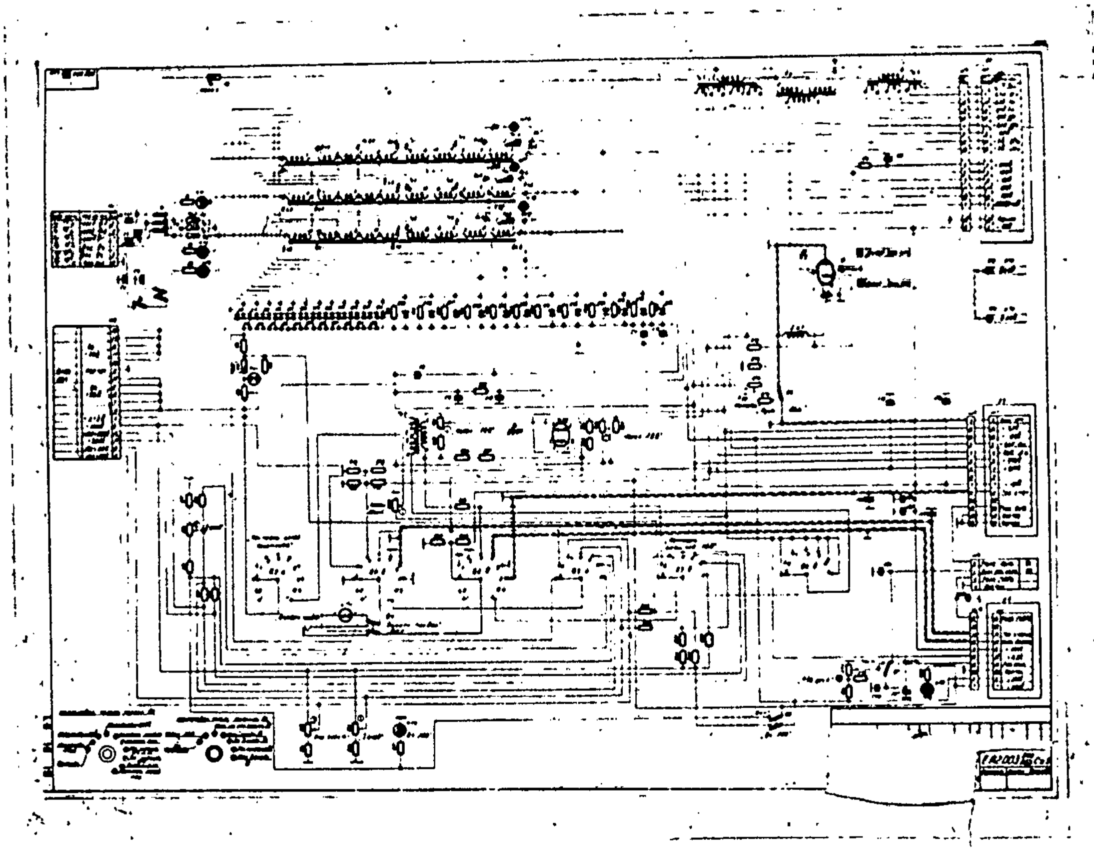

Fig 89. Schematic Diagram of the Control Desk and Power Sources for the Receiver (p 206)

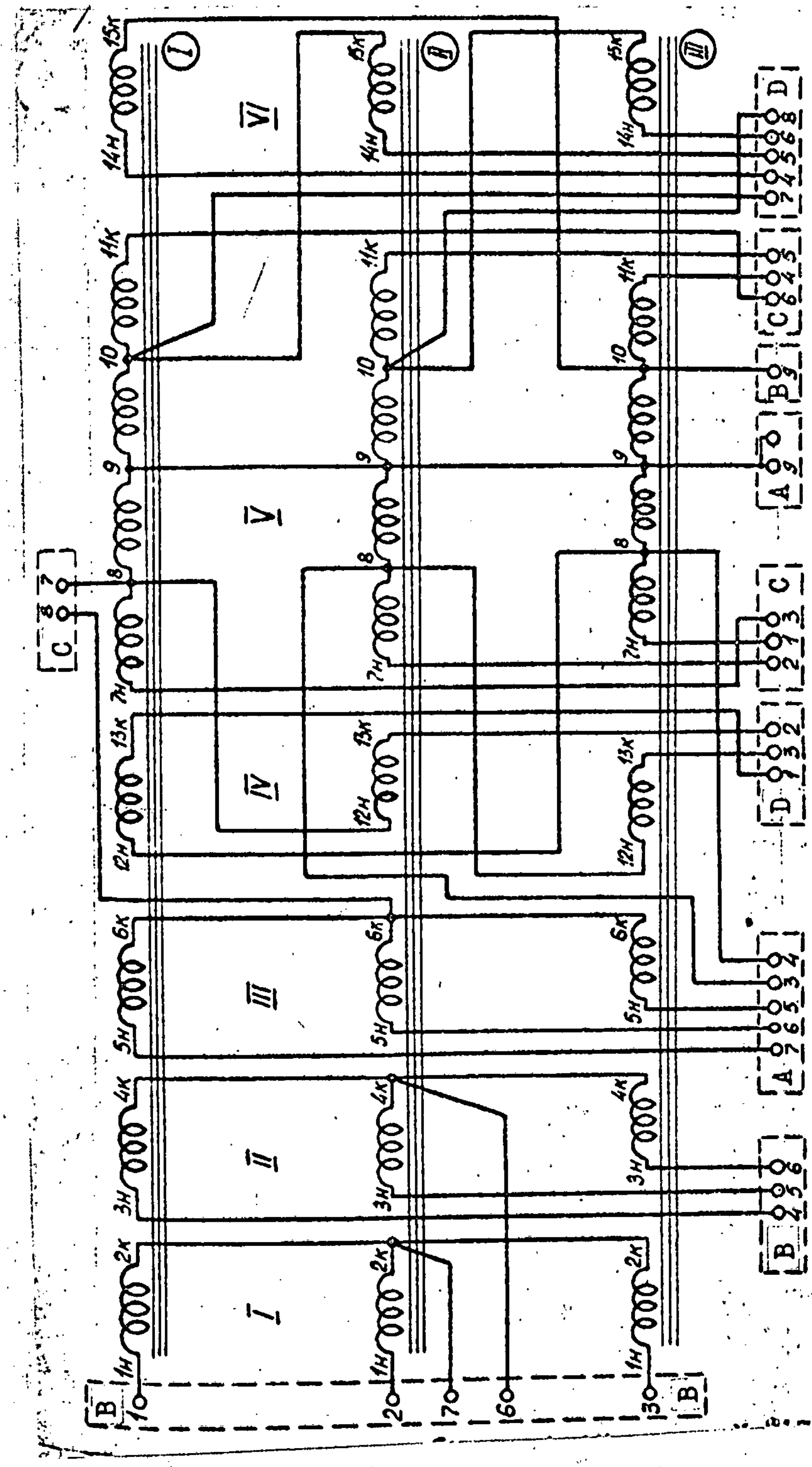

Fig 90. Schematic Diagramof the Tr-1 Transformer

(p 207)

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Schematic Diagram of the Receiver Power Supply

A schematic diagram of the receiver power supply is given in Figure 89.

A three-phase, 220-v, 50-cps voltage is applied to plug connector Sh1 (contacts 3, 5, 7) from unit PS and from there to the primary contacts of relay RA-1, to the primary winding of filament transformer Tr4, and to the primary winding of Tr3 which is connected in series with Dr1.

The rectifiers are supplied from the secondary windings of three-phase transformer Tr1, the primary winding of which is supplied from the 220-v 50 cps network, through the contacts of relay RA-1.

As seen in Figure 90, the transformer has five secondary windings for supplying the rectifiers:

winding II -- 300 v (120 v) (p 208)

winding III -- 250 v (-150 v)

windings IV, V, VI -- $\pm$26 v.

Local switching-off of the rectified voltage of unit PRS-1 is accomplished by means of switch VI which breaks the coil circuit of relay RA-1.

The +300-v and +120-v Rectifier

The +300-v and +120-v rectifier (Figure 91a) is designed on a six-phase circuit and is supplied from winding II of transformer Tr-1. Type D-211 silicon diodes are used as the rectifier valves.

One resistance-shunted valve is used in each phase. A filter consisting of two capacitors C11 and C12 with a total capacitance of 14 μf is used to smooth pulsations at the rectifier output.

From the filter output the rectified voltage is applied to a +300-v electronic stabilizer and through voltage-dropping resistor R71 to a +120-v electronic stabilizer.

The +300-v and +120-v Electronic Stabilizer

The +300-v electronic stabilizer is designed as a circuit with series-connected control elements connected to the load circu50X1-HUM stabilizer circuit is shown in Figure 91b.

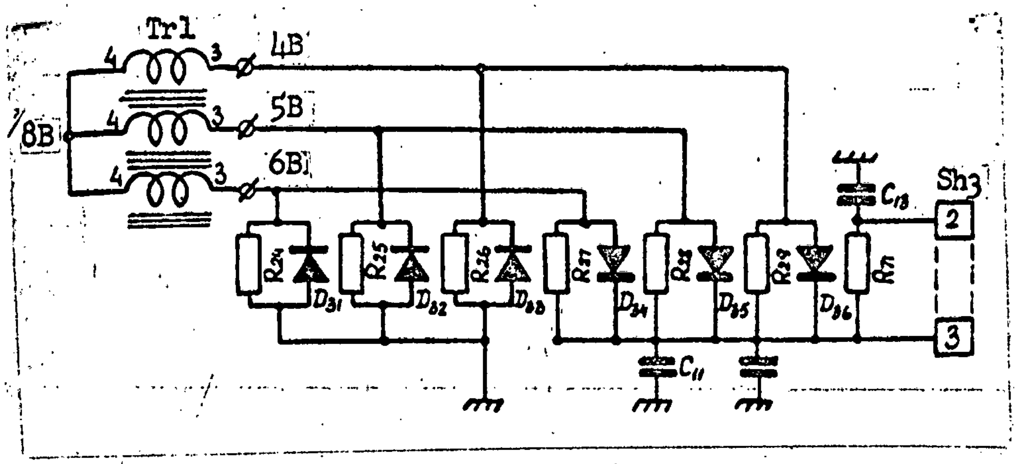

Fig 91a. Diagram of the +300-v and +120-v Rectifier (p 209)

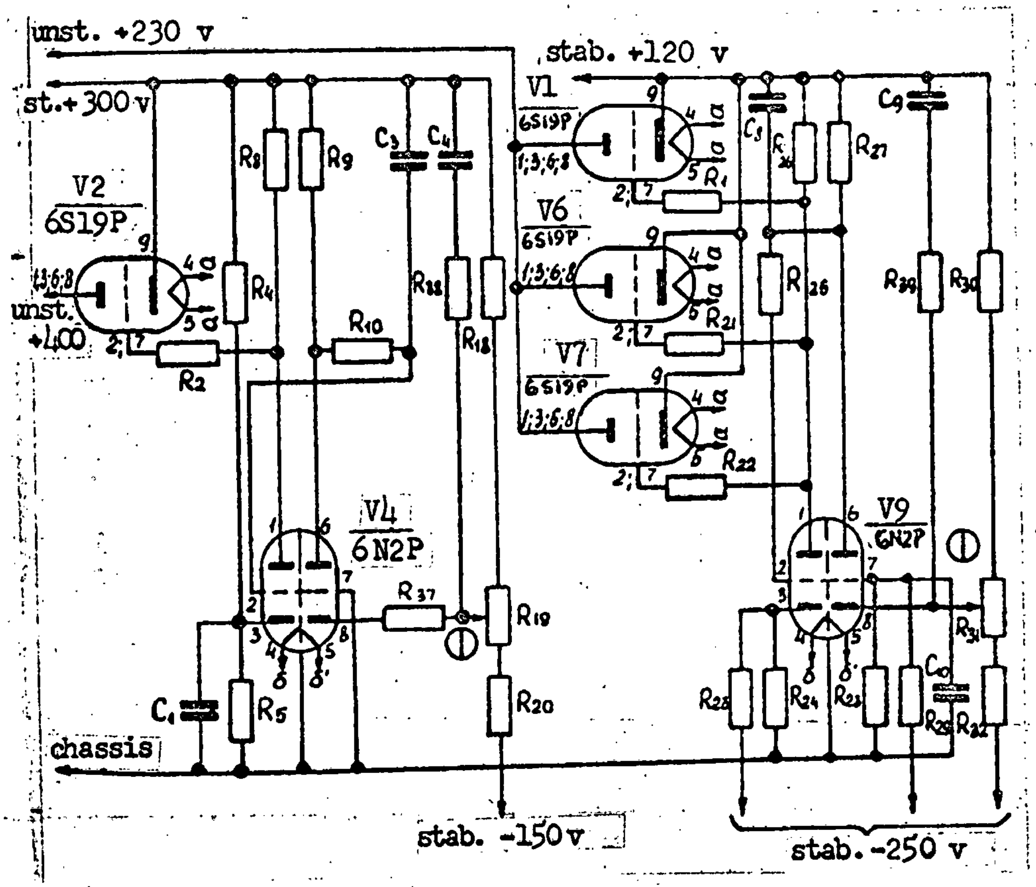

Fig 91b. Diagram of +300-v and +-120-v Electronic Stabilizer (p 209)

Tube V2, type 6S19P, is used as the regulating stage. (p.210)

The grid circuit of this triode is connected through grid suppressor R1 [?], R2 to the plate of the left triode of V4 of the control stage.

The cathode of this triode serves as the output of the + 300-v electronic stabilizer.

A control element with two amplification stages (twin triode V4, type 6N2P) is used to obtain high stability.

Resistor R8 serves as the plate load of the left triode.

The control grid for the left triode is connected to the plate of the right triode through grid suppressor R10. The cathode of the left triode is connected to the middle point of divider R4, R5, which is connected to the output of the +300-v electronic stabilizer.

Resistor R9 serves as the plate load of the right triode.

The control grid of the right triode is connected to the chassis. The cathode of the right triode is connected through resistor R37 to divider R18, R19, R20, one end of which is connected to the +300-v circuit and the other end to the -150-v reference voltage.

The stabilization circuit operates as follows. With a change (for example, increase) in the voltage at the output of the electronic stabilizer as a result of an increase in the voltage at its input or a drop in load current, the voltage applied to the input of the control system (the cathode of the right triode of V4) increases. This change (p 211) in voltage is amplified by the two-stage amplifier and is applied in opposite phase to the grid of the regulating element (tube V2). The internal resistance of the regulating element increases, increasing the voltage drop in the element, and compensates for the increase in output voltage.

The efficiency of the stabilization circuit during rapid changes in output voltage is increased by the presence of capacitors C3 and C4 which smooth pulsations of the output voltage, since any rapid change in voltage is applied directly to the grids of the amplifiers of the control element.

The +120-v electronic stabilizer is a circuit with a series-connected regulating element and two-stage amplifying element. A stabilized voltage of -250 v is used as the reference voltage.

Three parallel-connected tubes V1, V6, and V7 (type 6S19P) are used as the regulating stage.

A rectified voltage of approximately 240-v is applied to the plates of regulating tubes V1, V6, and V7 through voltage-dropping resistor R71 of the supply circuit; one end of the resistor is connected to the positive pole of the +400-v rectifier, which simultaneously supplies the +300-v electronic stabilizer, and the other end is connected to capacitor C13 which, with resistor R71, forms the smoothing filter.

The cathodes of regulating tubes V1, V6, and V7 serve as the output of the electronic stabilizer. (p 212)

The control stage of the electronic stabilizer uses a twin triode 6N2P, tube V9.

Resistor R26 is the plate load of the left triode. The control grid of the left triode is connected to the plate of the right triode through grid suppressor R25. The cathode of the left triode is connected to the middle point of divider R23, R24, which is connected to the -250 volt circuit.

Resistor R27, connected to the +120-v source, serves as the plate load of the right triode.

The control grid of the right triode is connected to resistors R28 and R29. The cathode of the right triode is connected to divider R30, R31, R32, which is connected to the -250 and +120-v sources.

The plate of the left triode is connected through grid suppressors R1, R21, R22 to the grids of regulating tubes V1, V6, and V7.

A high-resistance divider consisting of resistors R30 and R32 and potentiometer R31, the cursor of which is connected to the cathode of the right triode of V9, is used to regulate the stabilized output voltage.

Capacitor C8, which prevents excitation of the circuit from the side of the control stage and decreases pulsations of the +120-v circuit, is connected in the control grid circuit of the left triode of V9.

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The -250-v and -150-v Rectifier (p 213)

The rectifier (Figure 92) is based on a 6-phase circuit. Type D-211 diodes are used as the rectifier valves.

The rectifier is supplied from winding III of three-phase transformer Tr1.

The negative pole of the rectifier is the -250-v output.

The positive voltage of the rectifier is applied to the -250-v electronic stabilizer.

Capacitors C7, C8, and C9 are connected at the output of the rectifier for the purpose of smoothing the pulsations of the rectified voltage.

Voltage at the rectifier output is equal to approximately 340 v.

The -250-v electronic stabilizer is based on a circuit similar to that of the 300-v stabilizer, the difference being opposite polarity at the stabilizer output.

The positive pole of the stabilizer is connected to the chassis. The negative voltage of the stabilizer is used to supply the receiver circuits.

Tube V5 -- a type 6N2P twin triode -- is used as the control element.

The stabilizer circuit is shown in Figure 93a.

The -150-v Stabilized Circuit (p 216)

A stabilized voltage of -150 v (Figure 93b) is taken from the cathode of stabilovolt [voltage stabilizer] V8, type SG1P, which is the reference voltage source for the -250-v electronic stabilizer. The internal resistance of the -150-v circuit is determined by the internal resistance of the SG1P stabilovolt.

The external characteristic of the stabilovolt has a sector in which the voltage at the terminals of the tube changes insignificantly when a current of 5 ÷ 30 ma passes through it. This sector is used to operate the -150 v stabilization circuit.

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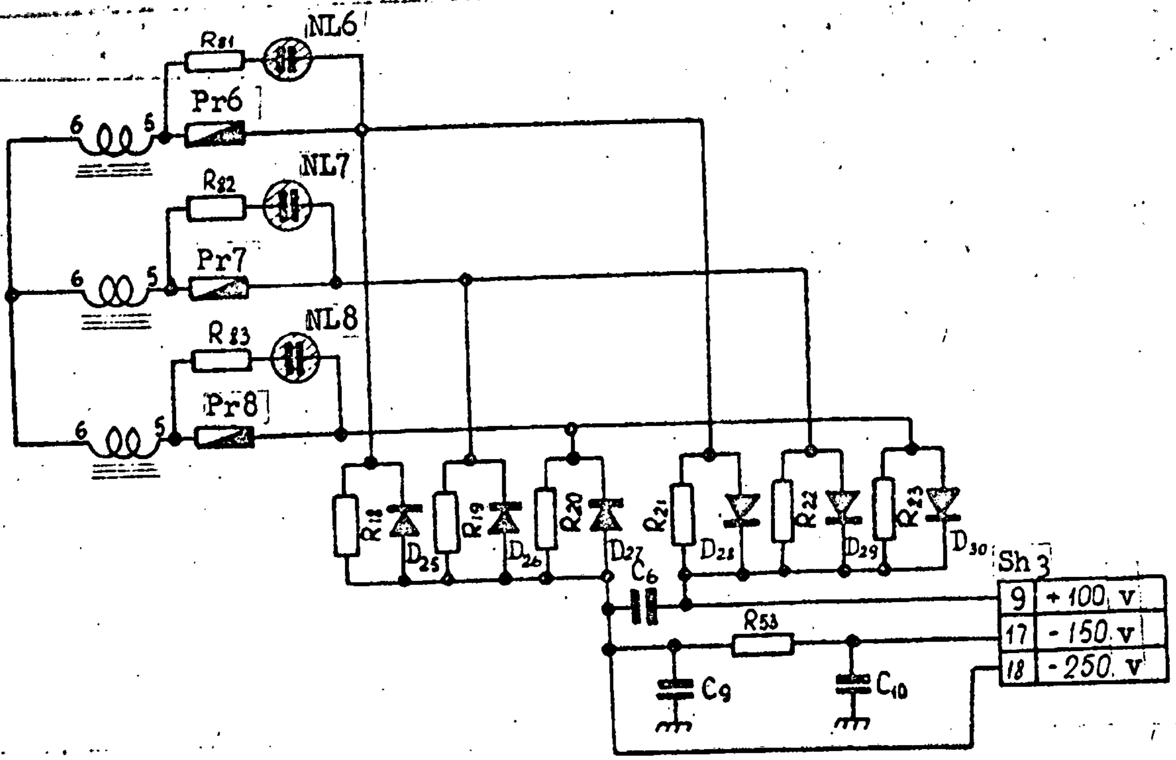

Fig 92. -250-v and -150-v Rectifier Circuit (p 214)

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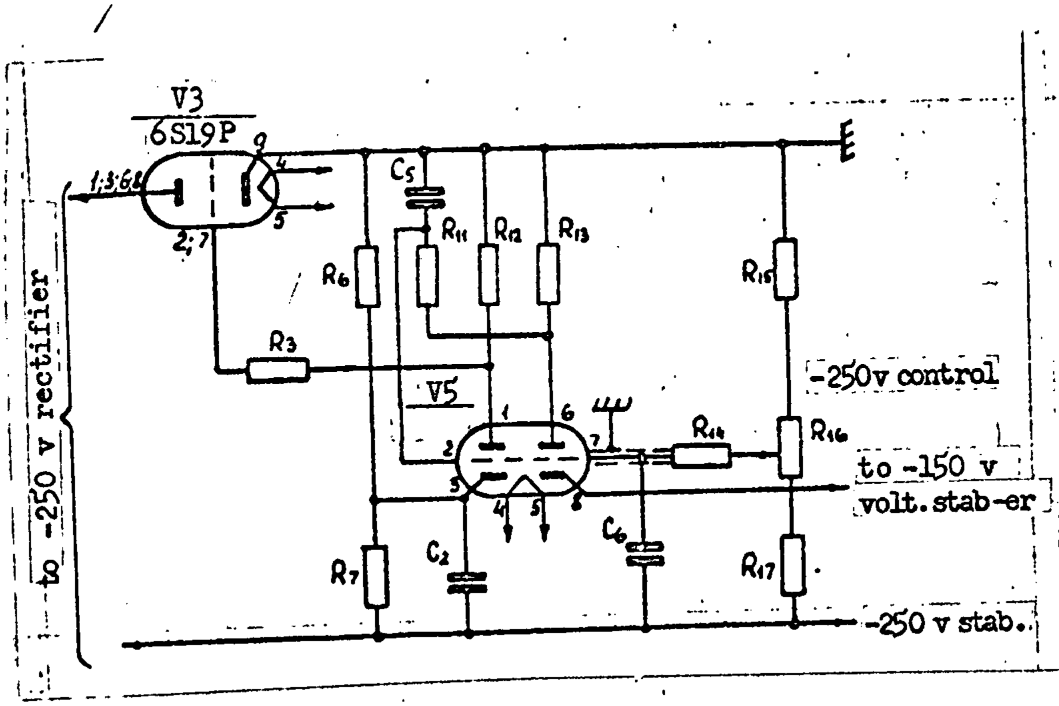

Fig 93a. -250-v Electronic Stabilizer Circuit (p 215)

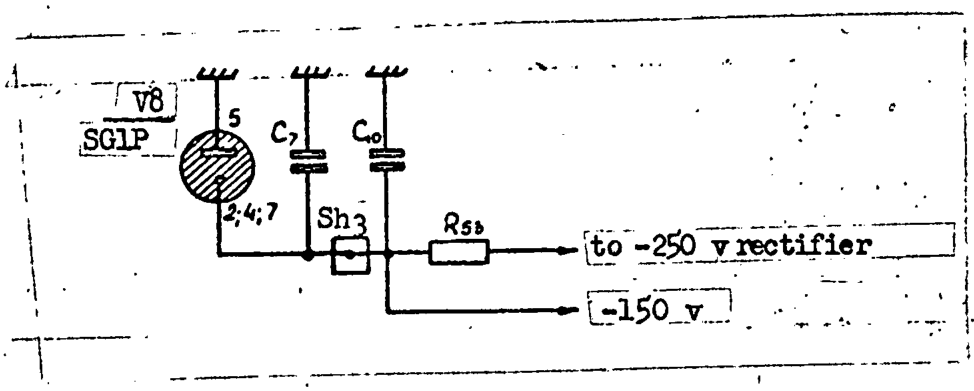

Fig 93b. -150-v Stabilized-Voltage Circuit (p 215)

Selection of an operating point on the characteristic of the stabilizer is provided by the connection of load resistor R53 into its circuit.

Capacitor C10, located in unit PRS-1, is used to decrease pulsations at the stabilizer output.

The 6.3-v Stabilized-Filament-Voltage Circuit

The 6.3-v stabilized-filament-voltage circuit (Figure 94) consists of the sensitive element of the circuit -- tube V10 (diode 4Ts14S) -- the control stage based on tube V11, type 6S19P, saturation choke Dr1, and filament transformer Tr3.

The control winding of the choke is connected directly to the +120-v circuit. The other end of this winding is connected to the plate of regulating tube V11, type 6S19P. The cathode of tube V11 is connected to the chassis. (p 217)

The control grid of the tube is connected to the plate of diode V10, type 4Ts14S, through grid suppressor R36.

Resistors R34 and R35, the load of the diode, are connected in the diode circuit.

The -150-v circuit is used as the reference voltage and is applied to the diode filament circuit through resistor R33.

The filament circuit of the control diode is supplied from filament transformer Tr3.

The stabilized voltage taken from the windings of transformer Tr3 is applied to the filament circuits of the receiver.

The circuit operates as follows:

Changes in line voltage are transmitted to the input of filament transformer Tr3. At this time, the heating of the diode intensifies, leading to an increase in the emission of its cathode and, consequently, to an increase in plate current. The potential of the plate decreases, causing an increase in negative bias at the grid of tube V11 and a decrease in its plate current. At the same time, the current in the control winding of choke Dr-1, which is connected in series with the plate, decreases.

The decrease in excitation current of the control winding of saturation choke Dr-1 causes an increase in a-c impedance of the regulating windings of the choke and, as a result, leads to an additional voltage drop within it. This voltage drop compensates for the initial increase in line voltage.

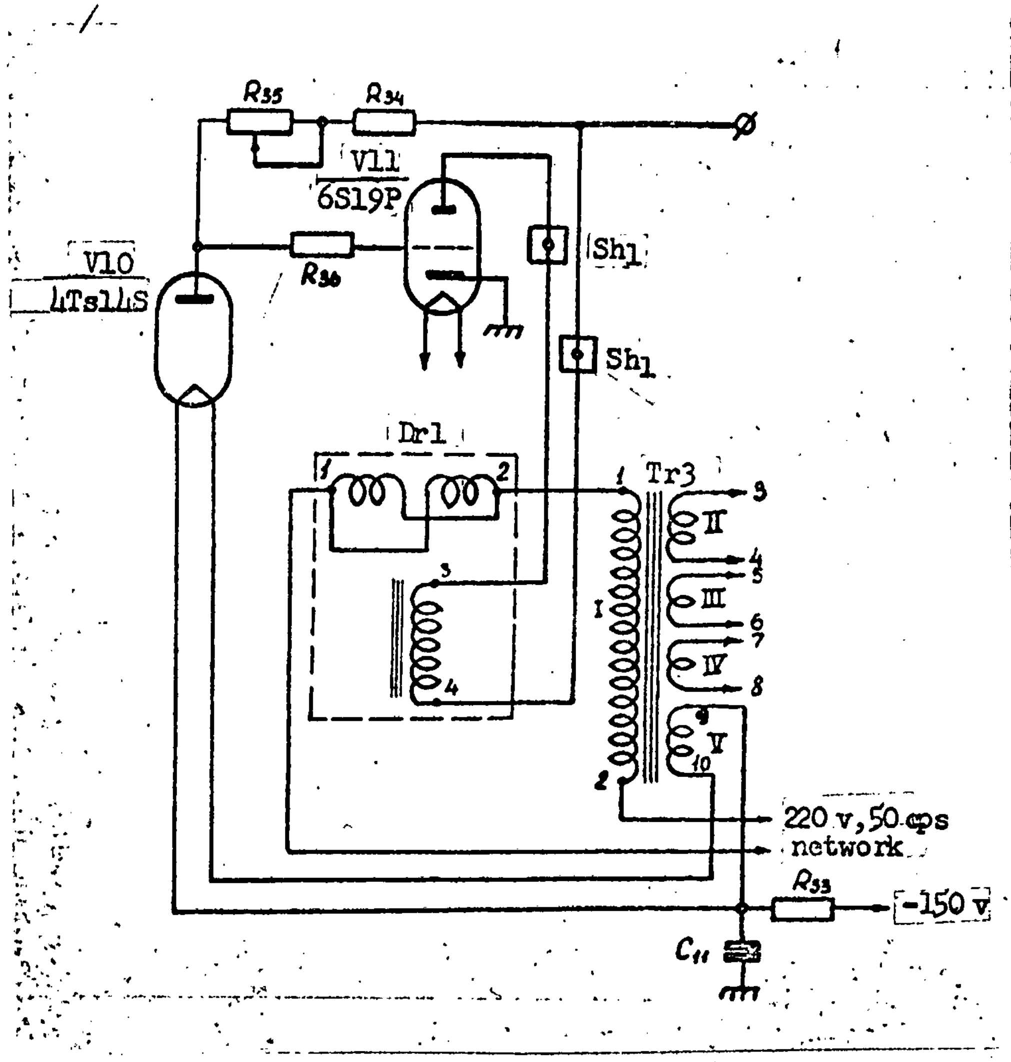

Fig 94. 6.3-Volt Stabilized-Filament-Voltage Circuit

(p 218)

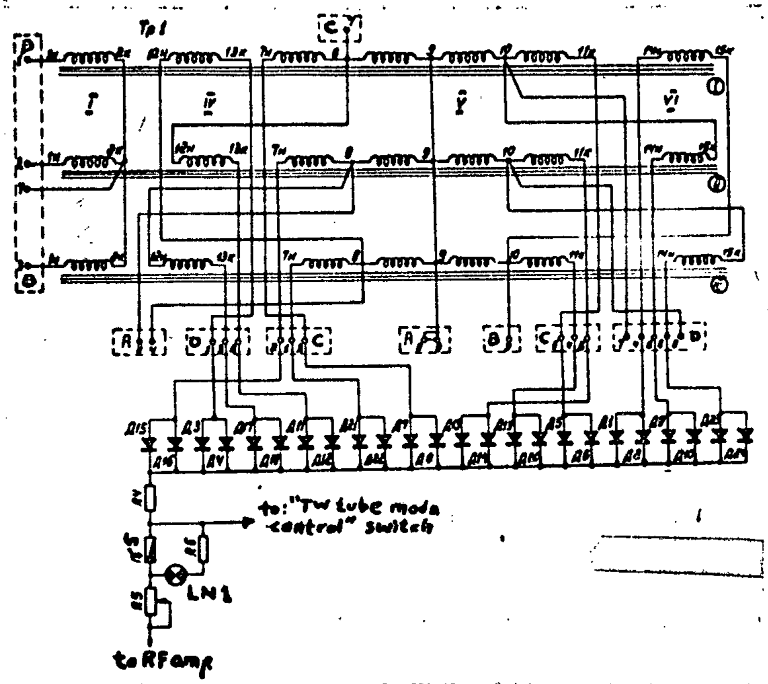

Fig 95. Plus-minus-26-volt Rectifier Circuit (p 220)

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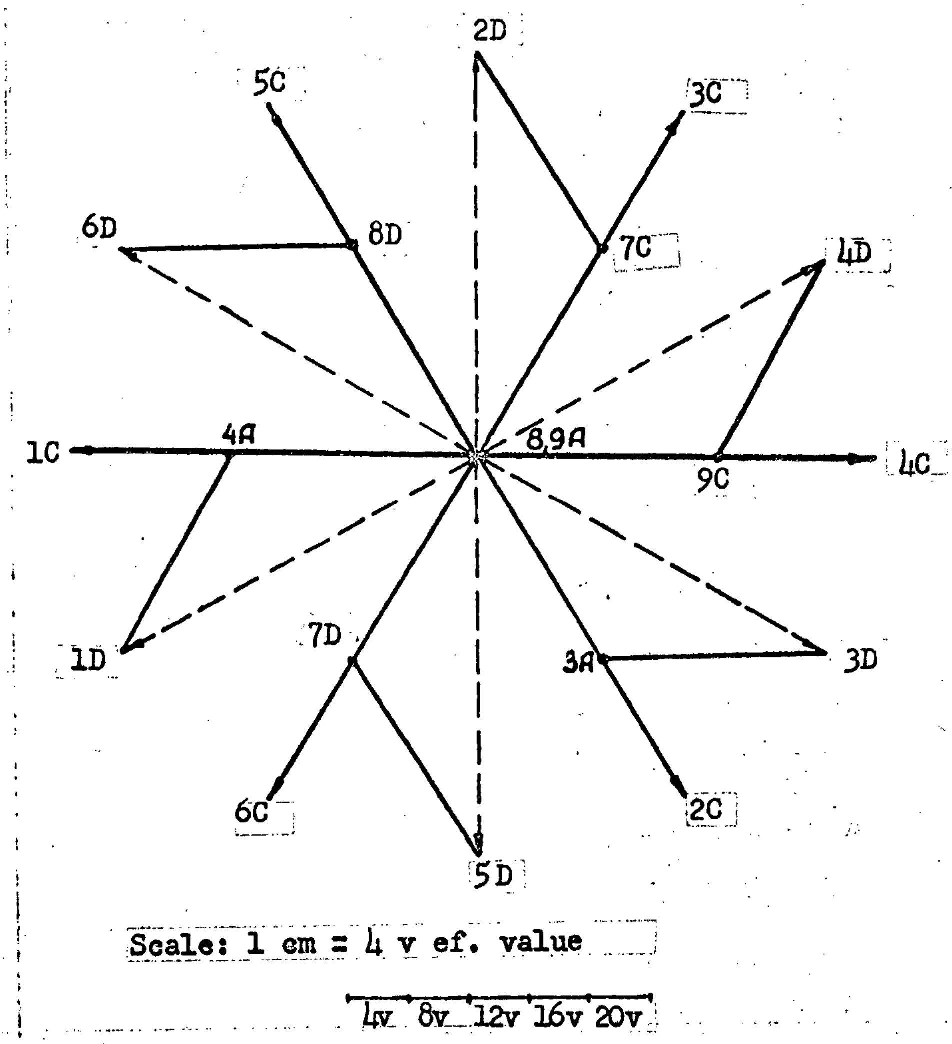

Fig 96. Vector Diagram for the Plus-Minus-26-Volt Rectifier Voltages (p 221)

A decoupling network consisting of resistor R33 and capacitor C11 is used to decrease the effects of induction of the magnetic amplifier on the -150-v circuit.

The +26-v Rectifier

The + 26-v rectifier is used to supply the coils of the traveling-wave-tube solenoid with a current of up to 8 amperes.

The + 26-v rectifier is arranged in a 12-phase circuit with type D-202 silicon junction-type diodes (two in parallel for each phase). The rectifier is supplied from windings IV, V, and VI of transformer Tr-1 connected in a 12-phase circuit. A schematic diagram of the rectifier is given in Figure 95.

The windings which supply the + 26-v rectifier are designed and connected in such a way that the output voltages form a symmetrical 12-phase star with a zero point. The vectors of these voltages are equal in magnitude and are shifted 30^{o} in phase with respect to each other, forming a symmetrical star.

The magnitude and direction of the vectors in each individual winding and at the output of the transformer may be determined by means of the vector diagram shown in Figure 96.

A voltage on the order of 22 ÷ 25 v, established by means of a wire resistor rated at approximately 1 ohm, is required for feeding the solenoid coil. The resistor is connected in series with the + 26-v circuit and a voltage on the order of 1 ÷ 6 v flows through it, depending on resistance fluctuations of the solenoid coil. (p 222)

Due to the use of a 12-phase rectifier, voltage pulsations are not more than 5%.

A 10-a fuse is incorporated in the rectifier circuit for protection against short-circuiting of the + 26-v circuit.

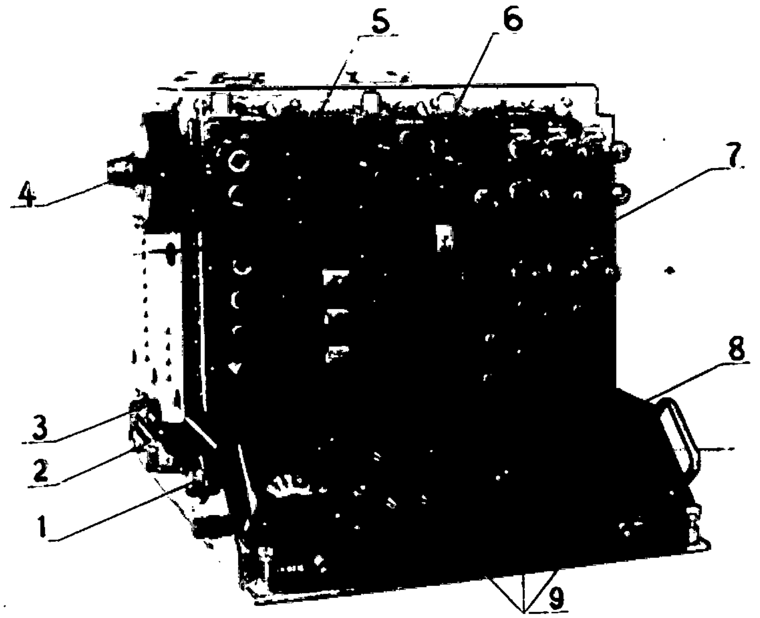

Fig 97. PRS-1 Centimeter-Wave Receiver (p 223)

1. connector for remote control
2. connection for UVCh-1 supply
3. connection for power supply to entire PRS-1 unit
4. local oscillator
5. UPCh-1 block
6. APCh-1 block
7. stabilization block
8. control panel
9. fuses

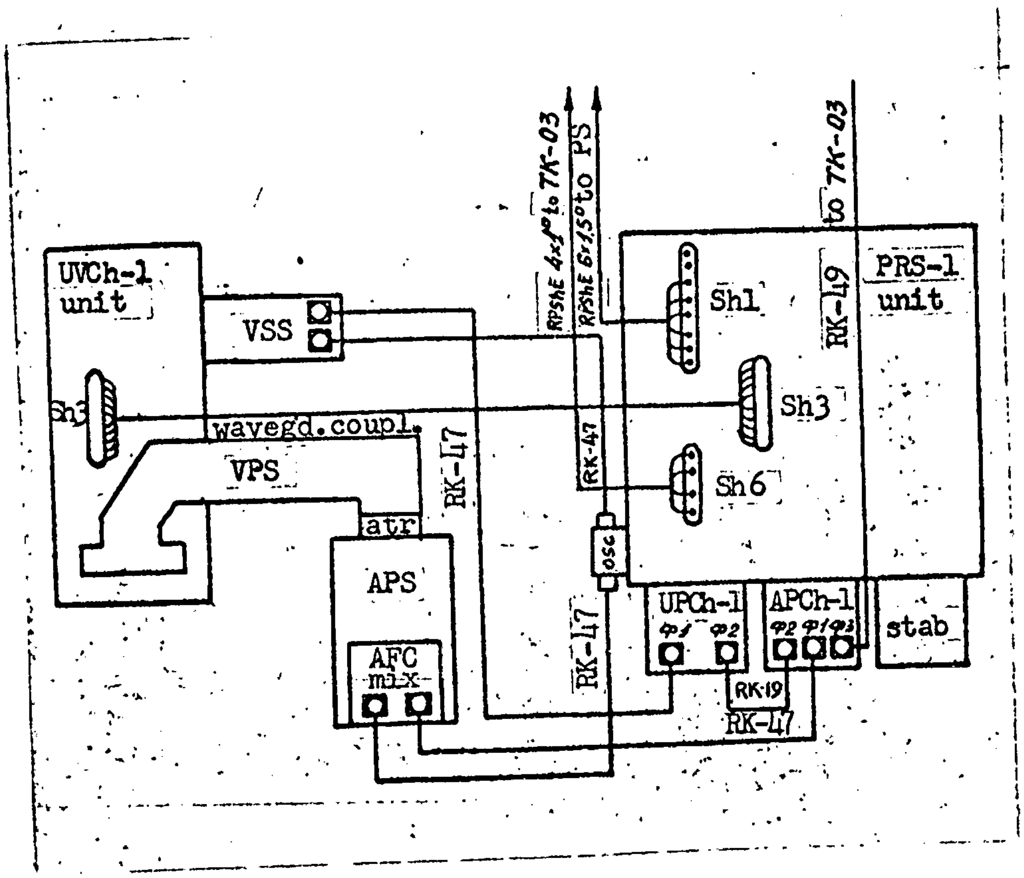

Fig 98. Connection Diagram for the Receiver (p 224)

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5. Design of the Receiver

Over-All View and Connection Diagram

The centimeter-wave receiver (Figure 97) is designed in the form of individual units housed in the PPS [transceiver] cabinet.

A connection diagram of the receiver is given in Figure 98.

The transmitter fan, connected by an air duct to an opening in the top of the PPS-cabinet, is used to cool the UVCh-1 unit. Additional spacers are placed between the cabinet and the UVCh-1 unit for the purpose of height adjustment.

The signal mixer and AFC-mixer are connected to the local oscillator and appropriate networks by cable jumpers (RK-47 cable).

All RF-plugs of the receiver have a wave impedance of 50 ohms corresponding to the wave impedance of the RK-47 cable. (p 225)

All external moving parts of the receiver (coupling rods for the local oscillators in the mixers, adjustment screw of the preselector resonator, crystal holders in the mixers, tuning stubs of the waveguide junction, and tuning knobs for the plungers of unit UVCh-1) are located in easily accessible positions.

The designs of unit UVCh-1, the mixers, and the waveguide junction are examined in the descriptive sections corresponding to these units.

The Design of Unit PRS-1 (Receiver)

Unit PRS-1 is composed of the following subassemblies: the UPCh-1 (IF-amp) block, the APCh-1 (AFC) block, the stabilization block, and the local oscillator circuit in a separate housing.

Subassembly construction makes it possible to easily replace faulty components with spares during combat operation of the radar.

The local oscillator circuit is attached to the left side of the unit by four screws.

Voltages are sent to the klystron through a tube socket placed on the base of the klystron inside the unit.

Voltages to the reflector plate and the resonator are carried individually by flexible conductors. (p 226)

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All external control elements of the receiver are exposed at the control panel. Additional elements for controling the circuits are mounted within the unit, mainly on a 36-contact wiring board, as well as on the side of the chassis.

Filter and blocking capacitors are placed on a horizontal panel and a side wall of the chassis.

At the top of the chassis are: three-phase transformer, two filament transformers, choke, a-c relay for local connection of high voltage, two plates with diodes of the -250, +300, and ± 26-v rectifiers, as well as the range multiplier of the solenoid circuit.

The fuse in the solenoid-supply circuit and the solenoid-current-measurement shunt are on a plate located in the upper part of the unit.

The fuses in the supply circuit of the "-250-v" rectifier are on a plate on transformer Tr-1.

The remaining range multipliers and shunts for the meters of unit PRS-1 are mounted below the chassis.

At the bottom left of the unit are three plugs and the fuse jack of the filament circuit.

The line voltage of 220 v, 50 cps, is applied to unit PRS-1 through an 8-pin plug; a 20-pin plug connects unit PRS-1 with unit UVCh-1.

A four-pin plug is used for the remote supply of relay voltages (p 227) for the differentiating and MARU-circuits and gain-control circuit of the IF-amplifier.

Design of the Blocks

All three blocks of the receiver — UPCh-1, APCh-1, and the stabilization block — are built on chassis of identical dimensions. The blocks are connected to unit PRS-1 by means of 20-pin plugs. Each block has two guide rods located in such a way as to avoid the possibility of error by placing one block in the position meant for another. The output of the detector of block UPCh-1 is connected to the input of the audio amplifier (block APCh-1) by means of an RK-19 cable terminated at both ends by plug-in connectors.

The wiring side of block UPCh-1 (Figure 99) is divided by a partition into two sections. In one section are mounted all IF-amplifier and detector stages, and in the other section are the MARU-stages (including three RES-6 relays).

The method used in attaching the cover of unit UPCh-1 provides reliable electrical contact between it and the chassis along the entire length of the block.

All wiring is positioned so as to minimize parasitic coupling between the stages.

On the front panel of the block are test jacks, screws of the cores of the eight circuit coils, and the instrument part of the "Detector-Output" plug.

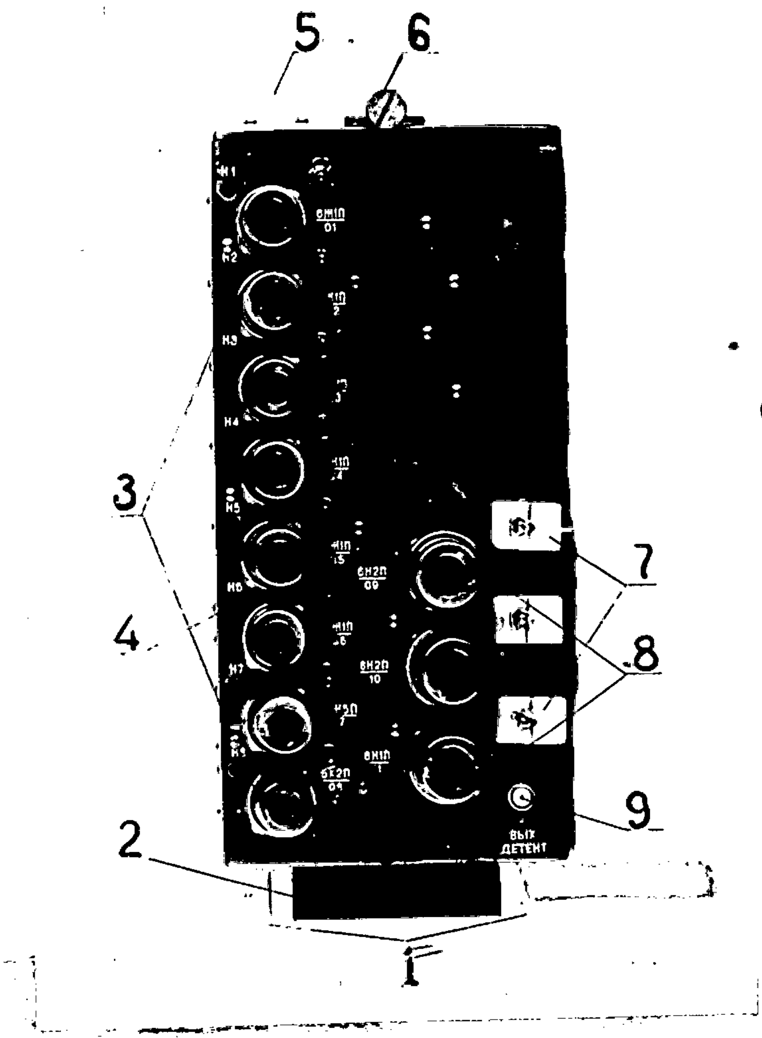
The APCh-1 block (Figure 100) has partial separation between the AFC-input stages and the audio-frequency amplifier-output stage to prevent coupling between these circuits. (229)

The discriminator circuit and relay RES-6 of the differentiating circuit are attached to the top of the chassis of the block.

On the front panel of the block are the shafts of the "AFC-Gain" and "Saw-Tooth-Pulse-Frequency" potentiometers, test measurement jacks of the two tubes of the IF-amplifier and discriminator, two test jacks "AFC-Pulse" and "IF-Amplifier Output," as well as the screws of the brass cores of the four circuit cells.

The electrical wiring in the stabilization block (Figure 101) is in the form of a bunched circuit.

On the front panel of the block are the shafts of the potentiometers for regulating the +120, -250, +300, and 6.3-v stabilized voltages.



(p 228)

Fig 99. UPCh-1 Block

1. guide bolts
2. 20-contact receptacle
3. UPCh stages
4. one of the test sockets
5. input connector for mixer cable
6. screw for attaching to PRS-1 unit
7. MARU relay
8. MARU stages
9. detector output

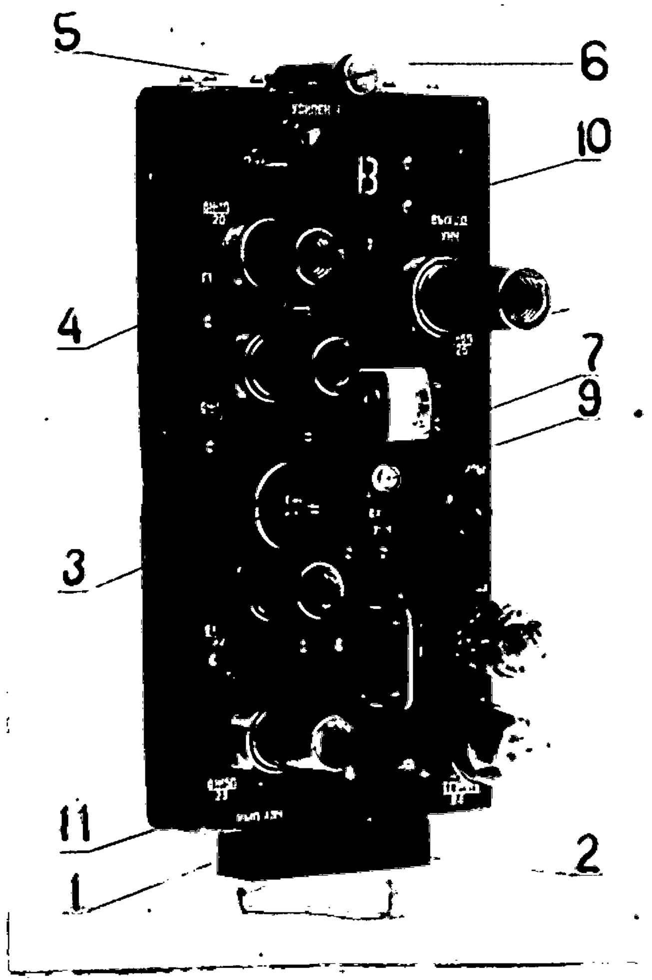


Fig 100. APCh-1 Block (p 230)

1. guide bolts
2. 20-contact receptacle
3. discriminator loop
4. one of the test sockets
5. APCh input connector
6. UNCh output connector
7. differential relay
8. (no entry)
9. UNCh input connector
10. "UNCh Output" test socket
11. "APCh Pulse" test socket

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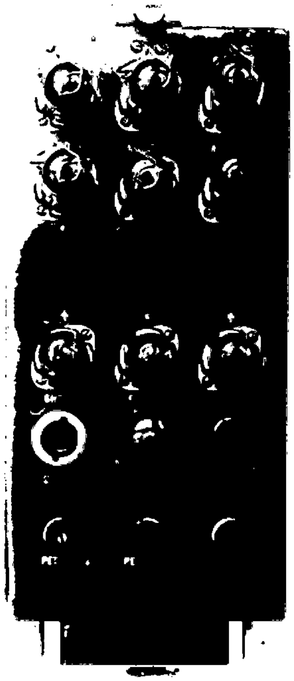

Fig 101. Stabilization Block (p 231)

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S-E-C-R-E-T

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CHAPTER SIX

CONTROL, TESTING AND PROTECTIVE EQUIPMENT

1. General Information

Function of the System and its Components

The control, testing and protective equipment provide:

- -- local and remote automatic switching of the transceiver;
- -- remote control of the receivers;
- -- check on the operating mode of the transceiver;
- -- remote control of the 400-cps generator voltage coming from the transceiver and indicator vehicles;
- -- local and remote control of the rotation of the transceiver cabin with the delivery of a warning sound signal;
- -- remote control of the antenna elevation;
- -- remote check on the elevation angles of the antenna;
- -- check on the 50- and 400-cps voltage of the three-phase power supply networks;
- -- control of the accessories to the transceiver;
- -- protection of the main components of the transceiver and accessories during breakdown or equipment failure. (p 233)

The control, testing and protective equipment further provide:

- -- control, testing and protection of transceiver equipment;
- -- 400-cps generator voltage control;
- -- control and protection of electric drive motors for rotating cabin;
- -- control, testing and protection of antenna rocking mechanism.

The system for control, testing and protection draws electric power from a 220-volt, 50-cps network.

Block Diagram of the System

The block diagram of the control, testing and protective system is given in Figure 102, which also shows the number of devices connected to the system and their interconnections and connections with the radar vehicles.

Some parts of the control, testing and protection system are grouped and designed as independent units; they are the:

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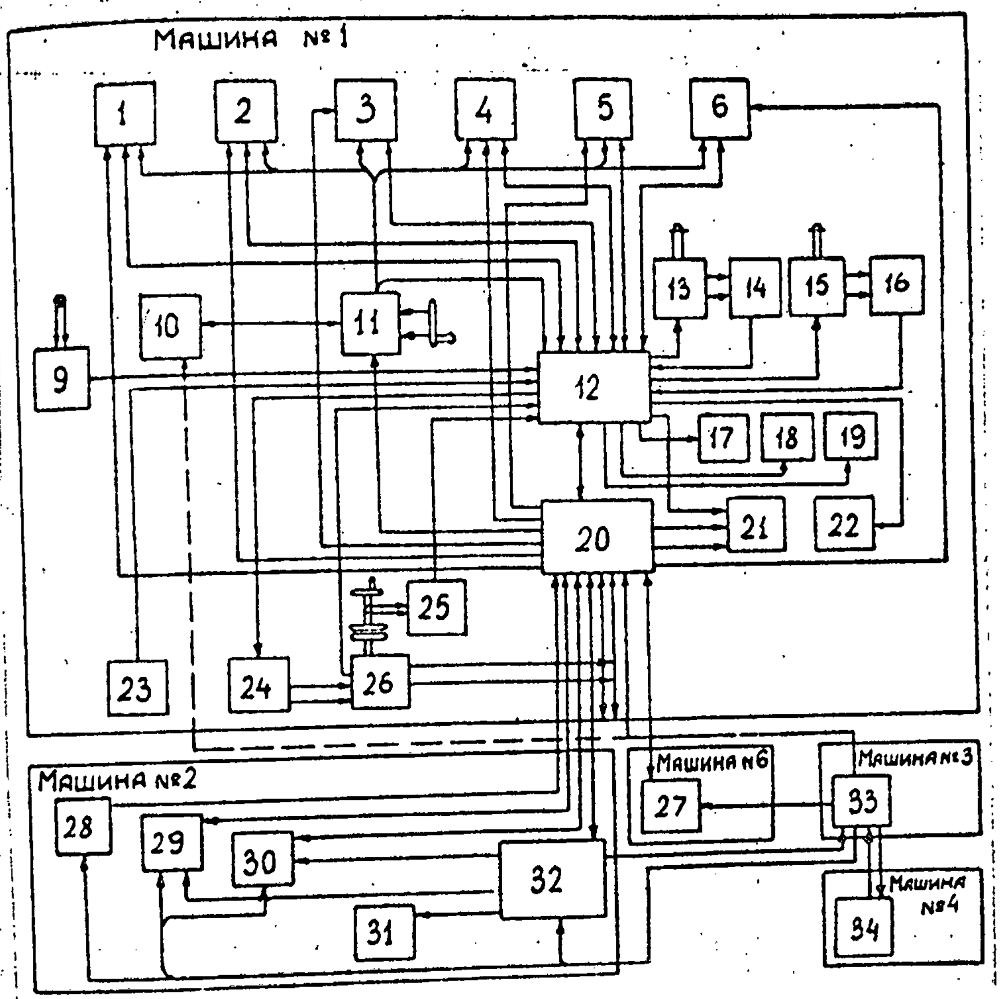
Fig 102. Block Diagram of Control, Testing and Protection System (p 234)



1-6. cm-wave transceivers
9. cabin lock safety
10. cable box No 3
11. distributor box
12. control cabinet
13. rocking mechanism for horizontal antenna
14. transmitting selsyn of horizontal antenna
15. rocking mechanism of slant antenna
16. transmitting selsyn of slant antenna
17. fan No 1
18. electric heater
19. fan No 2
20. slip-ring
21. main selsyn unit
22. ceiling lights
23. batteries
24. cabin-rotating motor
25. manual cabin lock
26. cabin-rotation reduction gear
27. 200-volt, 400-cps, generator set
28. voltage supply cabinet
29. horizontal-antenna rocking control
30. slant-antenna rocking control
31. tracking section
32. radar remote-control cabinet
33-34. 200-v, 50cps, diesel-generator set

ShchU-1 control cabinet, the PDU-1 remote control panel, the units UN-1, UN-II and the distributor box RK. All the other elements of the system are installed directly in the sections and devices and are connected to the circuits in these sections and devices. (p 235)

The ShchU-1 control cabinet is the central position among the system equipment according to the number of connections with other parts of the radar. In it are concentrated the main electrical devices of the system and the local control devices.

2. Technical Information On the Parts of the System

Function and Operation of the Control, Testing and Protective System of the Transceiver

When the transceiver is connected, the system provides:

-- instantaneous voltage to the filament circuits;
-- (within 30-65 seconds) voltage to the stand-by circuits that protect the PS-transmitters;
-- (within 130-165 seconds) voltage to the plate circuits of the PRS-1 receivers;
-- (within 340-375 seconds) voltage to the plate circuits of the transmitters.

The system provides independent operation of each of the transceiver channels.

Remote control of the transceiver equipment and regulation and testing of its operation are done from remote-control panel PDU-1 in the indicator vehicle. (p 236)

Local control of the transceiver equipment regulation of the operating mode of this equipment, and testing of the operations are done from units ShchU-1, PS, PRS-1 and RK, which are installed in the transceiver vehicle.

Figure 103 shows the principal circuit diagram for the control, testing and protection system. The diagram is divided into zones for the sake of convenience.

Switching from remote control to local control and back is done with the switch marked "priyemo-pered appar. ShchU-1-V2," which has 4 positions:

"DIST" - switch position for remote control;
"VYKL" - on-switch for transceiver apparatus;
"NAKAL" - on-switch for filament circuits of transceiver apparatus;
"ANOD" - local on-switch for plate circuits of the transceiver apparatus.

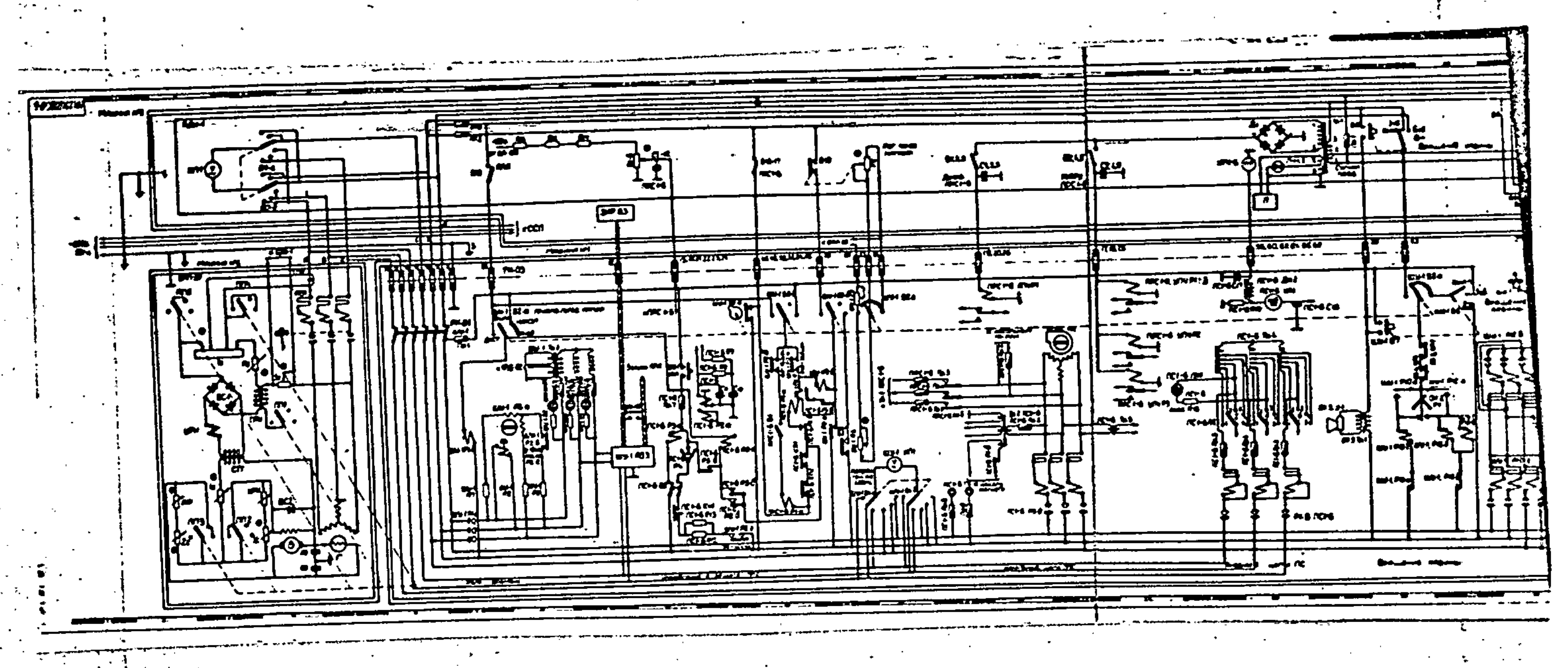


Fig 103. Circuit Diagram of the Control, Testing and Protection System (p 237)

In the "DIST" position, the electrical circuit for the automatic units is readied for remote switching on and off of the transceiver apparatus and for remote starting and stopping of electric motor that drives the rotating cabin.

In the "VYKL" position the power supplied to the automatic portion of the transceiver apparatus is disconnected and its main sections are shut down. The "NAKAL" and "ANOD" positions provide for local step-by-step switching-on of the apparatus. In the "ANOD" position the apparatus is turned on completely. (p 238)

The ShU-1 V2 switch can be thrown from the "NAKAL" position to the "ANOD" position at any time. It can also be set at the "ANOD" position immediately. In the latter case, the sequence and time delay of step-by-step switching-on of the apparatus are guaranteed automatically, as is also the case in remote control.

Remote Control of the Transceiver Equipment and Monitoring its Operation

The transceiver equipment can be operated by remote control after the ShU V2 switch has been set at position "DIST".

The transceiver equipment is switched on and off from the PDU-1 remote control panel with switch PDU-1 V 10 "PPA". (All components in the PDU-1 remote control panel appear on the schematic diagram without the panel number PDU-1 prefixed. For example, switch PDU-1 V2 is given in the diagram only as V2.)

When the PDU-1 V 10 "PPA" switch is turned on, the automatic process of switching on the transceiver equipment begins. The process is completed only if the contact PDU V19 (zone 19) of the push-button switch is closed; this switch is connected mechanically with the slide of the variable rheostat PDU R8 (zone 20) that regulates the 400-cycle generator voltage. In this case, the slide of the rheostat must be in a position corresponding to a low voltage fed from the 400-cycle generator to the plate circuits ofthe transmitter. (p 239)

For the sake of convenience, the single automatic process of switching on the transceiver equipment is divided into two parts: switching on of the filament circuits and switching on of the plate circuits. This division corresponds to the "NAKAL" and "ANOD" switching positions of the ShchU-1 V2 switch (zone 8) in local control.

Switching on the Filament Circuits: When switch PDU V10 (zone 7) is on, the following control circuits are supplied electrical energy; the winding of the automatic device ShU-1 R1-b (zone 7), the winding of the automatic devices PS1-R3a to PS6-R3a (zone 17), all for the operation of PPS1 to PPS6.

Electrical energy is fed to winding ShU-1 R1-b (zone 7) in steps: phase-A voltage 220 volts, 50 cps (zones 1, 2); fuse PDU Pr3 (zone 7); switch PDU V10; ring 51 of slip-ring TK-03; switch ShU-1 V2-a; winding ShU-1 R1-b; switch RK V1 (zone 6, 7); ring 73 of slip ring TK-03; phase-B, 220 volts, 50 cycles (zones 1, 2).

Unlike winding ShU-1 R1-b (zone 7), windings PS-1 to PS-6 (zone 17) obtain current flowing additionally through fuses PS1-Pr7 to PS6-Pr7 and switches PS1 V2 to PS6 V2. (p 240)

Automatic devices ShU-1 R1 and PS1-R3 to PS6-R3 respond and make contact with their contacts ShU-1 R1-a (zone 7) and PS1-R3-v to PS6-R3-v (zone 22, 23).

The closing of the main contacts PS1-R3-v to PS6-R3-v of the automatic filament controls of the transceiver cabinets PPS guarantees a supply of electrical energy to the filament circuits of transmitters PS 1 to PS 6 through transformers PS1-Tr2 to PS6-Tr2 (zone 22) and PS1-Tr5 to PS6-Tr5 (zone 23), as well as to the MI electric motors of PS1 to PS6 (zone 23) for the fans that cool the magnetrons, and to the filament circuit of receivers PRS-1 to PRS-6 through their filament transformers.

When the electric motors of the fans reach their required rpm, the centrifugal relays on the rotor shafts disengage their contacts PS1-R4 to PS6-R4 (zone 17).

The "filament-on" indicator lamps are fed from the OK-10 B1 battery through contacts ShU-1 R1-v (zone 34) and ShU-1 R3-d. At this time, however, no current passes through lamps ShU-1 LN2 and PDU-LN6, since the rectifiers ShU-1 and PDU D2 are connected in opposition to the battery. The moment the contacts ShU-1 R1-a (zone 7) are closed, the two-phase motor ShU-1 R2-a (zone 8) of the timing relay ShU-1 R2 begins to run. This relay guarantees the required delay of time and sequence of steps in the automatic switching-on of the transceiver equipment. (p 241)
As relay ShU-1 R2 begins to operate, its electromagnetic coupling ShU-1 R2-b is likewise activated.

The winding of the electromagnetic coupling receives current from phases A and B after the main contacts ShU-1 R1-a (zone 7). Motor ShU-1 R2-a (zone 8) is fed through resistances ShU R7, R8, and R9, which supply the winding with two voltages (110-v) 90 degrees out of phase.

The secondary contacts PS1 R3-b to PS 6 R3-b (zone 19) of the automatic filament controls are activated at the same time as the main contacts PS1 R3-v to PS6 R3-v (zone 22, 23); the secondary contacts activate the automatic plate controls PS1 R1 to PS6 R1.

From 30 to 65 seconds after switch PDU V10 (zone 7) and, consequently, the windings of motor timing relay ShU-1 R2-a (zone 8) are activiated, and contact ShU-1 R2-G (zone 17, 18), which prepares the protective circuit of transmitters PS1 to PS6 (zone 17) for operation, is closed.

Switching on the Plate Circuits: The plate circuits are switched on remotely only in those transciever (PPS) cabinets in which the switches PDU-1V 12 to PDU-1V 17 (zone 18) are on.

Some 130-165 seconds after the closing of the switching-on circuits PPA via switch PDU-1V10 (zone 7), contact ShU-1 R2-d (zone 18) of the motor relay closes the windings of the plate-relays of the receivers PRS1 R1-a-PRS6 R1-a. The windings PRS1 R1-a to PRS6 R1-a are fed via: phase A, 220 volts, 50 cps (zone 1, 2); fuse PDU PR3 (zone 7); fuse PDU V10; ring 51 of slip-ring TK-03; fuse ShU-1 V2-v (zone 18); contact ShU-1 R2-d; switches PRS1 V1 to PRS6 V1; windings PRS1 P1-a to PRS6 P1-a; rings 46, 48, 50, 52, 54, and 56 of slipring TK-03; switches PDU V12 to PDU V17; fuse PDU Pr2 (zone 7); phase B voltage, 220 v, 50 cps (zones 1, 2). (p 242)

When current has passed through windings PRS1 R1-a to PRS6 R1-a (zones 18, 19), contacts PRS1 R1-b to PRS6 R1-b (zone 22) close, supplying voltage to the Tr1 transformers of the receivers PRS1 to PRS6.

The plate circuits of the transceiver equipment, which draw current from the 400-cps generator (zone 5), can be switched on by turning all the way to the left the knob of rheostat PDU R8 (zone 20) used for remote voltage regulation of the 400-cycle generator (REG. TOKOV MAGNETR.).

Some 340-375 sec after the PPA switch-on circuits are closed by switch PDU V10 (zone 7), contact ShU-1 R2-e (zone 19) excites the winding of relay ShU-1 R3-v through the circuits: phase A, 220 volts, 50 cps (zones 1, 2); fuse PDU Pr3 (zone 7); switch PDU V10; ring 51 of slip-ring TK-03; switch ShU-1 V2-v (zone 18); contact ShU-1 R2-ye; winding Shu-1 R3-v; switch ShU-1 R2-d (z9ne 19); ring 59 of slip-ring TK-3 (zone 19); pushbutton switch PDU V19; fuse PDU Pr2 (zone 7); and voltage phase B, 220 volts, 50 cps (zones 1, 2). When winding ShU-1 R3-v (zone 19) is exicted, its contacts ShU-1 R3-b (zone 19), ShU-1 R3-r and ShU-1 R3-d (z9ne 34) close. (p 243)

The windings of the automatic plate controls PS1 R1-a to PS6 R1-a (zone 18) are fed through contact Shu-1 R3-b (zone 19).

The supply circuit for the windings of the PS1 R1-a to PS6 R1-a automatic plate controls is: voltage phase A, 220 v, 50 cps (zones 1, 2); fuse PDU Pr3 (zone 7); switch PDU V10; ring 51 of slip-ring TK-03 (zone 7); switch ShU-1 V2-v (zone 18); contact ShU-1 R2-ye; contact ShU-1 R3-b; contact PS1-6 R5-v; winding PS1 R1-a; contact PS1-6 R3-b; blocking devices PS 1-6KP1 and PS1-6KP2; rings 46, 48, 50, 52, 58, and 56 of slip-ring TK-03 (zone 18); switches PDU V12 to PDU 17; fuse PDU Pr2 (zone 7); and voltage phase B, 220-v, 50 cps (zones 1, 2).

Contact ShU-1 R3-a (zone 19) blocks the pushbutton switch P V-19. This blocking is necessary in order that, when the 400-cycle voltage is increased (by turning the knob of rheostat PDU-1 Rs) from 160-170 volts to its rated value of 200 volts, thereby disengaging the

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contacts of the pushbutton switch PDU V19, there will be no disengagement of the winding of relay ShU-1 R3-v (zone 19) and, consequently, no disengagement of the plate circuits of the automatic devices in the PPS transceiver cabinets.

The contacts of switch PDU-1 V-19 are blocked by contact ShU-1 R3-a as follows: on one side, contact ShU-1 R3-a (zone 19) is connected to winding ShU-1 R3-v directly, whereas pushbutton switch PDU V19 is connected to it via ring 59 of slip-ring TK-03 and switch ShU-1 V2-d. On the other side, contact ShU-1 R3-a is connected to voltage Phase B (220-v, 50 cps; zones 1, 2) through switch RK V1 (zones 6, 7) and ring 73 of slip-ring TK-03, whereas switch PDU V19 (zone 19) is connected to this phase through fuse PDU Pr2 (zone 7). (p 244)

Contact ShU-1 R3-d (zone 34) switches the electrical energy of the signal lamps LU LN2 (zone 35), ShU-1 LN3, PDU LN5 and PDU LN6, which comes from battery OK-1051 (zones 32, 34,) to the secondary winding of transformer ShU-1 Tr4 (zones 32, 33). When this happens, not only lamps ShU-1 LN3 (zone 35) and PDU LN5, which indicate that the filaments are on, light up, but also lamps ShU-1 LN2 and PDU LN6, which indicate that the plate voltage is switched on, since the latter lamps are fed from the half-wave rectifier circuit.

When current has passed through the windings of automatic devices PS1 R1-a to PS6 R1-a (zones 18, 19), their main contacts PS1 R1-v to PS6 R1-v (zone 26) close thereby supplying 160-170 volts (100 cps) to automatic transformers PS1 Tr4 to PS6 Tr4 from the generator of unit BPL-30 (zone 5) via the contacts of the starter with manual drive AV1 on VPL-30, rings 70, 72, and 74 of slip-ring TK-03 (zones 6, 7), switch RK V1, contacts PS1 R1-b to PS6 R1-b (zone 26), and fuses PS1 Pr3 to PS6 Pr3, PS1 Pr4 to PS6 Pr4, and PS1 Pr5 to PS6 Pr5. At this time, lamps PS1 LN1 to PS6 LN1 (zone 25) begin to light up, signalling that the transmitters are receiving plate voltage. (p 245)

Voltage is supply from autotransformers PS1 Tr4 to PS6 Tr4 (zones 25, 26, 27) to the primary windings of the high-voltage transformers in VVS (high-voltage rectifier of the transmitters) through switches (blocks) PS1 V1 to PS6 V1.

As the main contacts PS1 R1-v to PS6 R1-v close, blocking contacts PS1 R1b to PS6 (zone 22) open, which disconnects the filaments of the magnetrons in sections PS1 to PS6.

Some 5-10 seconds after contact ShU-1 R2-ye (zone 19) closes, thereby supplying plate voltage, contact ShU-1 R2-v (zone 8) opens; electric motor ShU-1 R2-a stops, whereas all the transceiver equipment remains in the fully on position.

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Remote Control of Various Circuits of the Transceiver Equipment

In normal operation of the radar, trigger pulses are fed to the indicator and to the transceiver equipment from section B3 (zones 9, 10), located in cabinet ZN-F1 of vehicle No 2.

During this time, the shaping circuit of section ABZ (emergency triggering unit) in the ShU-1 cabinet is in the condition, "warmed-up standby" (its load circuit is interrupted by the contacts of the trigger-switching relay in unit ABZ).

If, for any reason at all, the feeding of trigger pulses from the ABZ unit in cabinet ZN-F1 (master voltage cabinet) to the transceiver equipment is interrupted, the transceiver continues to operate, since the trigger circuit of the transceiver equipment is fed automatically from the ABZ unit in cabinet ShU-1. (p 246)

If unit ABZ is removed, or partially removed, from cabinet ShU-1, then the trigger circuit of the transceiver apparatus remains connected only to the BZ unit of cabinet ZN-F1 (master voltage), since the contacts of pushbutton-switch ShU-1 V1 are closed when the ABZ unit is removed (they are open during normal operation of the radar).

In order that plate voltage be supplied to cabinet ZN-F1 when the BZ unit is withdrawn or partially pulled out, the circuitry provides an interruption of current fed to cabinet ZN-F1, opening the filament circuit of the automatic device located in unit UPT-1 of this cabinet.

The operating principle of the power supply circuit for automatic trigger switching and for the ABZ (emergency triggering) unit are given in the description of unit ABZ.

For the remote gain control circuits of all the receivers, a voltage of -150 volts from the BP-150 unit in DUS-1 remote control cabin (zone 13) is fed to the PDU-1 voltage dividers, which consist of resistors PDU R 15 to PDU R 17 (zones 8, 9) and potentiometers PDU R1 to PDU R 6 (zone 16).

The remote gain control for receivers PRS 1 to PRS 6 is provided by potentiometers PDU R1 to PDU R6 (zone 10). (p 247)

The remote control circuits of the MARU (instantaneous automatic gain control) and differentiating relays are fed a voltage from selenium rectifier PDU-1 D1 (zones 26, 27), which is connected to the 220-volt, 50-cycle network through transformer PDU-1 Tr1. Switches PDU-1 V2, 4, and 6 (zone 23) turn the MARU-relay of the PRS-1 receivers to channels one and four; the second switch (PDU-1 V4) connects to channels two and five; and the third switch (PDU-1 V6) connects to channels three Each of the PRS-1 receivers has three MARU-relays (UPCh R1 in zone 24; UPCh R2 and UPCh R3 in zone 24), the windings of which are connected in parallel.

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Switches PDU-1 V1, 3, and 5 (zone 22) are used to engage and disengage the differentiating relays PRS1 APCh R1 to PRS6 APCh R1 (zone 22) in the PRS-1 receivers. The first of these relays connects to channels one and four; the second connects to channels two and five; and the third relay connects to channels three and six.

Local Control of the Transceiver Equipment

The transceiver equipment can be switched on from the panel of cabinet ShU-1 in the transceiver vehicle in two different ways, either first the channel then the plate voltage, or both together.

The entire transceiver installation can be switched on at once by throwing switch ShU-1 V2 (zones 8, 18, 19, 20, 29) from the "VYKL" position to the "ANOD" position. (p 248)

Here the process of switching on the equipment automatically is completely analogous to the direct process that takes place during remote switching-on of the transceiver apparatus.

Local Switching-on of the Filament Circuits: The filament circuits in the transceiver are switched on locally by throwing switch ShU-1 V2 from the "VYKL" position to the "NAKAL" position.

Here, in addition to the operations performed by the automatic components in the remote control situation (see "Switching-On the Filament Circuits"), contacts ShU-1 R2-d (zone 19) and ShU-1 R2-ye (zone 19) close, and contact ShU-1 R2-v (zone 8) opens. The closing of contacts ShU-1 R2-d and ShU-1 R2-ye does not cause the plate relays and automatic devices to disengage, since their circuit is interrupted when switch ShU-1 V2-v (zones 18, 19) is in the "NAKAL" position. The opening of contact ShU-1 R2-v (zone 8) causes the interruption of the ShU-1 R2-a circuit of the motor timing relay, which stops the motor. All the contacts of motor timing relay ShU-1 R2, as well as ShU-1 R2-v, remain closed.

The filament circuits of the transceiver equipment may remain closed for any length of time.

Local Switching-On of the Plate Circuits: The plate circuits of the transceiver equipment must be switched on separately at each transceiver; this is done by throwing switch ShU-1 V2 (zones 8, 18, 19, 20, and 29) from the "NAKAL" position to the "ANOD" position. (p 249)

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After the transceiver apparatus has been on "NAKAL" (filament) for more than 375 seconds, the plate circuits of the transmitters and receivers should be switched on immediately after setting switch ShU-1 to position "ANOD." However, switching-on of the plate circuits of the

PS transmitters [will not occur] if the knob of the voltage cont rheostat of the 400-cycle generator ShU-1 R8 (zone 20) is not turned all the way to the left. This extreme position of the knob corresponds to the 400-cycle generator voltage of 167-170 volts and to the closed position of the contact of the pushbutton switch Shu-1 V 19 (zone 19).

The instantaneous switching-on of the plate circuits of the transceiver equipment immediately after setting the ShU-1 V2 switch to the "ANOD" position is guaranteed by the previous functioning of the automatic components.

Local Control of Various Transceiver Circuits

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In case of necessity, the 50 and 400-cycle power circuits can be cut off by switch RK V1 (zone 6).

Complete cutoff of the transceiver equipment requires the additional disconnecting of the Sh6 plug in cable box No 2 of vehicle No 1, or disconnecting vehicles No 1 and No 2 at the power source.

The appropriate switch among switches PS1 V2 to PS6 V2 (zones 16, 17) which interrupts one of the PS1 R3-a to PS6 R3a windings and one of the PS1 Pr7 to PS6 Pr7 motor protecting fuses, may be used to shut down one (or several) of the PPS transceivers (the others remaining in operation).

When the circuit of one of the windings PS1 R3-a to PS6 R3-a is interrupted, contacts PS1 R3-b to PS6 R3-b (zone 19) and PS1 R3-v to PS6 R3-v (zone 23) open. Contacts PS1 R3-v to PS6 R3-v disconnect the circuit that feeds the 220-v 50-cps voltage to the apparatus of a given cabinet. When a contact PS1 R3-b to PS6 R3-b (zone 19) is interrupted, the circuit feeding a PS1 R1-a to PS6 R1-a winding is interrupted.

As a result, contacts PS1 R1-b to PS6 R1-b (zone 22) close, and contacts PS1 R1-g to PS6 R1-g (zones 25, 27, 27) open; consequently the supply of the 400-cps power is interrupted.

The cabinet is completely disconnected. After some time, an electric motor PS1 M1 to PS6 M1 (zone 23) of the fan in the particular cabinet stops and its centrifugal relay PS1 R4 to PS6 R4 (zone 17) closes its contacts; but the fuse PS1 Pr7 to PS6 Pr7 (zone 17) does not burn out, since the switch PS1 V2 to PS6 V2 (zone 16) is off. (p 251)

The plate voltage of any of the receivers is cut off by its particular switch PRS1 V1 to PRS6 V1 (zone 18) in the circuit of the winding PRS1 R1-a to PRS6 R1-a. The contacts PRS1 R1-b to PRS6 R1-b (zone 22) of this relay disconnect the rectifier supply circuit in the receiver. No local control is provided for the MARU-relays nor for the differentiating relays in the PRS-1 receivers.

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Checking Transceiver Operation

Among the factors that decide the operating mode of the transceiver equipment are the 50-cps and 400-cps three-phase voltages, which are consequently checked both locally and remotely in the indicator vehicle.

The voltages are checked remotely in the indicator vehicle by voltmeter PDU-1 IP-7 (zone 3) with switch PDU-1 V7, and are checked locally in the transceiver vehicle by voltmeter ShU-1 IP1 (zone 20) with switch ShU-1 V4 (zone 20).

The control values for the operation of the PS1 to PS6 transmitters themselves are the plate currents of the magnetrons, which are check by milliammeters PS1 IP1 to PS6 IP1 (zone 26),PDU-1 IP1 to PDU-1 IP6.

In addition, the operation of the transceiver equipment is monitored with the following signal lamps: (p 252)

— ShU-1 LN3 (zone 35) and PDU LN5, which indicate whether the PPA filament circuits are on;

— ShU-1 LN2 and PDU LN6, which indicate whether the plate voltage is being supplied to the PPS cabinets (check on 50-cps circuits);

— PS1-6 LN1 (zone 25), which indicate whether plate voltage is being supplied to transmitters PS1 to PS6 (check on the 400-cps circuits);

— ShU-1 LN1 (zone 35) and PDU LN4 (zone 36) which indicate breakdown of transmitters PS1 to PS6;

— ShU-1 LN1, ShU-1 LN2 and ShU-1 LN3 (zone 9), which indicate fuse failures in the 220-volt, 50 cps supply circuits to units ABZ and FD-02.

Operation of the Protective Equipment of the Transceiver

The 50-cps three-phase power circuits at the input of the PPS cabinets are protected from overloads by the thermal protection of the PS1 R3 to PS6 R3 automatic controls (zone 23) and from short circuiting by the overload protection of these same controls.

The 400-cps three-phase power circuits at the input of cabinets PPS1-PPS6 are protected from short-circuiting (never less than double protection) by safety fuses PPS 1-6 Pr-35 (zones 25, 26, 27), and from overloads by the termal protection of the R1 (zone 26) automatic controls. (p 253)

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The PS transmitters 1-6 have special protective circuits against continuous sparking of the magnetrons, overloading of the high-voltage rectifier VVS, and the absence of cooling air supplied to the magnetrons. These protective circuits operate as follows:

When breakdown occurs in any of the transmitters PS1 to PS6, the corresponding contact (depending on the type of breakdown) [of relays] PS 1 R2-b to PS6 R2-b (zone 17) or PS1 R4 to PS6 R4 is closed.

The contact PS1 R2-b to PS6 R2-b of the particular relay closes when there is continuous sparking of the magnetron, or when the high-voltage rectifier is overloaded.

A delayed response of the relay is necessary so that the transmitter will not shut off during a brief, weak sparking of the magnetron. The contact of centrifugal relays PS1 R2 to PS6 R4 (zone 17) closes when the rpm drops or the motor of the electric fan cooling the magnetron stops.

When there is an extended period of sparking by the magnetron in any of the transmitters PS1 to PS6, the relay is forced to respond once the current in winding PS1 R2-a to PS6 R2-a (zone 17) reaches a certain value.

The R2-b contact of PS1 to PS6 closes the circuit of the PS (B-Zh) R-5a winding of the relay protecting the PS transmitter (B - Zh). The PS (B - Zh) R5-a winding (zone 18) is fed by phase A voltage (220 volts, 50 cps) (zone 4), through fuse PDU-1 PR3 (zone 7), switch PDU-1 V10, ring 51 of slip-ring TK-03, switch ShU-1 V2-a, winding Ps (B - Zh) R5-a (zone 18), contact PS (B-Zh) R2-b (zone 18), blocking devices PS (B - Zh) Kp 1 and Kp 2 (zone 18), rings 46, 47, 48, 50, 52, and 54 of slip-ring TK-03, switch PDU-1b 12-17, fuse PDU-1 Pr 2, and voltage phase B (220 volts, 50 cps; zone 4). The passage of current in winding PS (B ÷ Zh) R5-a causes the corresponding relay PS (B ÷ Zh) R5 to operate, breaking contacts PS (B ÷ Zh) R5-b. (p 254)

The PS (B ÷ Zh) R5-v contact (zone 19) interrupts the circuit of the PS (B ÷ Zh) R1-a winding of the automatic plate control. This causes contacts PS (B ÷ Zh) R1-v (zone 26) to open and contacts PS (B ÷ Zh) R1-b (zone 22) to close. The first of these contacts shuts off the plate circuit of the transmitter, and the second contact closes the filament circuit of the magnetrons in the PS (B ÷ Zh) units. During this operation, the power supply to the transmitter plate circuits is cut off.

Contact PS (B ÷ Zh) R5-g (zone 34) closes the circuit of the breakdown signalling lamps ShU-1 LN1 (zone 35) and PDU-1 LN-4 (zone 36), which are connected in parallel.

When the magnetron-cooling-fan motor stops, the protective circuit for the PS (B ÷ Zh) transmitters operates differently than when there is continuous sparking of the magnetron, i.e., when the contacts of the centrifugal relay PS (B ÷ Zh) (zone 17) close, the current passes through the following circuits:

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phase A (225-v, 50 cps; zones 3, 4), switch PDU-1 Pr3 (zone 7), ring 51 of slip-ring TK03, switch ShU-1 V2-a, fuse PS (B ÷ Zh) Pr 7, contact PS (B ÷ Zh) R4, switch PS (B ÷ Zh) V2 (zone 17), pushbutton PS (B ÷ Zh) KN1, resistor PS (B ÷ Zh) R12, R13, contacts ShU-1 R2-g, switch RK-V1, ring 73 of slip-ring TK-03, and phase V (220-v, 50 cps). Fuse PS (B ÷ Zh) Pr7 melts; the PS (B ÷ Zh) R3-a winding of the automatic control disconnects; the automatic control is switched off, cutting off the 220 volts (50 cps) from the power networks of unit PS (B ÷ Zh). (p 255)

The interruption of the contacts PS (B ÷ Zh) R3-b entails the interruption of the automatic control PS (B ÷ Zh) R1-a and the disconnection of the 220-volt 400-cps power. When the automatic control PS (B ÷ Zh) R3-a shuts off, the PS (B ÷ Zh) R3-v contacts close, and the 220-volt, 50-cycle phase B voltage is fed to the winding of relay PS (B ÷ Zh) R5-a. Relay PS (B ÷ Zh) R5 operates; contacts PS (B ÷ Zh) R5-g close and 12 volts from transformer ShU-1 Tr4 are fed to the breakdown signalling lamps (ShU-1 LN1, PDU-1 LN4).

The doors of the PPS cabinets have electrical cutoffs for safety during operation with high voltages.

Remote Reclosing of the Plate Circuits of the PPS (B ÷ Zh)

When there is a breakdown in the plate circuits, the filament circuits remain on, and cooling of the transmitter continues; this affords the possibility of reclosing the circuits any time after the emergency relay PS (B - Zh) R5 operates.

Remote reclosing of the plate circuits is done by first throwing the toggle switch PDU-1 V12-17 to the off position and then on again, after first reducing the current in the magnetrons to minimum. (p 256)

When the toggle switch is off, the circuit that feeds relay PS (B ÷ Zh) R5 is deactivated, thereby:

a) interrupting contacts PS (B ÷ Zh) R5-g, which removes the emergency signal;

b) closing contacts PS (B ÷ Zh) R5-v, which prepares the circuit for closing the automatic plate control;

c) interrupting contacts PS (B ÷ Zh) R5-b, which clears the automatically blocked relay.

When toggle switch PDU-1 V12-17 is subsequently thrown to the on position, the plate circuit is reclosed as described above.

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There are three cases when any one of the transmitters can be reactivated by remote control:

Case 1. After reactivation, the emergency signal goes off and magnetron current (in the PDU unit) appears. The reasons for this breakdown could have been: an incidental brief sparking of the magnetron; an incidental brief spark-over in the waveguide; a brief "sparking" of the thyratron; a brief surge in the voltage supply circuit; a brief change in the trigger pulse repetition rate.

Case 2. The emergency signal goes off when the toggle switch is thrown to the off position but comes back on when the toggle switch is thrown to the on position. When the toggle switch is thrown on, the magnetron current appears and then disappears. The cause here could be a persistent sparking of the magnetron, thyratron, pulse transformer or (p 257)
charging line.

Case 3. The emergency signal does not go off when the toggle switch is thrown to the off position. The breakdown in this case is due to a failure in the filament circuit and transmitter-cooling fan circuit, thereby:

a) stopping the motor of the fan that cools the magnetron;

b) disconnecting the automatic control PS (B - Zh) R3 as a result of a failure or of the tripping of the overload [relay].

If the toggle switch is thrown off and on a couple of times without reclosing the plate circuits, the PPK [transceiver] must be shut down and the reason for the failure investigated, or the toggle switch PDU-1 V 12 to PDU-1 V17 of the faulty transmitter must be switched off. Here (when the breakdown is in the plate circuits) the emergency signal from the particular transmitter will die out, and the signalling devices (breakdown lamps) may produce a signal when there is a breakdown in any one of the other transmitters.

Local Reclosing of a Plate Circuit

a) The plate-circuit cabinet is automatically hooked up when the door is opened and then closed, i.e., when the blocking-mechanisms PS (B - Zh) Kp1 and Kp2 are temporarily interrupted.

b) All the cabinets are immediately reconnected when the mode switch ShU-1 V2 is successively thrown to the positions "ANOD-NAKAL-ANOD".

The local reclosing process is analogous to remote closing
as the manipulation of the toggle switch PDU-1 V12-17 is concerned.

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The 400-Cycle Voltage Generator System

The system for regulating the voltage of the 400-cps generator is designed to guarantee remote adjustment of this frequency during automatic control.

The components of the voltage regulating system are found in the PDU-1 unit, the ShU-1 cabinet (both zone 20) and in the high-frequency unit VPL-30 (zones 3-5). The schematic circuit diagram of the VPL-30 unit provides a manual and automatic control of the 400-cps voltage and a local adjustment of the 400-cps voltage during automatic control.

The control, testing and protective system of the radar is designed for automatic regulation of the 400-cps voltage with remote control (adjustment-setting) of its level.

The PDU R8 and ShU-1 R6 remote voltage regulating rheostats and the current-limiting resistor ShU-1 R5 are connected in parallel with the resistance of the VPL-30 unit (zone 4). Such an arrangment allows a change of the voltage level within the limits of 160 - 215 volts.

The 400-cps voltage can be regulated at different times with two rheostats ShU-1 R6 and PDU R8, which are located in the transceiver vehicle and indicator vehicle and are controlled by switch ShU-1 V2-g. (p 259) When this switch is thrown to the "DIST" (remote control) position, the voltage level can be controlled remotely from the PDU-1 remote control panel.

In the other three positions of this switch ("VYKL," "NAKAL" and "ANOD"), the 400-cps voltage level can be controlled remotely from the ShU-1 control cabinet.

System for Controlling and Protecting the Cabin Drive

The system that controls and protects the electric motor that rotates the transceiver cabin provides:

- -- local and remote on and off switching of the electric motor;
- -- rotation of the cabin at 3 rpm at 720 rpm motor speed;
- -- rotation of the cabin at 6 rpm at 1,440 rpm motor speed;
- -- warning sound signal prior to rotation of the cabin;
- -- protection of the power circuits and control circuits for the electric motor from short-circuiting and appreciable overloads;
- -- interruption of the power supply to the electric motor of the cabin drive during manual operation, as well as when the cabin lock is up (locked).

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A schematic circuit diagram of the system that controls and protects the electric motor cabin drive is shown in zones 27-31 in Figure 103. (p 260)

The OK1-M1 electric motor (zone 31) can be switched on and off, regardless of whether the transceiver equipment is on or off.

The electric motor that rotates the cabin is turned on and off by means of the PDU V11 (zones 28, 29) switch, marked "VRASHCHENIYE KABINY" (rotation of cabin), which has three positions: "VYKL.", "3ob", and "6 ob" ("on", "3 rpm", and "6 rpm"). The ShU-1 V6 (zone 29) switch used for local control of motor-rpm has these same positions.

The PDU V11 and ShU-1 V6 switches can be thrown from the "on" position to the "3 rpm" position by merely depressing either of the pushbuttons PDU V18 or ShU-1 V7.

Starting the Cabin-Rotating Motor

In order for the PDU V11 switch to be thrown from the off position to the position "3 rpm", the PDU V18 pushbutton switch (zone 28), which is coupled to it, must be depressed; this supplies power to the OK 5 Tr1 (zone 28) transformer. The current in the primary winding of this transformer passes from voltage phase A (220-v, 50 cps; zones 1, 2) through fuse PDU Pr2 (zone 7), pushbutton switch PDU V18 (zone 28), ring 55 of the TK-03 slip-ring, switch RK V1 (zone 6), ring 73 of the TK-03 slip-ring, to voltage phase B (50 cps, 220-v; zones 1, 2).

At this time the OK 5 U1 (zone 28) warning sound signal operates. (p 261)

When the PDU V11 (zone 29) switch is in the "3 rpm" position, power is supplied from voltage phase A to the winding of the ShU-1 R10-b relay (zones 28, 29), and flows from there through fuse PDU Pr3 (zone 7) switch PDU V11 (zone 29), ring 53 of the TK-03 slip-ring, switch ShU-1 V2-ye (zone 29), blocking [capacitors] OK 3 Kp1 and OK 4 Kp1, the normally closed contact of the OK2 R1 relay, the relay winding ShU-1 R10-b, the normally closed contact of relay ShU-1 R13 (zone 29), switch Rk V1, ring 73 of the TK-03 slip-ring, and to the phase B voltage (220-v, 50 cps; zones 1, 2).

The automatic [relay] ShU-1 R10 operates, breaking its contacts ShU-1 R10-v (zone 29); contacts ShU-1 R10-a (zones 28, 29) are reversed, and the ShU-1 R10-g contacts (zone 30) close. The ShU-1 R10-v contact (zone 29) is a blocking contact, which prevents the switching-on of automatic [relays] ShU-1 R12 and ShU-1R13 when the ShU-1 R10 is at position "3 rpm."

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The closing of contacts ShU-1 R10-g (zone 30) connects the windings of the OK1 electric motor (zone 31), which is connected in a delta network, to the 220-volt, 50-cps power supply; then the electric motor begins to rotate the cabin of the transceiver vehicle.

When the rotor of the electric motor reaches a speed of 550-650 rpm, the contact of the mechanical (centrifugal) relay OK2 R1 (zone 29) is reversed, allowing the circuit of the automatic "6 rpm" relay windings ShU-1 R12-b and ShU-1 R13-b (zone 29) to be closed. (p 262)

If the cabin-rotating switch, "VRASHCHENIYE KABINY", is prematurely thrown from position "3 rpm" to position "6 rpm" before the motor has attained sufficient speed, the motor will die out. If the switch is thrown immediately to "6 rpm", the motor will not turn on.

When the switch is thrown from 3 rpm to 6 rpm, the ShU-1 R12-b and ShU-1 R13-b windings (zone 29) of the automatic 6 rpm control are not able to close the OK2 R1 contact (zone 29). At the same time, both ends of the ShU-1 R10-b winding of the automatic 3 rpm control are connected to the same phase B, i.e., to points of equal potential.

When the switch is thrown from 3-rpm to 6-rpm after the reversal of contact OK2 R1 (zone 29), the automatic 3 rpm control [relay] ShU-1 R10 is deactivated, and the automatic 6-rpm relays ShU-1 R12 and R13, whose windings are connected in parallel, are activated.

When these R12 and R13 relays operate, contact ShU-1 R13a (zone 29) opens, and contacts ShU-1 R12a (zone 29), R12-v (zone 30) and R13-v (zone 31) close.

Contact ShU-1 R13a (zone 29) of the mutual blocking device of the automatic 6-rpm and 3-rpm relays opens the circuit of the ShU-1 R10-b winding (zone 28) of the automatic 3-rpm relay. (p 263)

Contact ShU-1 R12-a (zone 29) blocks the normally open contacts of relay OK2 R1 (zone 29), and the main contacts ShU-1 R12-v (zone 30) of the automatic 6-rpm relay ShU-1 R 12 switch the windings of the OK 1 M1 electric motor (zone 31) from the delta to the double-star network.

The main contacts ShU-1 R13-v of the automatic 6-rpm relay connect the windings of the OK 1 M1 electric motor to the 220-volt, 50-cycle network. The electric motor that drives the cabin increases speed until it reaches the operating speed to rotate the cabin at 6 rpm.

Local control of the system is similar to that described above.

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Protection of the Electric Motor

The protection of the power circuits of the motor from shorting and overloading is guaranteed by the overload and thermal protection of the automatic 3-rpm control ShU-1 V10 and of the automatic 6-rpm relay ShU-1 R13.

A reciprocal blocking arrangement in the control circuits of the automatic 3-rpm and 6-rpm [relays], consisting of contacts ShU-1 R10-v (zone 29) and ShU-1 R13-a (zone 29), prevents the possibility of the two speeds being turned on at the same time.

The safety fuses that protect the control circuits of the transceiver equipment are used to protect the control circuits of the electric (p 264) motor that rotates the cabin from shorting and appreciable overloads.

The manual-drive blocking contacts OK3 KP1 are connected to the control circuit of the cabin-rotating motor in order to guarantee safe operation of the manual cabin-rotating drive. In series with these contacts is a cabin-lock cutoff OK4 PK1, which cuts off the electric motor when the cabin is braked (or stuck).

In order for the cabin-lock cutoff to operate properly, the lock rods must be all the way in the socket.

Control, Testing and Protection of the Antenna-Elevating Mechanisms

The system for controlling, testing and protecting the antenna-elevating mechanisms provides:

— remote switching-on, switching-off and reversing of the electric motors that drive the antenna-elevating mechanisms (horizontal and slant antennas separately);

— mechanical disconnection of the electric motors of each of the antennas when the latter reach their limiting positions;

— mechanical elevation of the antennas by manual drive;

— remote monitoring of the angle of elevation of the antennas (horizontal and slant antennas separtely);

— protection of the electrical circuits of the motor and selsyns.

A schematic circuit diagram of the system for controlling, te[redacted] (p 265) ing and protecting the antenna-elevating mechanisms is shown in zones 30-35.

Remote control and monitoring are done from the PDU-1 remote control panel and the UN1 and UNP voltage-regulation units.

This system consists of two systems similar in type (the system for elevating the horizontal antenna and the system for elevating the slant antenna), the elements of which differ in design only very slightly.

Controlling the Electric Motors of the Antenna-Elevating Mechanisms

The MK1 M1 motor (zone 31) of the mechanism that elevates the horizontal antenna is switched remotely (on, off, reverse) by switch PDU V8, which has three positions: "VERKH" (high), "NIZ" (low) and a third central position at which the motor is disconnected.

The switch automatically moves from the extreme positions to the center off position.

The MK1 M1 motor can also be switched remotely (on, off, reverse) from the UN1 antenna-rocking control unit by means of switch UN1 V1 (zones 30-31), which also has the same three positions.

An analogous switch PDU V9 (zone 32) controls the MK1 M1 motor (zone 32) of the slant-antenna elevating mechanism from the PDU-1 unit, and switch UNP1 (zone 32) controls the mechanism from the slant-antenna rocking control unit UNP. (p 266)

The UNP V1 (zone 32) switch also returns automatically to the center (off) position from the extreme positions. The PDU-1, UN1 and UNP units control the antenna elevating mechanisms in separate (not combined) operation only.

The design and principle of operation of the antenna elevating mechanisms are described in CHAPTER ELEVEN.

Remote Monitoring of the Elevation Angles of the Antennas

The elevation angle of each antenna is checked by the corresponding selsyn generators.

The angle of elevation of the horizontal antenna is read from the dials of the receiving selsyn PDU M1 (zone 33) and UN1 M1 (zone 34), and the angle of elevation of the slant antenna is read from the dials of the PDU M2 and UNP M1 receiving selsyn.

110 volts from the PDU Tr1 transformer (zone 27) is fed to the excitation windings of the receiving selsyn.

110 volts from the ShU-1 Tr4 transformer (zone 33) is fed to the excitation windings of the SD1 M1 (zone 33) and SDP M1 (zone 35) transmitting selsyn through safety fuse ShU-1 Pr6 (zones 32, 33). (p 267)

Circuit Protection

The electric motors of the elevating mechanisms are protected from overloads by the thermal protection of the automatic ShU-1 R14 (zone 31) and ShU-1 R15 (zones 32, 33) relays, and are protected from short-circuiting by the overload protection of the same automatic relays.

Safety fuses protect the selsyn circuits from shorting and from extreme overloading.

System For Controlling and Protecting Transceiver Accessories

The system for controlling and protecting the auxiliary devices for the transceiver equipment:

— connects all external electrical circuits with the rotating cabin;
— switches the 50-cps and 400-cps three-phase power networks on and off;
— switches the light bulbs in the transceiver cabin on and off locally, and switches them from the regular operating power to emergency power; (p 268)
— switches the rotating-cabin exhaust fans and electric heaters on and off;
— switches the same exhaust fans and electric heaters from regular power to external power during repairs;
— switches on the measuring instruments;
— switches on the portable lights and soldering irons;
— protects the 50 and 400-cps power networks for the illumination, electric fans, electric heaters and plug and jack assemblies;
— protects against lightning.

The components of this system of auxiliary control and protection are shown in the schematic circuit diagram of the system for controlling, checking and protecting the radar.

The rings of slip-ring TK-03 (zones 6-36) connect up all the external electrical circuits with the rotating cabin.

Switch RK V1 (zones 6, 7) switches the 50-cps and 400-cps power networks on and off locally.

Local switching-on, switching-off and reversing from regular to emergency power of the OK7 LN1 (zone 33), OK8 LN1 and OK12 LN1 cabin lights is done by the ShU-1 V7 (zone 33) switch, marked OSVESHCHENIYE (illumination), which has three positions: SET' (network), VYKL (off), and AKKUM (battery). Under ordinary conditions, the illumination lamps are connected up to the 50-cps power network through transformer ShU-1 tr-4 (zone 33). (p 269)

Three OK10 batteries connected in series (zone 34) are used as an emergency power source for illumination.

The automatic [relays] ShU-1 R16 (zones 36, 37) and ShU1 R17 (zones 37, 38) provide local switching of the OK5 ML (zone 36) and OK 6 ML (zone 37) electric motors of the cabin exhaust fans, and also provide protection against overloading and shorting. Switch ShU-1 V8, marked OBOGREV KABINY (cabin heating), turns the OK9 electric heaters (zones 38, 39) on and off.

Switch RK V2 (zones 37, 38), which has the three positions, VNUTR (internal), VYKL (off) and VNESHN (external), switches the cabin fan motors and electric heaters from the internal power network to the external.

Sockets of the ShU-1 and PPS cabinets on the TK-03 slip-ring RK distributor box and in the KK-3 cable box on the outside wall of the rotating cabin are used to connect up the measuring instruments, portable lights and soldering irons. These sockets are supplied with 220 volts, 50 cps.

On the ShU-1 cabinet are sockets with 12-volt AC-DC power, connected to the cabin-lighting circuit, which supply power to the low-voltage lamps and soldering irons.

The 220-volt, 50-cps power networks are protected from overloads and short-circuiting by automatic devices [relays] in the corresponding units. (p 270)

The 200-volt, 400-cps, power networks are protected from overloads and shorting by the VPL-30 AV 1 (zone 5) starter and safety fuses in the PS transmitters 1 - 6.

Fuses in the various units of the transceiver cabin protect the lighting, heating, and plug-and-socket circuits from shorting and high overloads.

All the vehicles have lightning rods; lightning rod "3" of the transceiver vehicle is shown in zone 7. The ground in the transceiver vehicle passes through ring 5 of the TK-03 slip-ring (zone 7), the chassis of the ShU-1 cabinet, and from there to all the cabinets and units of the equipment.

The transceiver-cabin grounding terminal, which is connected to the cabin undercarriage and ring 5 of slip-ring TK-03, is located in the KK-1 cable box.

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3. Units of the System

The ShU-1 Control Cabinet

The ShU-1 control cabinet (Figure 104) is in the transceiver cabin.

In the control cabinet are the controlling, adjusting and testing devices, relays and automatic devices which connect and service the transceiver equipment fuses and signal lamps. The control cabinet also contains items not integrally connected to it, namely the ABZ emergency trigger unit, the transformer that supplies the main transducer unit FD-02 (selsyn unit), the transformer that supplies both the cabin lighting circuits and those of the selsyns in the antenna-elevating mechanisms. (p 271)

The RT-10B radar tester is on the top cover of the control cabinet.

Two three-phase voltages (220 volts, 50 cycles; 200 volts, 400 cycles) are supplied to the control cabinet from distributor box RK.

Twelve volts AC are fed from the OK 10 battery to the control cabinet.

Figure 105 shows the schematic circuit diagram for the ShU-1 control cabinet. Section 2 of this chapter describes the operation of the automatic devices and control devices of the ShU-1, which are a component part of the control, testing and protective system of the radar.

Their distribution in the panel is shown in Figure 106. The lower part of the cabinet contains the pull-out ABZ trigger unit.

Between the swing-open panel and the pull-out units are the automatic protective devices for the antenna rocking mechanisms and the automatic cabin fan switches. (p 274)

Behind the front panel, inside the cabinet, is a panel with relays and automatic devides; this panel can be swung forward until stopped by two extensions; in the operating position, it is held by two safety-locked screws.

When the front panel is open and the swing-out panel is swung out, the contact strips inside the control cabinet are accessible.

A schematic circuit diagram of the ShU-1 is on the inside right wall of the cabinet.

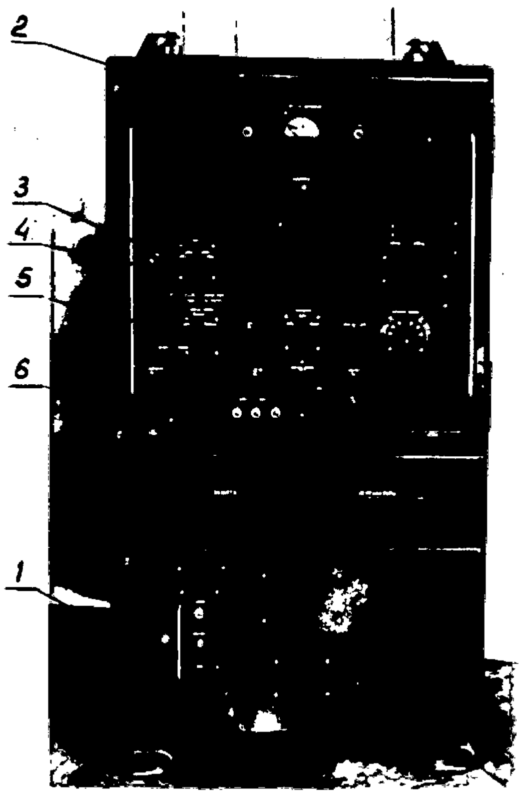

Fig 104. ShU-1 Control Cabinet (p 272)

1. ABZ trigger unit
2. meter
3. mode switch
4. pushbutton switch
5. cabin-rotation switch
6. 12-volt socket

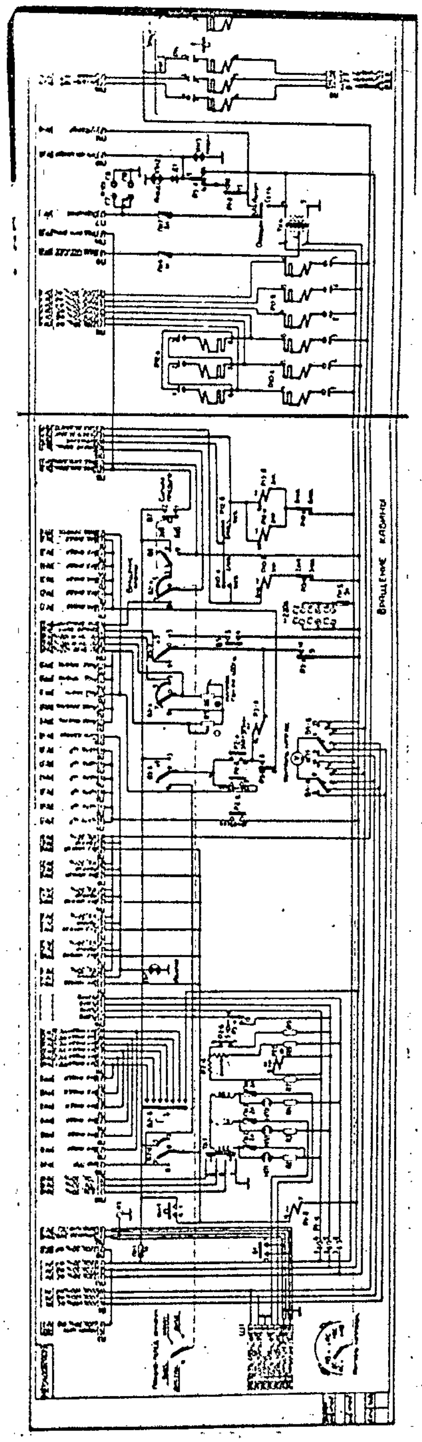

Fig 105. Schematic Diagram of the ShU-1 Control Cabinet (p 273)

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The PDU-1 Remote Control Panel

The PDU-1 (Figure 107) is in the center upper part of the DUS-1 remote-control cabinet in the indicator vehicle and is used for the remote control of the transceiver equipment and auxiliaries and to regulate, check, protect and indicate their operation.

A schematic circuit diagram of the PDU-1 is shown in Figure 108. (p 275)

The PDU-1 components are supplied 220 volts, 50-cycles, from one three-phase network and 200 volts, 400 cycles, from the other three-phase network, as well as -150 volts from the BP-150 power pack in the DUS-1 remote control cabinet.

The operation of the PDU-1 components is described in section 2 of this chapter. The PDU-1 is of a flat metal design and swings down on hinges to the horizontal position where it is held by side rods attached tothe DUS-1 cabinet.

When the panel is opened, the circuit components can be reached for testing or repair.

In the operating position, the panel is held in the vertical position by two safety-locked screws.

A schematic circuit diagram of the PDU-1 is displayed on the metal rack mounted on the top of the PDU-1 cabinet.

The UN I and UN II Units

The UN I and UN II units (Figure 109) control the rocking of the horizontal and slant antennas.

These units are located in vehicle No 2; the UN I unit is at the top right of the IKO-1 (PPI) cabinet, and the UN II is also at the top right of the IIV-1 height-measuring indicator. The units contain receiving selsyns and switches for controlling the rocking of the antennas. (p 279)

Figure 110 gives the schematic diagrams of the units. The units are fed phase A and phase B voltages, 220 volts, 50 cycles, from the three-phase network, through the RShch [control panel?] of vehicle No 2.

The operation of these units is described in the section on the operation of the antenna rocking mechanisms. Both units are made of a welded steel frame and sheet side panels, which can be removed for access to components.

The schematic circuit diagrams are on the outside walls of the units, the UN I on the right, the UN II on the left wall.

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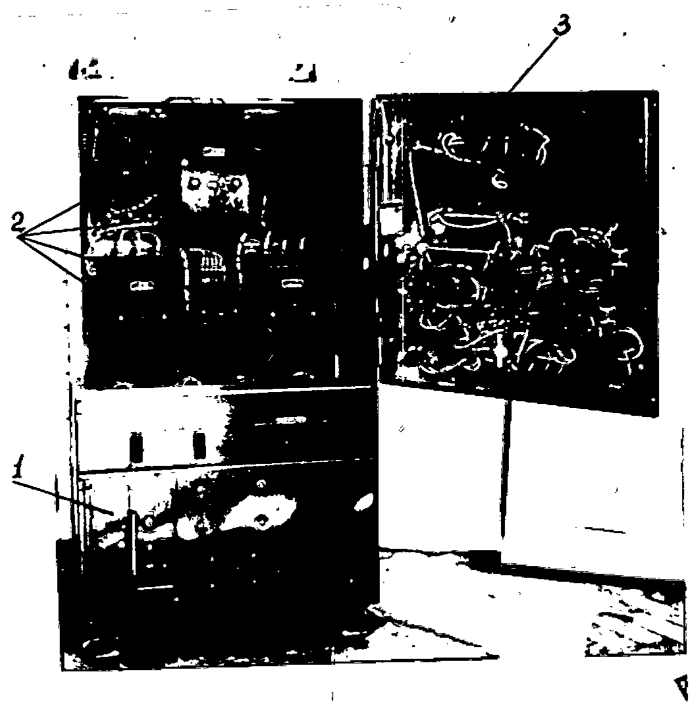

Fig 106. ShU-1 Cabinet With Open Front Panel (p 276)

1. ABZ control unit
2. automatic controls and relays
3. control panel

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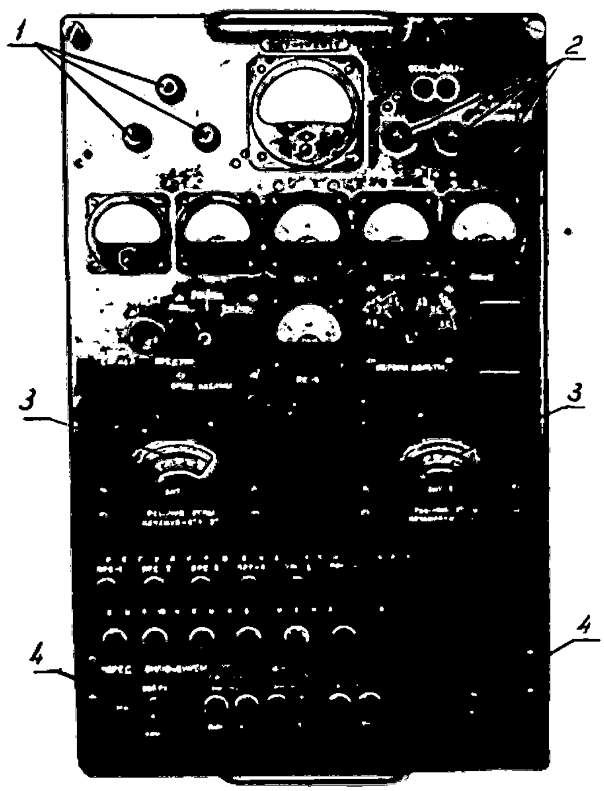

Fig 107. PDU-1 Remote Control Panel (p 277)

1. fuses
2. signal lamps
3. dials of receiving selsyns
4. rocking-mechanism switches

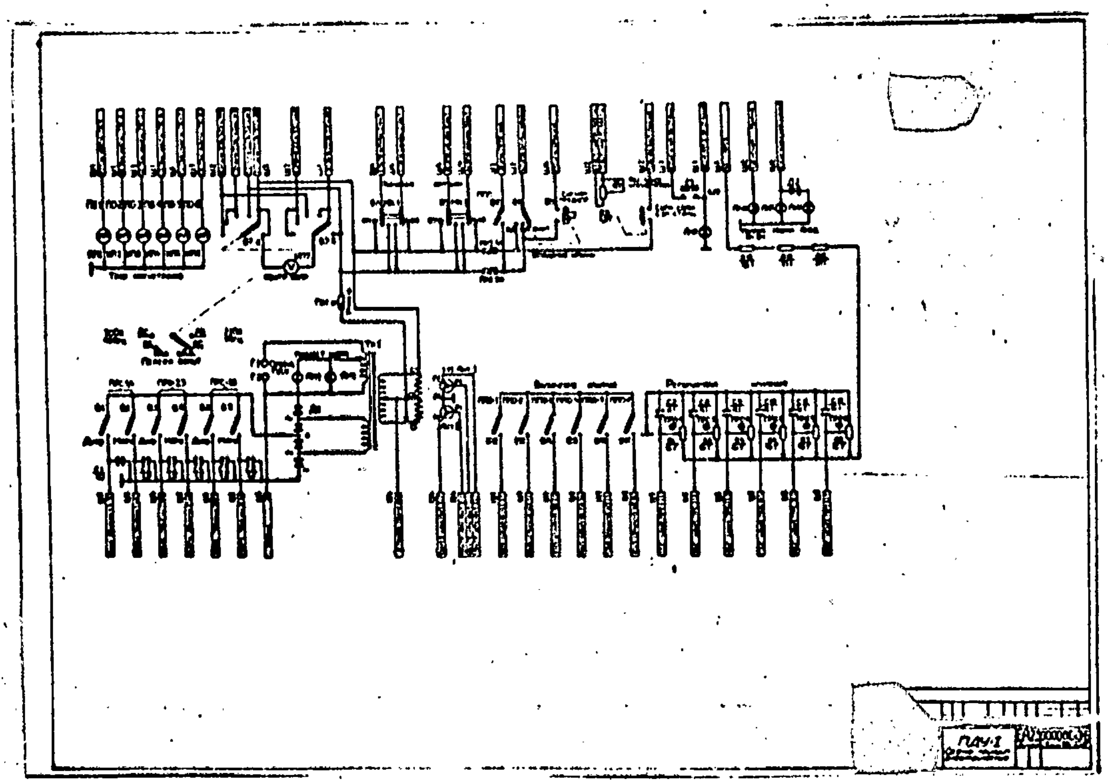

Fig 108. Schematic Diagram of the PDU-1 Remote Control Panel (p 278)

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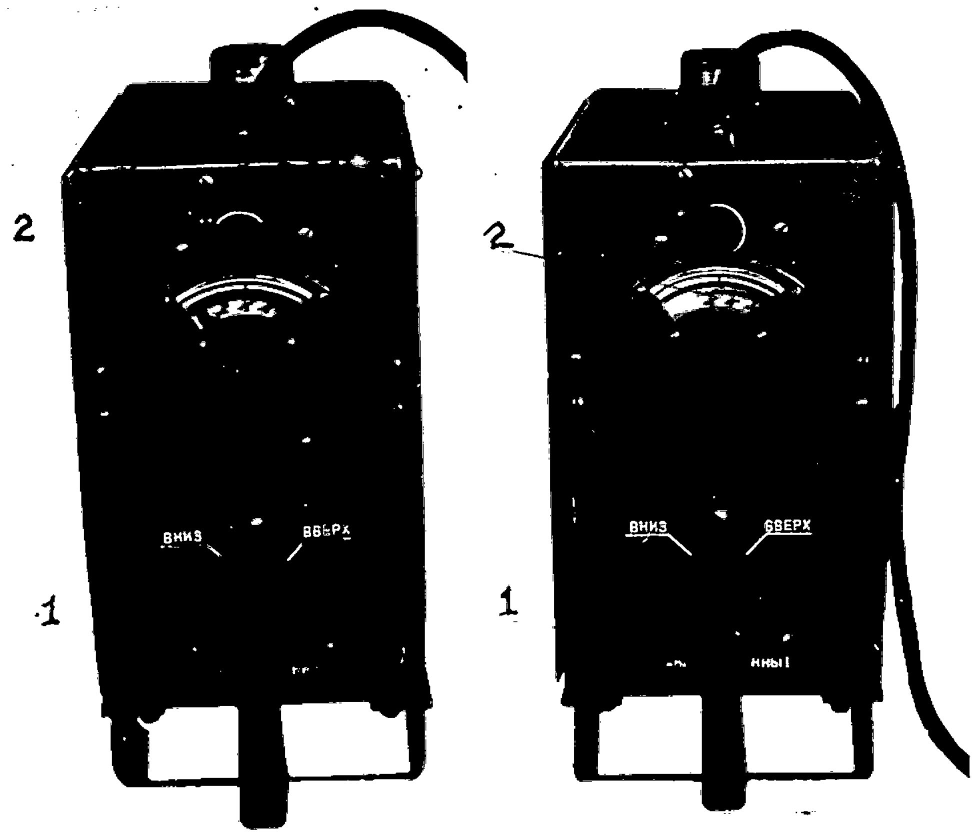

Fig 109. UN-I and UN-II Antenna Rocking Controls (p 280)

1. switches of antenna rocking mechanisms
2. dials of receiving selsyns (selsyn motors)

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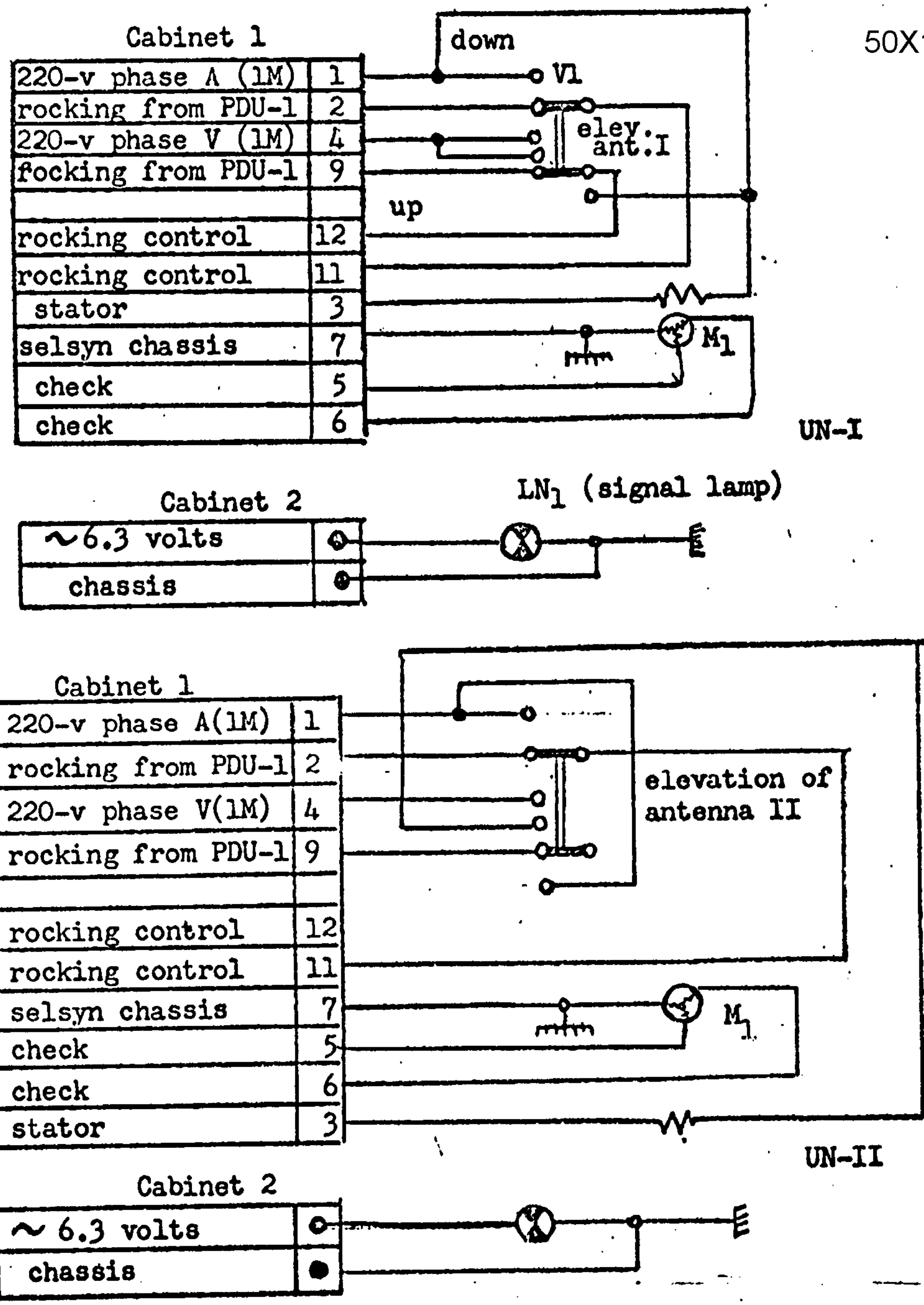

Fig 110. Principal Circuit Diagram of the UN-I and UN-II Antenna Rocking Controls

(p 281)

4. The ABZ (Emergency Trigger) Unit

The purpose of the ABZ unit:

1. to form trigger pulses used in the automatic operation of the PPA; and

2. to switch the triggering of the PPA (transceiver) automatically.

When trigger pulses arrive from the BZ unit of the ZNF (master voltage) cabinet, they are applied to the input of the transmitter trigger circuit; when the supply of trigger pulses from the BZ unit of the ZNF-1 cabinet to the input of the PPA trigger circuit is cut off, equivalent pulses are fed from the ABZ unit of the ShU cabinet.

The switching circuit provides a switching-over from the BZ unit in the ZNF cabinet to the triggering of the transmitters from the ABZ unit in the ShU-1 cabinet. (p 282)

The current supplied from the 50-cycle network does not exceed 0.3 amp at 220 volts.

The protective circuit for the unit guarantees the removal of the output voltage whenever there is á short in the "plus 330-volt" circuit.

Principal Circuit Diagram of the ABZ. NB2.075.901 SKhE

The unit is fed with 220 volts AC, 50 cps at the primary of transformer Tr-1 through fuse Pr-1 (0.25 amp). The rectifier is designed as a bridge circuit with four selenium piles, type AVS-25-15.

The rectified voltage is fed through a pi-shaped filter, consisting of resistor R1 and capacitors C1 and C2, to the plate circuit of tube V1 (6P8S) of the pulse triggering circuit and to the plate circuits of tubes V3 (6N8S) and V4 (6P9) of the automatic trigger switching circuit.

The trapezoidal voltage from the output of the second stage of the amplifier-limiter is fed through capacitor C5 to the 3.6 winding of blocking transformer Tr2 where it is differentiated. (p 284)

The peaked pulses formed as a result of differentiation are fed to the grid circuit of the blocking oscillator which is operated in the triggered mode by a negative bias taken from resistor R10 of voltage divider R11, R10.

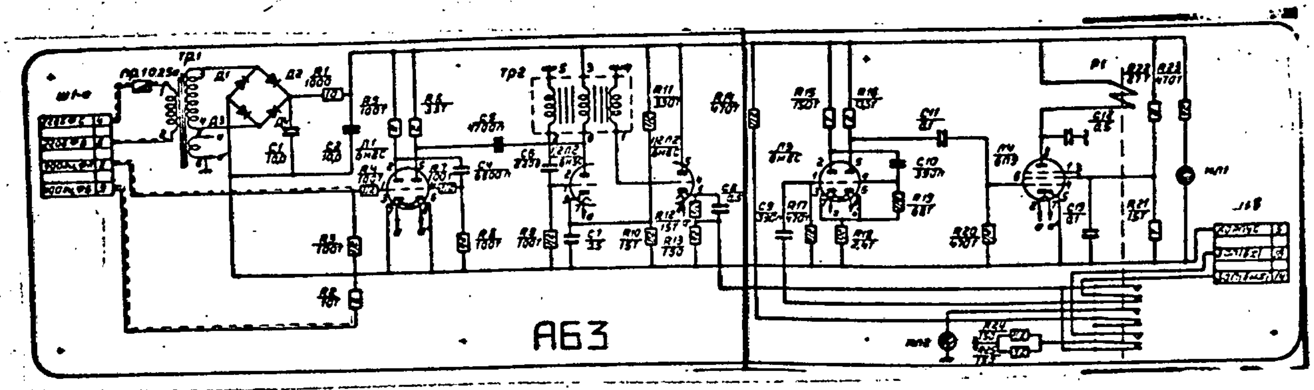

Fig 111. Principal Circuit Diagram of the ABZ Unit (p 283)

This trigger-pulse forming circuit consists of a two-stage plate-grid amplifier-limiter tube V-1 (6N8S), and blocking oscillator V-2 (½ 6N8S), cathode follower V-2 (½ 6N8S). Through contacts 8 and 9 of the ShU-1 socket, a sinusoidal 400-cps voltage is fed from the ShU cabinet to the input of the first stage of the amplifier-limiter.

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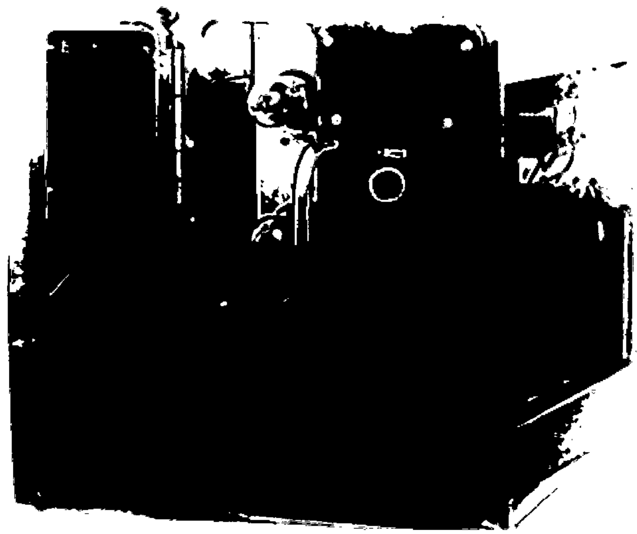
Fig 112. (p 287)

General View of the ABZ Emergency Trigger Unit



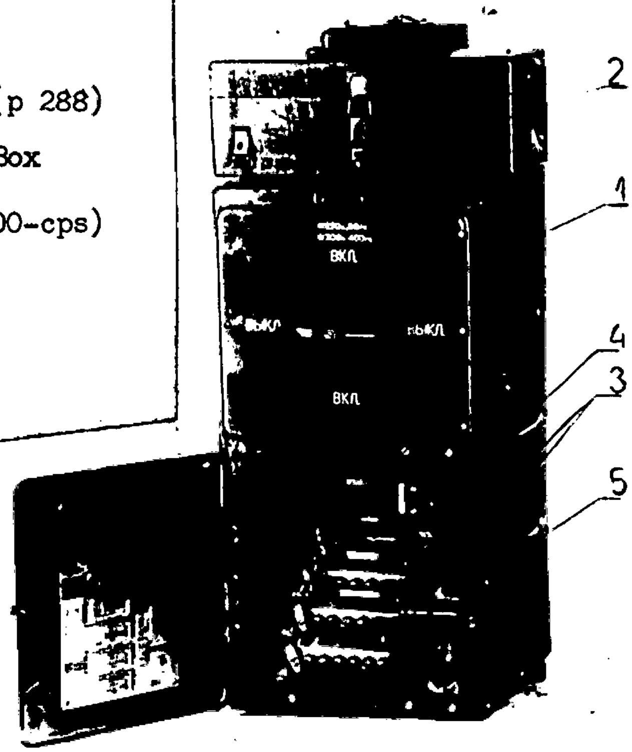


Fig 113. (p 288)

General View of RK Distributor Box

1. voltage switch (50 and 400-cps)
2. tester in case
3. fuses
4. switch V2
5. busbar assembly

low value of the plate current. Since the winding of relay RSCh-52 is connected to the plate circuit of tube V4, the relay is de-energized, and its moving contacts come together with the lower fixed contacts.

When the trigger pulses are cut off at the input of the thyratron, the negative bias is removed from the grid of tube V4; its plate current increases, causing relay RSCh-52 to operate.

The moving contacts of the RSCh-52 relay are closed against the upper fixed contacts.

Design of the ABZ (Emergency Trigger) Unit

The unit is assembled on a standard chassis and installed in the left lower opening of cabinet ShU-1.

The tube section of the assembly contains: three 6N8S tubes (tubes V1, V2, and V3) and one 6N9 (V4). Inside are transformers Tr-1 and Tr-2, selenium piles AVS-25-15, capacitors C1 and C2, relay RSCh-52, and a resistor (R1) type PEV-10.

Type MLT resistors and type KSO capacitors are mounted on tube panels, supporting contacts and two mounting plates.

On the front panel of the unit are the PR1 fuse and two TN-0.3 signal lamps.

The distributor box contains the components for switching-on, switching-off, reversing and directing electrical energy, the distribution busbar, safety-fuse holders and plug sockets. (p 289)

On the top of the box, with the special sockets, are the ampere-voltmeter (tester) and microammeter in containers.

When switch V1 is on, a three-phase voltage (220 volts, 50 cps; 200 volts, 400 cps) is fed to busbars P1-P6, which distribute the electrical energy to the equipment of the PPS (transceiver) cabinets and the ShU-1 control cabinets. Switch V2 connects the electric heaters and electric exhaust fans, plus the plug and jack assemblies G1-G4 to the internal or external voltage network (220 volts, 50 cps).

Safety fuses Pr1 and Pr2 protect against short circuiting during operations with the portable electrical equipment and instruments.

The distributor RK is designed as a rectangular box and consists of a frame, top cover, front panel, packaged six-pole switch, busbar assembly, external power supply panel, a front door that opens, two side pa[illegible] one bottom panel.

The busbar assembly is near the bottom of the chassis. The 50X1-HUM busbars are attached to insulating sheets and have bolt and screw connectors.

The external power supply panel is on the right of the busbar assembly, behind the front door.

A schematic circuit diagram is attached to the back of the door. (p 290)

5. Control, Testing and Protective Equipment. General Information

Among the electrical equipment and instruments of the control, testing and protection system for the radar are certain special automatic devices and relays that are designed for use under conditions other than normal.

These are classified as follows:

Automatic devices:

— automatic devices with electromagnets (remote AC drives, types AD-3x5, AD-3x5 b/z; AD-3x15);

— automatic devices with hand operation, types AP50-ZMT, AZ120.

Relays:

— AC timing relays: motor relay type RVM-300-2 and thermal relays type TRV-1VM;

— centrifugal speed-control relays, types TsR-1 and mechanical (MR);

— electromagnetic voltage relays:

a) DC relays, types RAD-4P, RSCh-52
b) AC relays, type RA-4P;

— electromagnetic current relays: DC relays, type (p 291) RKMP-1, RES-6.

The schematic circuit diagrams of these automatic devices and relays are shown in Figure 114.

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Automatic Devices

The type AD-3x5 automatic device is designed to switch on and switch off the three-phase electrical circuits (220 volts, 50 cps, nominal current 5 amp) and to protect them from current overloads.

It has a main electromagnet GE, three main contacts GK, two groups of block-contacts BK, three thermal tripping devices (bimetal sheets) BP, which operate at medium current overloads, and three electromagnetic tripping devices ME, which operate at maximum current overloads. Each of the three poles of the automatic device consists of a GK, BP, and ME connected in series.

The nominal voltage of the GE winding is 220 volts, 50 cycles.

A simplification of the kinematic diagram for the AD-3x5 automatic device is given in Figure 115. The simplification involves the presentation of the elements of only one pole of the automatic device, instead of three, and of one group of BK, instead of two. The rigidly coupled parts form one section.

There are eight moving parts and one fixed chassis.

On the diagram the moving parts are shown with the automatic device in the "on" position (armature of the main electromagnet drawn in). (p 292) The directions of movement of the parts when the automatic device is turned off are shown by the unbroken arrows. These directions are opposite when the main electromagnet is turned on.

When a current overload passes through the pole of the automatic device, its current tripping device BP or electromagnetic tripping device ME causes the shaft of the protective relay to rotate, which opens the main contact GK and reverses the switch VK. The motion of the parts in such a case is shown on the kinematic diagram by broken arrows. The automatic device is switched on again only when the main electromagnet is energized.

<u>The Automatic Device Type AD-3x5 b/z</u> (without protection) is designed to switch on and switch off the three-phase electrical networks with 200 volts, 400-cps, nominal current 10 amps, or 220 volts, 50 cps, nominal current 5 amps. Unlike the type AD-3x5 automatic device, it has no electrical protection, neither BP (bimetal sheets) nor ME electromagnetic tripping device (Figures 114 and 115).

The nominal voltage of the GE (main electromagnet) winding is 220 volts, 50 cycles.

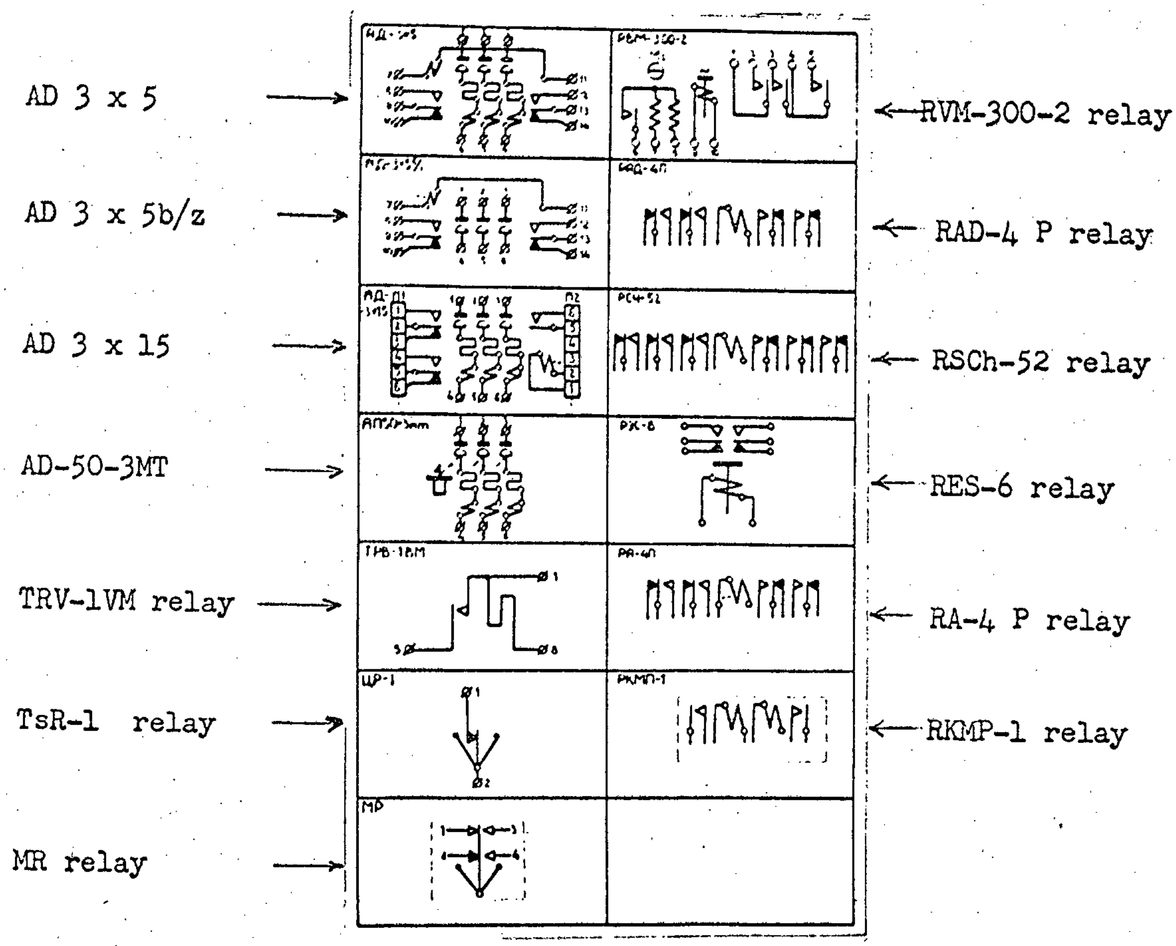


Fig 114. Schematic Circuit Diagrams of Automatic Devices

(p 293)

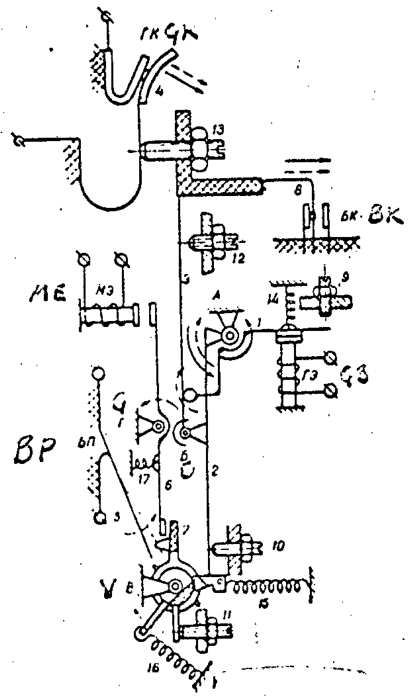


Fig 115. Simplified Kinematic Diagram of the AD-3 x 5 Automatic Device (p 294)

1. armature of main electromagnet with arm and cylindrical push rod
2. protective clamp with cam
3. clamp with plastic push rod and adjusting screws
4. spring-actuated main contact GK
5. bimetal sheet BP
6. moving contact BK

9-13. adjusting screws

14-17. retracting springs

A,B,V,G: pivots
GE: main electromagnet
GK: main contact
BK: block contact
ME: electromagnetic current tripping device
BP: thermal current tripping device

The Automatic Device Type AD-3x15 is designed to switch on and switch off the three-phase electrical networks with 220 volts, 50 cycles and nominal current 15 amperes, in order to protect these networks from current overloads.

It has one main electromagnet GE, three main contacts GK, two groups of block-contacts BK, one signal contact SK to check the operation of the tripping devices, three thermal tripping devices (bimetal sheets) BP, which operate when maximum current overloads occur, and a blocking (p 295) mechanism BM which produces a visual signal when the tripping device operates. Each of the three poles consists of a main contact GK, an electromagnetic tripping device ME and a bimetal-sheet tripping device connected in series.

The nominal voltage of the GE winding is 220 volts, 50 cps.

A simplified kinematic diagram of the AD-3x15 automatic device is shown in Figure 116. The simplification involves the illustration of the elements of only one pole of the automatic device, rather than three. The rigidly coupled parts form one section.

The moving parts are shown on the diagram with the automatic device in the "on" position (armature of the main magnet drawn in). The direction of motion of the parts when the automatic device is turned off is shown by unbroken arrows (directions opposite when automatic device is on).

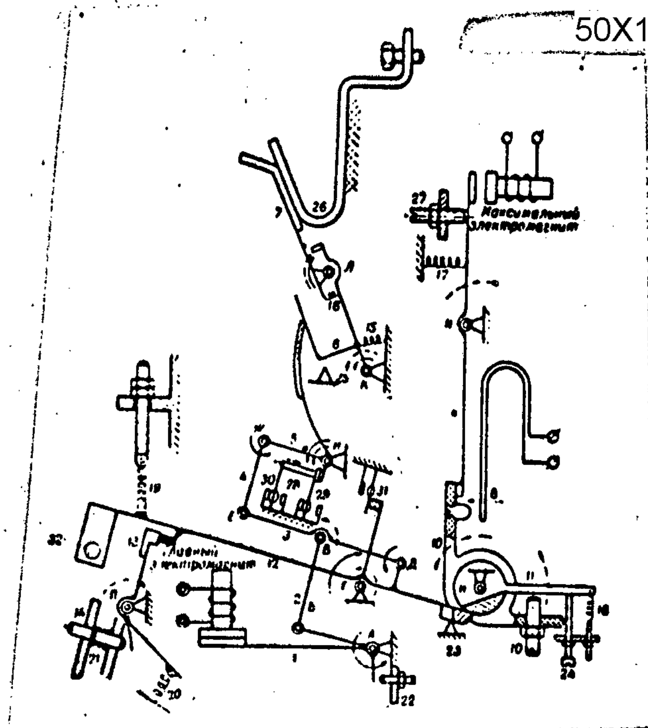
When an overload current passes through the pole of the automatic device, the current tripping devices BP and ME cause the shaft of the protective relay to turn, which opens the main contact GK, reverses the block-contact BK and closes the signal contact SK. The motion of the parts for this case is shown on the kinematic diagram by broken arrows. The positions of the parts of the automatic device and, consequently, of the contacts after the tripping device has operated are held by the blocking mechanism MB (BM). The automatic device is switched on again only when the main electromagnet is energized, after being released manually.

The Automatic Device AP 50-3MT is designed to switch on and switch (p 297) off the electrical networks with 380 volts, 50 cps, or the networks with 220 volts and nominal current of 2.5 amps.

The AP 50-3MT has a manual drive mechanism, with pushbutton on and off switches, three main contacts GK, three thermal tripping devices (bimetal sheets with heaters) BP, which operate under medium current overloads, and three electromagnetic tripping devices ME, which operate at maximum current overloads. Each of the three poles of the automatic device consists of one main contact GK, one thermal tripping device BP and one electromagnetic tripping device ME connected in series. The adjusted current of the thermal tripping device is 1.75 amps.

Fig 116. (p 296)

Simplified Kinematic Diagram of AD-3 x 15 Automatic Device



1. armature of main electromagnet, axis of armature, lever arm on axis and arm limiting armature movement
2. link
3. intermediate lever
4. link
5. lever on axis of push rod axis of push rod, push rods of main contacts with screws for adjusting gaps between main contact and lever of block dontacts
6. lever of moving contact
7. moving (floating) contact
8. bimetal sheet of thermal current-tripping device
9. armature of electromagnetic current-tripping device
10. plastic lever on shaft of cutoff with adjusting screw
11. shaft of cutoff with flat and lever arms
12. axle of cutoff lever and of signal contact
13. catch, axle and its lever
14. pushbutton for MB blocking mechanism
15. retracting spring of mving contact
16. spring producing contact pressure
17. retracting spring of electromagnetic current tripping device
18. retracting spring of cutoff shaft
19. retracting spring of spring levers
20. spring of catch
21. spring of pushbutton for blocking mechanism
22. armature travel limiter
23. support
24. adjusting screw
25. support
26. fixed contact
27. adjusting screw
28. push rod of block contact
29. second group of block contacts
30. first group of block contacts
31. signal contact
32. signal slot

A, Б, В, Г, Д, Е, Ж, З, И, К, Л, М, Н, and П : pivots

The principle of operation of the tripping mechanisms of this automatic device is analogous to that of the automatic devices type AD-3x5 (Figure 115).

Relays

The Motor Timing Relay, Type RVM-300-2 operates on two-phase (approximately 90 degrees phase difference) AC (110 volts, 50 cps), and is designed to close and open three electric circuits with 220 volts, 50 cps, nominal currents of 3 amps, with time lags of from 30-65 seconds to 340-375 seconds.

The circuits are opened simultaneously.

The relay has a two-phase synchronous motor, solid and hollow shafts, four adjustable cams, electromagnetic clutch, which connects the above- (p 298) mentioned shafts mechanically, gear and worm drives which reduce the rpm of the motor shaft down to the rpm of the camshaft, and four switches, one of which shuts off the electric motor.

The nominal voltage of the electromagnet of the clutch is 220 volts, 50 cps.

A kinematic diagram of the RVM-300-2 type relay is shown in Figure 117.

The Thermal Timing Relay, Type TRV-1VM is designed to close the electric circuit with 220 volts, 50 cps, and maximum current of 0.5 amp. The closed circuit should have an electrical cutoff to guarantee disconnection of the relay immediately after it has operated. The relay contact should open without current.

The time delay is produced in the TRV-1VM relay by indirect heating of the bimetal sheet, when the heater winding is fed a 220 volt, 50-cps current through a 2-kilohm resistor connected in series. With this resistance value a nominal time lag of 25-35 seconds is obtained.

Since the relay has contact-type temperature compensation, the time of its response depends little on ambient temperature. There is additional compensation by the bimetal sheet with the winding.

The Type RSR-1 Relay acts as a commutator of one electrical 220-volt, 50-cps, network with nominal current of 0.5 amp when the speed of the (p 299) shaft of the relay rotor is increased or decreased within the limits 1,800-2,100 rpm.

The nominal rpm for the relay is 3,000 rpm.

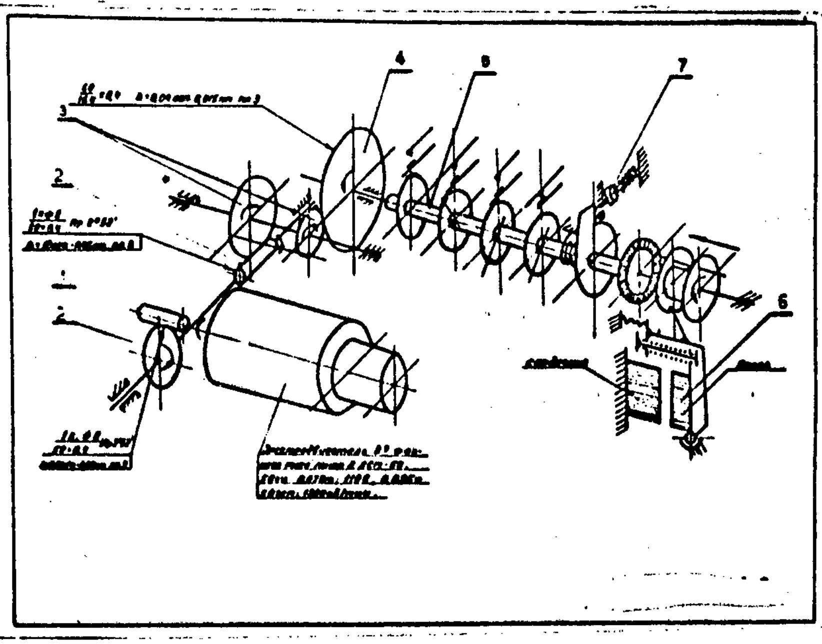


Fig 117. Kinematic Diagram of Relay RVM-300-2 (p 300)

1. worm on shaft of electric motor
2. worm wheel and worm
3. worm wheel and gear
4. gear on inside (solid) shaft
5. outside (hollow) shaft with adjustable cams
6. armature of electromagnet of the clutch with parts that provide a shifting of the meshing part of the clutch with the cam
7. shock absorber

The relay consists of the fixed body (stator) with brushes and rotating rotor with two-ring slip-ring, separately connected to the supporting (fixed) contacts, and with the weighted flat contact (moving) spring.

The Mechanical Relay (MR) switches one electrical network (220 volts, 50 cps, one amp) in two directions when that shaft speed is reached at which the relay motor is set.

When the rotor speed increases, the relay operates (reverses contacts) at 550-600 rpm. The nominal relay rotor speed is 1,500 rpm.

The relay has a fixed stator and rotating rotor with solid ring, which is almost perpendicular to the axis of the rotor when it is rotating. In the initial position, the ring is not perpendicular to the axis of rotation. The centrifugal force of the ring creates the axial force required to reverse the relay contacts.

The RAD-4P Type Relay is designed to switch four electrical networks (220 volts, 50 cps, 3 amp) in two directions simultaneously. The nominal voltage of the electromagnet in the relay is 220 volts DC. A 4,000-ohm limiting resistance is connected into the circuit of the relay winding. Upon starting, it is short-circuited by the forcing block-contacts of the relay. (p 301)

The RSCh-52 Type Relay can simultaneously switch in two directions six noninductive circuits with 26 volts, 2 amps, or with 300 volts and 0.125 amp nominal current.

The nominal voltage of the electromagnet winding in the relay is 135 volts DC.

The RES-6 Relay switches on and off two 28-volt DC (one amp) electrical circuits with noninductive load.

The nominal current of the electromagnet winding of the relay is 32 milliamps.

The current is DC.

The RA-4P Relay simultaneously switches in two directions four circuits with 220 volts, 50 cps and nominal current of 2 amps.

The nominal voltage of the electromagnet winding in the relay is 220 volts 50 cps.

The DC Type RKMP-1 Relay is a two-coil relay which uses an operating current of 526-575 milliamps for the secondary winding of its electromagnet, or 135-175 milliamps for the primary and secondary connected in series.

When the secondary functions and the primary is shorted, the relay (p 302) has a 50-microsecond delay in responding.

This relay is used to protect DC networks from current overloads.

The relay contacts can switch a 2-amp current when the voltage at the open contacts is 32 volts DC, or a -.1-amp current at 300 volts DC, with noninductive loads.

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(p 303)

CHAPTER SEVEN

ROTATING CABIN ACCESSORIES

In addition to the cabin equipment described above, there are also other accessories inside the cabin. These include: the cabin rotating mechanism, the slip-ring, exhaust fans, heaters, lights, signalling and cutoff devices, parts to the mechanical and electrical equipment, cabinet and box containing inventory items and instruments.

1. The TK-03 Slip-Ring

The slip-ring (shown in Figure 118) connects the external power circuits to the transceiver equipment and other equipment inside the cabin.

The TK-03 slip-ring, which is in the center of the cabin, provides: the transfer of electric power (50 cps) from the power plant and (400-cps) from the VPL-30 high-frequency unit; electrical connection of the video signal circuits, the synchro-generator circuits, control circuits, testing and protective circuits, and the ground.

The TK-03 has six power rings, each designed for up to 40 amperes; (p 304) 12 high-frequency shielded rings; 56 low-frequency rings, each designed for up to 10 amperes; and one grounded ring.

The linear speed of the wiping contact of a slip-ring pair (brass collector, copper-graphite brush) does not exceed 0.13 meter per second.

The specific pressure of the power rings is not less than 630 grams per square centimeter, not less than 840 grams per square centimeter for the high-frequency and low-frequency brushes, and not less than 350 grams per square centimeter for the brush of the grounding ring.

The slip-ring insulation is computed for an operation voltage not over 250 volts (50 cps).

The stator of the slip-ring has the brush holders attached to it. Inside the stator is the rotor, the axis of which coincides with the axis of rotation of the transceiver cabin. When the cabin rotates, the rotor of the slip-ring remains stationary, and the stator rotates with the cabin.

Carbolite disks, encircling the brass rings, slip over the rotor shaft. The ring taps have rod-shaped busbars and RK-49 cables running parallel to the axis through the openings in the carbolite disks.

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The rotor, together with the rings, comprises a collector, with which the slip-ring brushes are in contact. Each pair of copper-graphite brushes is in one brush holder which is attached to the stator housing.

The brush holders are located on all four sides of the stator.

The collector has 75 rings, divided into three groups. (p 305)

The lower group, consisting of six wide rings, is used for the power circuits; the upper group, consisting of 13 wide rings, is used for the high-frequency circuits and the ground.

Each power ring has two brush holders each with two large brushes. The power brush holders for one ring are connected in parallel.

Each of the high-frequency rings has one brush holder containing two small brushes. In the center of this group is a special ground ring with one brush holder containing two large brushes. The brushes of this group of rings have a common cover.

The middle group, consisting of 56 small narrow rings, is used for the remaining electrical circuits. Each of the rings in this group has one brush holder with a pair of small brushes.

The rotor flange has taps extending from the rings in the form of terminal clamps, and [from the] instrument sections [in the form of] high-frequency plug-and-jack assemblies.

The rotor shaft rides in the stator on two bearings: a single radial ball-bearing at the lower end and a roller-bearing at the upper end.

All the rings, brush holders and inside cable are covered by a removable, two-piece corrugated cover.

The common (rotor) flange, with terminal clamps and high-frequency (p 307) plug-and-jack assemblies, is in the upper part of the rotor and is covered by a cap. The upper part of the cap is connected to an intermediate sleeve (adapter coupling), which provides a clutch coupling with the input shaft of the main selsyn unit FD-02. At the top, this unit is installed on the slip-ring and is connected to it electrically by two cables. On top of the FD-02 main selsyn unit is a rotating platform for the oscilloscope and telephone.

A plate giving the distribution of the rings of the slip-ring is attached to the housing of the slip-ring. At the base of this plate, on the right side, are two pairs of plug-and-jack assemblies and fuse holders.

The cables lead to the brush holders through the lower flange of the housing. The external cables, which lead to the upper rotor flange, run inside the hollow rotor shaft.

Table 5 lists the TK-03 rings.

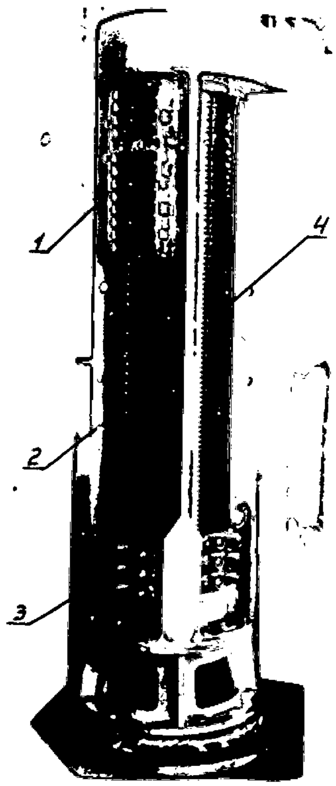

Fig 118. The TK-03 Slip-Ring (p 306)

1. unit of brush holders for high-frequency circuits
2. brush holders for the signalling circuits
3. brush holders for the power circuits
4. rings of the slip ring

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Table 5

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Ring Number	Designation	
1 - 4	/[no entry]	
5	ground	
6	PRS-1 receiver (No 1) output	
7	PRS-1 receiver (No 2) output	(p 308)
8	PRS-1 receiver (No 3) output	
9	PRS-1 receiver (No 5) output	
10	PRS-1 receiver (No 6) output	
11	PRS-1 receiver (No 4) output	
12	starter	
13-14	[no entry]	
15	PRS-1 amplifier (No 3) control	
16	PRS-1 amplifier (No 4) control	
17	PRS-1 automatic gain control relays (Nos. 3 and 6)	
18	PRS-1 automatic gain control relays (No 4)	
19	PRS-1 differential relays (Nos 3 and 6)	
20	PRS-1 differential relays (Nos 1 and 4)	
21	PRS-1 gain control (No 6)	
22	PRS-1 gain control (No 4)	
23	PRS-1 gain control (No 2)	
24	PRS-1 gain control (No 5)	
25	PRS-1 automatic gain control relays (Nos 2 and 5)	
26	PRS-1 differential relays (Nos 2 and 5)	
27	Antenna 1 control	
28	rotor of selsyn with 5-degree graduations	
29	antenna 1 control	
30	rotor of selsyn with 5-degree graduations	
31	antenna 1 rocking control	
32	rotor of selsyn with 5-degree graduations	
33	antenna 1 rocking control	
34	rotor of selsyn with precision graduations	
35	antenna 2 control	
36	rotor of selsyn with precision graduations	
37	antenna 2 control	
38	rotor of selsyn with precision graduations	
39	antenna 2 rocking control	
40	rotor of selsyn with coarse graduations	
41	antenna 2 rocking control	
42	rotor of selsyn with coarse graduations	(p 309)
43	stator of selsyn with 5-degree graduations	
44	rotor of selsyn with coarse graduations	
45	[no entry]	
46	PPS plate control No 1	
47	emergency signal	
48	PPS plate control No 2	
49	on-signal for filament and plate	
50	PPS plate control No 3	
51	PPA control	

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52	PPS plate control No 4
53	rotation control
54	PPS plate control No 5
55	rotation warning signal
56	PPS plate control No 6
57	telephone
58	current to PS magnetron No 1
59	rheostat terminal switch
60	current to PS magnetron No 2
61	400-cps voltage regulation
62	current to PS magnetron No 3
63	400-cps voltage regulation
64	current to PS magnetron No 4
65	400-cps voltage regulation
66	current to PS magnetron No 5
67	[no entry]
68	current to PS magnetron No 6
69	[no entry]
70	200 volts, 400 cps, phase A
71	220 volts, 50 cps, phase A
72	200 volts, 400 cps, phase B
73	220 volts, 50 cps, phast B
74	200 volts, 400 cps, phase C
75	220 volts, 50 cps, phase C

2. High-Frequency Motor-Generator Unit VPL-30 (p 310)

The VPL-30 is a unit that produces three-phase DC at 40 cps and three-phase AC at 400 cps.

Main technical data for the VPL-30:

The Electric Motor

feed voltage	380/220 volts
feed frequency	50 cps
input current	75/130 amps
synchronous speed of rotation	3,000 rpm

The Generator

voltage	208 volts
current load	140 amps
load power factor	0.8
frequency at synchronous speed	400 cps
gross weight (of motor-generator unit)	760 kilograms

Dimensions

length	1,330 millimeters
width	650 millimeters
height	1,235 millimeters

Components of the Assembly (p 311)

The VPL-30 assembly (Fig. 119) includes:

- an electric-motor assembly consisting of an asynchronous motor with a squirrel-cage rotor and a synchronous higher-frequency generator, housed on a common frame, and a flange-mounted driver;

- a control panel;

- a voltage regulator unit;

- terminal blocks for connecting the power supply to the motor and other loads.

The control panel, voltage regulator unit, and terminal blocks are mounted on a common frame attached to the assembly housing.

3. Ventilation, Heating, and Lighting of the Rotating Cabin

Ventilation of the Cabin

A circulating system of ventilation consisting of two exhaust fans and intake vents is designed to maintain a normal temperature within the cabin.

The moveable vents are over the external opening in the housing of the fan. At the time of the station's transportation, the vents are closed; and when the station is put into operation, they are opened by means of cranks located in the cabin.

An asynchronous three-phase, MAO-32/2M type, 0.35-kw electric motor, (p 313) 3000 rpm, operates the fans in the cabin.

In the housing of fan No. 1 (OK5), mounted on the front wall of the cabin, is an S-56 type buzzer which gives a warning signal when the cabin begins to rotate. In the housing of fan No. 2 (OK6), mounted on the back wall of the cabin, are terminals for connecting the cables which supply voltage to the SDG selsyn-transmitter and the MKG rocker mechanism of the slant reflector.

The fans are turned on from the cabinet of automatic mechanisms ShU-1 R16 and ShU-1 R17.

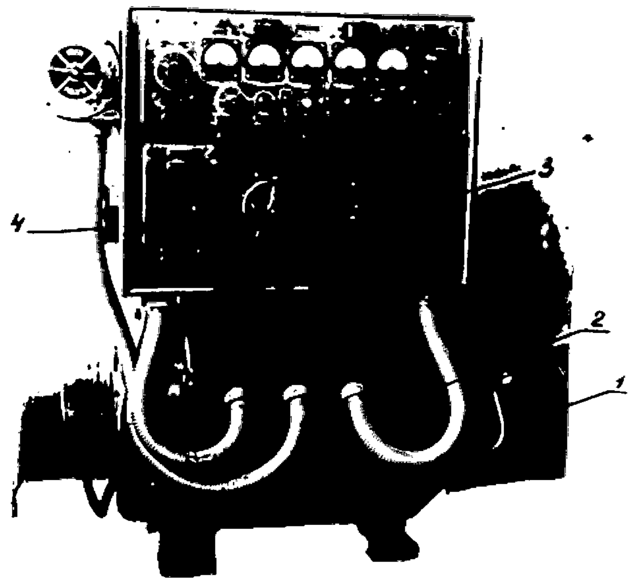

Fig 119. VPL-30 Assembly (minus housing) (p 312)

1. driver
2. motor-generator unit
3. control panel
4. terminal box

There are four locations for the intake vents in the cabin: in the lower part of the door to the cabin, on the side wall behind the cabinet of PPS No. 5, and on the right wall behind the cabinets of PPS No. 6 and ShU-1. The vents on the door are closed from within by means of a handwheel. The other vents have screen filters on the inside which prevent the passage of dirt and dust from the equipment in the cabin.

Heating of the Cabin

Heating and insulation of the cabin does not cause a marked change in temperature relative to that of the surrounding air. Therefore, in winter before turning on the receiving and transmitting apparatus when shutting down the equipment for a routine check, use the two PET-10-2 type coupled electric heaters in order to raise the temperature in the cabin and maintain it above zero (freezing). (p 314)

1. Each heater operates on 220 v with 1 kw of power.

The heaters are turned on by a "HEATER" switch on the panel of the local control cabinet.

Lighting of the Cabin

An AC-circuit is the main source of illumination for the cabin. Batteries are used in case of emergency.

The cabin has three T-97-type dome lights with SM-13 airplane (or tank) type electric bulbs (13 v, 15 w).

A 200-watt transformer located in the local control cabinet is used to reduce the AC-voltage from 220 to 12 volts.

If the AC-circuit is not operating, the lights are powered from two series-connected 5NKN-45 type alkaline storage batteries, each having a capacity of 45 a/hr and a rated voltage of 6.25.

The batteries are located at the port of the cabin. Switching from the AC-power supply to the batteries is done from the panel of the local control cabinet by means of a special three-position switch. The lights are turned on and off with this same switch. (p 315)

On the panel of the local control cabinet are sockets for plugging in portable lights (12 v and 220 v). Sockets for 220 volts are also located on the panels of the PS [? (not legible)] units. On slip ring TK-03 there are sockets through which 220 volts can be supplied directly by plugging in a cable to the PPK.

4. Signalling and Holding System

A signalling and holding system has been devised as a safety measure when the cabin begins to rotate.

The electric motor used to rotate the cabin is turned on remotely or by means of a switch on the panel of the control cabinet. In this case a signal is automatically given, warning of the beginning of the cabin's rotation.

An electric holding device (brake) prevents the motor from starting when the cabin is locked in place. This holding device is controlled by a terminal switch located at the rear lock.

Telephone communication of the cabin with other units on the station is maintained by means of a TAI-43 type telephone with a hand generator.

5. Electrical and Mechanical Accessories

(p 316)

All the cabinets of the equipment are installed on shock-absorbers secured to the floor as well as against the walls of the cabin.

In the right rear corner of the cabin is a cabinet with reserve transmitting and receiving equipment for the cabin.

In the lower compartment of the cabinet are spare receiver blocks and a thyratron unit. Above the compartment are eight removeable boxes containing spare tubes, detectors, fuses, and a special instrument. A complete list of spare parts for the cabin is given in the station parts list.

A folding table is fixed to the rear wall of the cabin under the window. When the station is operating, the table serves as a support for the RT-10B. The boxes are transported under the table with the spare parts kit and ShG-01 noise generator. Generator RT-10B is installed and secured to the top of the ShU-1 cabinet.

On the cover of the distributor box of the cabin are located the portable test instruments: a 125- a microammeter and a TT-1 type ampere-voltmeter.

6. External Auxiliary Equipment of Cabin

(p 317)

Outside the cabin are: the cabin lock, guys for the cabin in the traveling position, the antenna-securing equipment, the stairway, ladder, cable housing and troughs, and other attachments for van KZU-16.

Cabin Lock

This is situated in the after part of the van and serves to connect the cabin to the van in the traveling position.

An electric holding device is designed to prevent the cabin-rotating motor from starting while the cabin is locked in place. When the lock is in place, the terminal switch breaks the circuit of the power supply to the motor.

Four guys attached to the main boom of the van and engaging hooks in the frame of the cabin serve to additionally secure the cabin in the traveling position.

Assembly for Securing the Horizontal Reflector

The horizontal reflector is supported by an arm attached to the front of the cabin and rests against a frame attached to the sides of the cabin. Rocking mechanism MK-1 is supported by an arm attached to the frame.

During travel, the beam supporting the arm of the horizontal reflector is transported in vehicle No. 6; and the frame, in vehicle No. 5.

Assembly for Securing the Slant Reflector

(p 318)

Hinged supports are fixed to two arms secured to the rear of the cabin. A frame is attached to the supports by two pins.

A third point of support for the frame is provided by a beam attached to the roof of the cabin. The trunnion of the MKN rocking mechanism is attached to this beam.

In the traveling position the braces of the beam, together with the frame, are pulled down and secured to the back of the cabin. The truss for the reflector rocker is also secured there.

Cable Housing

On both sides of the main boom of the van are cable housings, in which are located electrical outlets. The cables from these housings pass through the main boom and are secured to the latter with clamps and covered with troughs.

On the front of the cabin is a cable panel with electrical outlet
In the traveling position the outlets are covered with a canvas hood.

CHAPTER EIGHT

(p 319)

TRUCK WITH ROTATING CABIN

The transceiver apparatus and antenna (in the deployed radar) are mounted on a special two-axle truck consisting of the vehicle, the pivot support, the cabin, the rotating mechanism and the equipment.

The vehicle is the mobile part of the truck. It also holds the rotating mechanism and serves as a support for the cabin.

The link between the vehicle and the cabin is the pivot support, on which the rotating mechanism is mounted.

Electric Motor of the Rotating Mechanism

A type A-61-4/V induction motor (two speed) rotates the cabin. It is fed from the three-phase, 220-volt, 50-cps network. The nominal power of the electric motor is five kilowatts, and the synchronous speed when connected to the windings of the delta network is 1,500 rpm.

The electric motor is attached to the reduction gear by means of a flexible clutch.

The driving plate of the clutch is attached to the motor shaft by a feather key and kept from shifting axially by a special screw which is (320) locked by a screw collar. The driven plate of the clutch is keyed to the shaft of the driving gear of the reduction gearing by means of a segmented key, and is kept from moving longitudinally by a nut with lock washer. Four pins and a set of rubber rings are placed in the cone of the driven plate and fastened with nuts.

Reduction Gear of the Rotating Mechanism

The reduction gear is four-step with three pairs of cylindrical gears and one pair of bevel gears.

One of the pairs of cylindrical gears has spiral teeth, the other two pairs have straight teeth.

A kinematic diagram of the reduction gear is given in Figure 120.

Manual Drive for the Rotating Mechanism

The manual drive is used when the radar is oriented, adjusted or regulated.

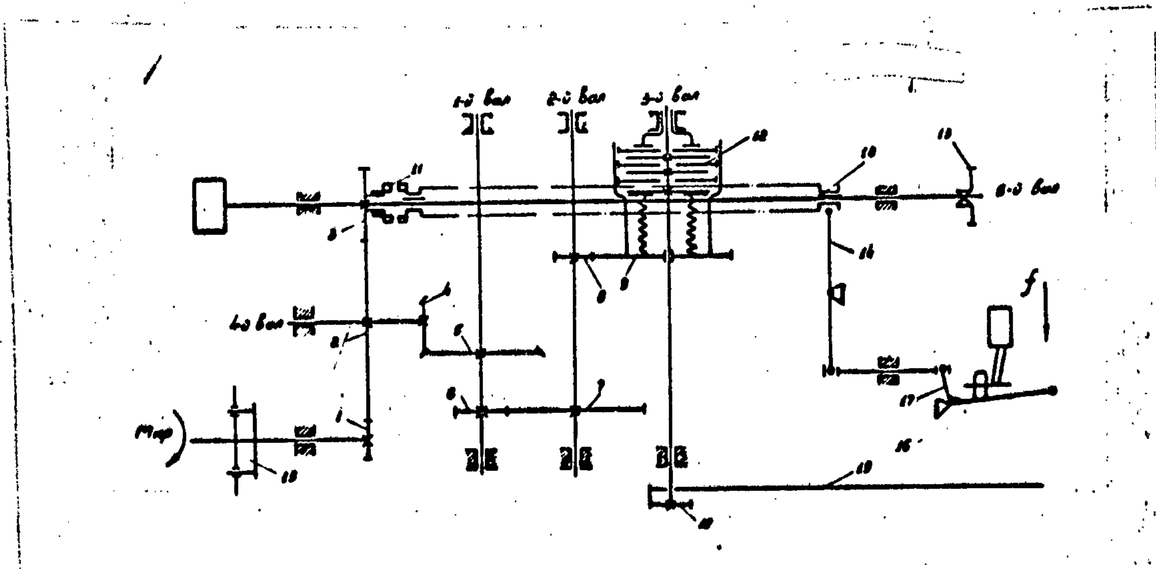

Fig 120. Kinematic Diagram of the Reduction Gear of the Rotating Mechanism

(p-321)

1. spiral driving gear (t = 3; Z = 18)
2. spiral idler gear (t = 3; Z = 45)
3. spiral driving gear (t = 3; Z = 18)
4. small bevel gear (t = 3; Z = 45)
5. large bevel gear (t = 4; Z = 43)
6. cylindrical gear (t = 4; Z = 20)
7. cylindrical gear (t = 4; Z = 40)
8. cylindrical gear (t = 5; Z = 16)
9. cylindrical gear (t = 5; Z = 40)
10. disengaging gear (t = 6; Z = 17)
11. claw-half of clutch
12. clutch plate
13. sprocket wheel (Z = 20)
14. horizontal lever
15. flexible clutch
16-17. vertical levers
18. bushing
19. fixed gear on vehicle (t = 6; Z = 136)

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The main part of this drive consists of a pair of bevel gears, sprocket, horizontal and vertical shafts and springed coupling rod. The drive is in a cast-iron housing attached to the vertical wall in the cabin hatch.

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