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METHODS OF TESTING AND TUNING THE P-20 RADAR INSTALLATION

PROCEDURES FOR TESTING AND TUNING THE TRANSCEIVER

Introduction

/ Experience in the use of the P-20 radar has shown that, in the majority of cases, poor target visibility, particularly of fighter aircraft flying at high altitudes, is connected with insufficient care in the testing and regulating of the transmitting section and of all circuits involving the reflected signals.

/ The result of this has been that strong signals and signals from large targets are sure to reach the display, but weak signals fail to arrive at the display. Thus a high-quality operation of the radar is guaranteed only when both the transmitting section and all the circuits involving the reflected signal have been tested and tuned with particular care.

The testing of the transceiver and the path of the reflected signals is done in the following order:

1. check the operation of the transmitter;
2. test and tune the receiver;
3. test the collector ring;
4. test and tune Block SB-02;
5. check the path of the reflected signals and the display.

NOTICE: All designations of parts and values encountered in this text correspond to those given in technical operations (manual) of the P-20 radar.

CHAPTER I.

Checking the Operation of the Transmitter

1. Setting the Phase of the Discharge

Before testing the operation of the transmitter section of the radar, it is necessary to confirm the reliability of operation of the AR-2 discharge switch according to the phase of the discharge. An indication of normal discharge phase is the absence of interference pips on the display, uniformly in a radius of 40-60 kilometers. If the phase is not correct, it must be corrected. The first setting of the phase is done with the magnetron operating on reduced power, and the final setting is made with the transmitter operating normally. Both the testing and the correction of the phase of the discharge are done with the aid of an oscillograph with direct scan. This requires: setting up the oscillograph on a rotating table; hooking the oscillograph; connecting the plug of the shielded cable to the vertical sweep amplifier input of the oscillograph; plugging in the cord plub at the socket marked "discharge" phase: (faza razryada) on the panel of the ShchU-02 local-control cabinet; and, by means of the oscillograph (oscilloscope) knobs marked "gain: (usileniye) and "scanning frequency" (chastota razvertki), making sure that the image on the oscilloscope screen covers about half the screen vertically and about two or three scan cycles.

When the discharge phase is correct, the oscillogram configuration will be such that an abrupt drop will be evident in the center of the plus side, and a slight rise above the zero line as it goes over into the mimus side. Oscillogram configurations are shown in Fig. 1.

Fig. 1.
Oscillograms of the Discharge Phase

If the drop is not long enough to reach the center of the upper part of the positive half period, it is necessary to loosen the two setscrews of the spark-discharge stator and, by turning the discharge switch knob, set the desired discharge phase, then lock the discharge-switch stator by tightening the setscrews.

2. Main Characteristics of the Magnetron Oscillators

The main characteristics of the magnetron oscillators, which can be checked under wartime conditions are the currents of the magnetrons, the frequency and spectrum of oscillations.

The service life of a magnetron is determined primarily by its

operating regime and extent of cathode emission. The extent of emission can be judged on the basis of the magnetron anode current, even a slight reduction of which lengthens the service life of the magnetron. For this reason it is well to keep the magnetron currents at 22-24 milliamperes, when they are operating under full power.

In order to avoid the mutual interference of channels and instability of operation of the transmitting section, the frequencies of the magnetrons should lie within the following limits:

Tube No.	Type	Frequency in Mc	Wavelength in cm
Tube I (G)	MI-25	[2065-2085]	[10.017-10.178]
Tube II (D)	MI-28	[2085-3005]	[9.917-10.017]
Tube III (P?)	MI-23	[2725-2785]	[10.185-11.000]
Tube IV (L)	MI-22	[2625-2725]	[11.000-11.332]
Tube V (K?)	MI-24	[2825-2875]	[10.345-10.657]

If the magnetron frequency lies outside the indicated limits, it must be retuned to the channel with the corresponding frequency range, and the frequency must again be measured with the RT-10 instrument (See Section 4 of this Chapter).

The spectrum of oscillations of the magnetron is that combination of sinusoidal oscillations at which the high-frequency pulse produced by the magnetron is transmitted. The shape of the pulse and the continuity of the spectrum of oscillations of a magnetron has a considerable influence on the operation of the radar. From the above it is evident that an appraisal of the operation of the transmitting section of the radar requires a check on the above-enumerated parameters. The instruments which can be used to judge the correctness of the operation of the transmitting section of the radar are the RT-10 and the ER-10.

The RT-10 provides a measurement of the frequency of the magnetron oscillators.

The ER-10 provides information on the frequency spectrum of the magnetron oscillators.

3. Measuring the Frequency Spectrum of the Magnetron Oscillators With the ER-10 Instrument

The frequency spectrum of a magnetron oscillator is measured whenever a magnetron is replaced, when the position of the magnetic shunt is changed, and periodically as a precautionary measure. Before a measurement is conducted, the apparatus must be heated up for 10-15 minutes in normal operation.

A measurement of the spectrum of frequencies requires:

1. connecting the ER-10 to the directional coupler (AP) by means of the long cable;
2. connecting the micro-ammeter with the ER-10 chamber by means of the short cable;
3. setting the two way switch "MGN-KLS" (Fig 2.) on position "MGN";
4. setting the two-way switch "OSTSILL - PRIB" on position "PRIB;
5. setting the handle "CHUVST" in the far left position (maximum sensitivity);
6. finding, according to the calibrated diagram (dependence of λ on l), the tuning position of the ER-10 corresponding to the wavelength of the block to be measured;
7. finding, by turning the ER-10 tuning knob, the position corresponding to the maximum deviation of the instrument needle, which may require a series of closely spaced adjustments; tuning is necessary on a higher [larger] maximum.

NOTICE: The accuracy of the measurement depends to a great extent on the magnitude of the coupling of the cavity circuit of the ER-10 with the directional coupler of the antenna switch AP. In checking the spectrum, it is necessary to regulate the coupling in such a way that the indications of the micro-ammeter and the maximum amplitude of the spectrum do not exceed one-quarter of the scale; furthermore, such a regulation is necessary in order to avoid burning the detector of the [ER-10] instrument. If the coupling value is too high (instrument indications larger than one-quarter of the scale), the spectrum will be distorted by the control oscillator itself. If the coupling is too weak (indication less than one-quarter of the scale), the instrument reading becomes unreliable.

8. loosening the set screw of the coupling loop between the micro-ammeter and the chamber of the ER-10 and, by advancing or backing off the coupler, obtaining the maximum deviation of the micro-ammeter pointer;
9. loosening the set screw of the ER-10 coupling loop from the directional coupler of the AP and, by advancing or backing off the coupler, obtain a micro-ammeter setting of 20-25 micro-amperes;

(Whenever the coupling loop is shifted, the ER-10 must, each time, be fine-tuned, with an attempt made each time to obtain the minimum coupling value for the given values of the micro-ammeter indications.)

10. by smoothly turning the control knob, passing through the entire frequency spectrum of the magnetron oscillator, which can produce the following results:

a) a smooth rise to the maximum and a smooth decrease of the micro-ammeter indications; tunings away from the major maximum are almost never observed; in this case the spectrum of the magnetron is

considered good;

b) a smooth rise to the maximum and smooth decrease of the micro-ammeter indications; to the side of the main tuning is observed an additional rise of the indications of the micro-ammeter; if the amplitude of the additional tuning does not exceed 30-35 percent of the major tuning, the spectrum can be considered satisfactory;

c) a second tuning because of an amplitude greater than 35 percent of the major tuning makes the spectrum unsatisfactory;

11. setting the ER-10 at maximum micro-ammeter deflection; taking a reading according to the dial, checking, and entering the obtained value (f);

12. detuning the instrument from one quarter from the maximum value; taking a reading according to the dial, checking, and entering the obtained value (f_1);

13. detuning the instrument from one quarter from the maximum value to [the other side] of the maximum, taking a reading according to the dial, checking, and entering the obtained value (f_2);

14. computing the difference between the two [side measurements] $(f) - f_2 = f_1$;

15. determining, according to the graphic attached to the ER-10 instrument (dependence of f on f_2), the wavelength λ_1 corresponding to the setting of the instrument at maximum according to the graphic (dependence of n on λ), determining the coefficient n; and computing the width of the frequency spectrum of the magnetron oscillator according to the formula

$$\Delta f \left[\text{Mc/sec}\right] = n \Delta \lambda \left[\text{mm}\right].$$

The width of the frequency spectrum of the magnetron, measured with the ER-10 instrument, must not exceed 4 megacycles.

4. Measuring the Frequency of Magnetron Oscillators With the RT-10

Before any measurements are made, the transmitting device should be heated up by 10-15 minutes of normal operation, after which the instrument must be balanced as follows (Fig 3);

switch on the power (220 volts);
turn switch No. 1 to the position at NEZATUKHAYUSHCH (continuous);
turn switch No. 4 to position IZMER MOSHCHN (measure power);
set switch No. 6 at position OTSCHET (indication), and, by turning knob No. 9 marked USTAN. NULYA (zero setting), set the instrument pointer 14 at zero (on right side of the scale);
set switch No 6 at position PROB NULYA (test for zero) and, by turning knobs 3 and 5, marked GRUBO and TOCHNO (coarse and fine), set the instrument pointer 14 at zero (on right side of scale);

Fig 2. The ER-10 Echo-Box (Cavity Resonator)

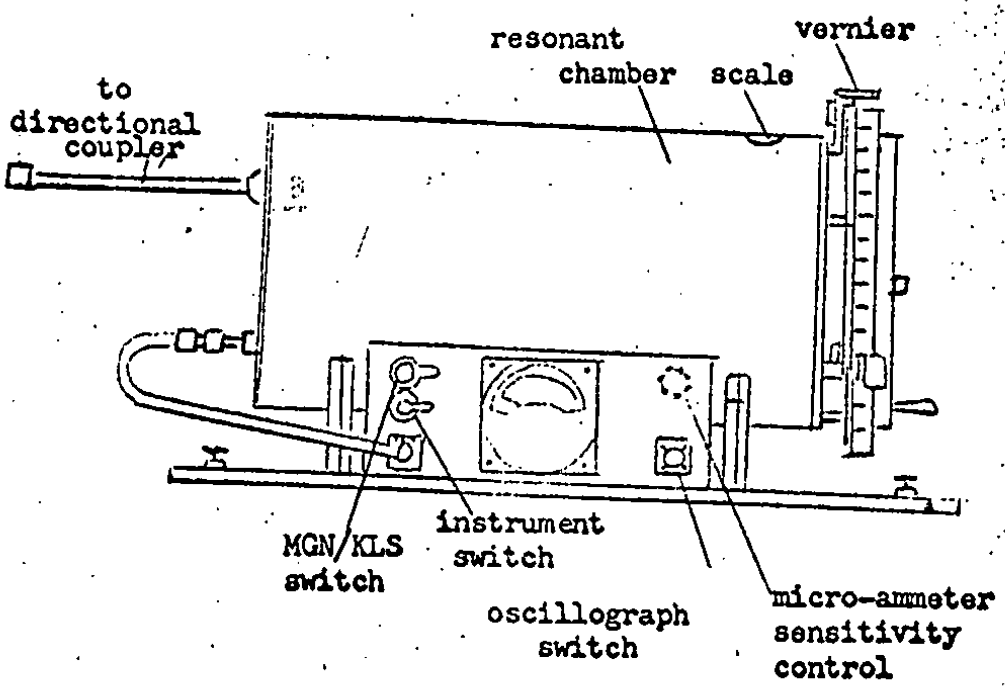
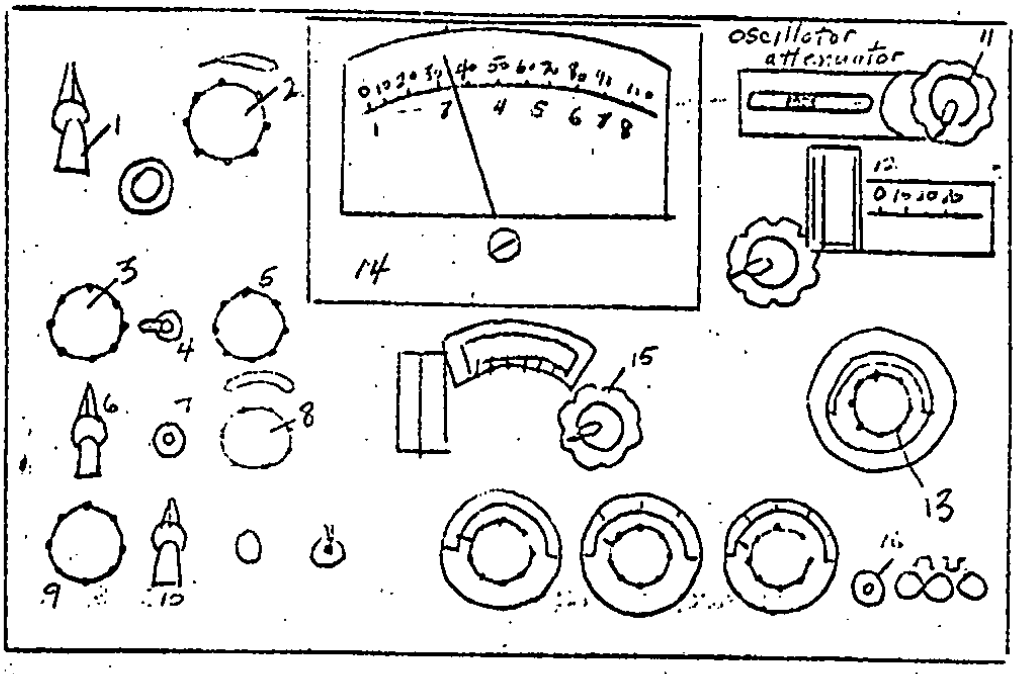


Fig 3. Front View of the RT-10 Tester [markings illegible]



set switch No 6 in position UST BAL (balanced setting) and, by turning knob 5 (TOCHNO), set the instrument pointer 14 on the red line (on zero) on left side of the scale;

connect one end of the RT-10 cable to the receptacle marked VKHOD VOLNOMERA I IZERITELYA MOSHCHNOSTI (input of frequency meter and power meter) on the side wall of the instrument, and the other end of the directional coupler element on block AP (Fig 4).

NOTICE: When the RT-10 instrument is turned on, the attenuator of the frequency meter and the power meter should be at the position of maximum attenuation (x 50) to avoid burning out the thermistor in the frequency meter.

Sequence of Operations in the Measurement of Frequency

With knob 13 (see Fig 3), marked ATTENYUATOR VOLNOM I IZMERITELYA MOSHCHN (frequency-meter and power-meter attenuator) set the attenuation so that the radar-tester instrument needle 14 is at the center of the scale.

Turn knob 15 of the frequency meter until the needle 14 reaches minimum. If, during adjustment to minimum, the needle goes beyond the limits of the scale, knob 3, marked USTAN BALANCA (balance setting), must be manipulated in order to bring it back.

NOTICE: In finding the minimum, knob 13 must be turned slowly, since the frequency meter has a certain lag.

Take a reading according to the scale and the frequency-meter vernier 15 and, using Table (Fig 5) supplied with the radar-tester, determine the frequency of the magnetron and compare it with that on the name (rating) plate.

Example: reading from scale: [2 ?]
reading from vernier: [ ]
frequency equal to: [ ]

5. Normal Test Instrument Readings For the Transmitter

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Excitation voltage of the VPL-12 according to the instrument of the local control cabinet ShchU-02.....	50-90 volts	90-130 volts
Voltage of the 350-cycle frequency according to the instrument of the local control cabinet ShchU-02.....	150-170 volts	185-225 volts
Magnetron currents according to the instruments ShchA-02 of all the high-frequency sections and at the central control panel TsU-02.....	15-18 milliamps	22-24 milliamp

NOTICE: The anode currents of the magnetrons must not be increased beyond 28 milliamperes.

CHAPTER IV

TESTING AND TUNING THE RECEIVER

1. Sequence of steps in testing and tuning the receiver.

1. Test the operation of the gas dischargers
2. Test and tune the automatic-fine-tuning (APCh) channel and tune the klystron oscillator.
3. Connect up the oscillator with the signal mixers and the automatic fine-tuning (APCh) of the frequency.
4. Check the gain of the UPCh.
5. Measure the receiver sensitivity.
6. Adjust the gas dischargers.

2. Testing the Operation of the Gas-Discharges

Testing Rectangular Dischargers

First, the liminescence of the dischargers must be checked; the luminescence must be uniform and without sparks.

1. Measure the sensitivity of the receivers with transmitters turned on (for precedure see No. 7 of this Chapter) and with the switch marked APCh-RRCh on the front panel of the receiver set at position RRCh, while manipulating the knob of the potentiometer

RRCh to maintain maximum micro-ammeter deflection, the micro-ammeter being hooked up to the receptacle marked TOK KRISTALLA SIGNALA (current, signal crystal).

2. Measure the sensitivity of the receivers with transmitters turned on, without touching the tuning knobs of the RT-10 and receiver, and with the mode switch and the TR-switch on position PRODUB [PRODUV - "air-blast"] on the ShchU-02 [panel]. In the AP section, open the choke valve by pressing on its unfastened side and lock it in this position. With the RT-10 oscillator attenuator, obtain the same micro-ammeter indications as with the transmitter turned on. Read off the sensitivity. When the measurement has been completed, close the choke valve.

If, when the transmitters are turned off, the sensitivity is greater than with the transmitters turned on, for example by one decibel, then the discharger is sparking. If the difference of indications during a measurement is greater that the indicated value, the discharger must be replaced.

It must be noted that, during these measurements, the cabin should be turned in a direction from which the smallest possible reflections from local objects in the area are observed, otherwise the results of the measurements will be inaccurate.

NOTICE: During receiver sensitivity measurements the cockpit should always be oriented in the same direction. Atmospheric conditions: Sensitivity tests are not recommended under conditions of heavy rain or heavy cloud cover.

3. Check leakage of high-frequency power through packings where the discharger joins the waveguide. For this the discharger-to-waveguide coupling must be locked tight. [A loosening] of the coupling indicates an escape of high-frequency energy. In this case it is necessary to [tighter the screw four turns] or test [the stress in the spring attachment] of the discharger.

Testing Circular Dischargers

Circular side dischargers are tested according to the degree and nature of their brightness or operating [current] of the transmitter. The luminosity should be a purple light without sparking. If there is sparking, or if the light is white, the discharger should be replaced.

The circular discharger of the signal mixer is tested by measuring the discharger ignition current. This requires opening the

lower lefthand access hatch in the front door of the high-frequen... block and hooking-up the plug of the 300-microampere ammeter to the... receptacle marked TOK PODZHIGA (ignition current) on the front panel of the ignition rectifier. If the discharger and ignition rectifier are in good order, the instrument should show a current of 90-150 microamperes.

Reasons for the Absence of current:

failure of the RR-7 discharger;
fuse blowout in block YaP-01;
hot-cathode rectifier (kenotron) I out of order;
failure of the R = 3.9-megohm resistance in the connection which feeds the ignition voltage to the antenna switch.

The failure of the RR-7 discharger of the AP block or the absence of the ignition current causes a preliminary ionization of the gas, which leads to the condition where part of the magnetron power leaks through the RR-7 discharger and is fed to the crystal mixer, impairing its sensitivity. For this reason, the ignition current of the RR-7 discharger must be measured before the high voltage is fed to the magnetron.

If no ignition current is available, disconnect the single-contact connector located below the circular discharger of the signal mixer and check there for a DC current by using the TT-1 tester (instrument is connected to the central pin in the case of the high-voltage connector).

The ignition voltage should lie within the limits -700 to -800 volts.

If no ignition voltage is present, the hot-cathode tube must be replaced or the YaP-61 rectifier repaired. If there is ignition voltage but no ingition current, the discharger must be replaced.

NOTICE: When exchanging a type-RR-7 discharger, keep in mind that its flexible fasteners attach to the outside of the chamber ribs. The discharger should be attached about its axis, so that the flexible fasteners will be parallel all around. Keep in mind also that the thin spring washers must have their arched conical portion toward the metallic fasteners when the discharger is being installed.

To insure stable mixer operation, keep the adjustment springs of the RR-7 tight.

8. Testing and Tuning the Channel of the Automatic Frequency Tuner (APCh).

Tuning the Klystron Oscillator

Test the operation of the scanning stage with the transmitters on.

Switch on the mode switch, and set the transmit-receive device on

the ShchU-02 at position PRODUV (air blast). When the 100-microamp micro-ammeter is connected to the receptacle marked TOK KRISTALLA APCh (crystal current, automatic frequency tuner) on the front panel of the YeE-02 receiver, the needle should oscillate rhythmically at a frequency of about one per second. When the APCh (automatic frequency tuner) current is off, the micro-ammeter should oscillate smoothly. The frequency and smoothness of the oscillations of the needle can be controlled by means of the potentiometer marked PILA, the slot of which is on the front panel of the receiver (Fig 6).

The tracking stage is tested with the transmitters on. This stage is operating properly when the oscillations decay on the 100-microamp micro-ammeter attached to the receptacle TOK KRISTALLA APCh on the front panel of the receiver.

Whenever possible, the gain of the APCh channel should be set at maximum.

In certain cases when the gain of the APCh channel is tuned up high, parasitic pulses will also be amplified, which leads to a cutoff of the APCh operation, whereby the needle of the 100-microamp ammeter, which measures the crystal current of the APCh, drops to zero and remains there.

In such a case, the gain must be reduced until the instrument indicates normal APCh crystal current. If it is not possible to reduce the gain, then the tuning of the klystron oscillator must be checked, or the magnetron must be replaced.

The klystron oscillator is tuned whenever a klystron or magnetron is replaced, or whenever the frequency of either is changed appreciable. If the automatic tuner channel in the receiver has been checked-out, and no appreciable klystron frequency change is required, then the klystron is adjusted without the use of the frequency meter. In this case the procedure is as follows:

1. Set the ShchU-02 mode switch at PRODUV (air-blast).
2. With the 100-microamp ammeter connected to the TOK KRISTALLA APCh jack on the front panel of the receiver, the oscillations should be smooth.

3. With the ARCh-RRCh switch on the RRCh position, manipulate knob RRCh until the needle reaches maximum deflection, then manipulate the APCh mixer coupling screw to get a current amplitude of about 60-80 microamps.

NOTICE: If, when the RRCh knob is turned slowly, the instrument indication rises and falls abruptly, or if the change of current of one mixer is down to the current of the other, then the resistance values of the mixer balancing disks must be checked, since they vary with the load on the cables running from the oscillator to the mixers. The coupling-control screw of the mixer must be backed off until it is still on the coupling rod but not touching the mixer housing; then disconnect the cable between the tee and receptacle 1271 (signal mixer) or 1269 (APCh mixer) and measure the resistance between the central contact in the receptacle and the mixer housing, which should be about 40-60 ohms. The resistance values can be changed by making grooves (with a needle file) in the absorbing layer of the matching disks of the signal mixer and the APCh (frequency-tuner) mixer.

4. Switch on the transmitter (ShchU-02 modes switch on position POLNOYE VKLYUCHENIYE [full power]).

5. Switch the ARCh-RRCh switch on position ARCh.

6. With the screw-driver-key slowly rotate the plunger of the klystron circuit until the instrument needle stops oscillating and the maximum deviation is about 60-80 microamps. This tuning must be done carefully, by rotating the klystron circuit plunger half a turn, and each time tightening its nut. When the switch on the front panel of the receiver is tuned from position ARCh to position RRCh, the instrument needle should show approximately uniform indications.

The accuracy of the tuning of the klystron oscillator can be checked as follows:

Hook up the oscillograph with direct scan to the receiver receptacle marked IMP APCh; connect the 100-microamp ammeter to the receptacle marked TOK KRISTALLA APCh; put the ARCh-RRCh switch on position RRCh; by rotating the RRCh potentiometer knob, obtain the position where the negative pulse disappears from the oscilloscope screen, but the positive does not yet appear, which will correspond to tuning the klystron

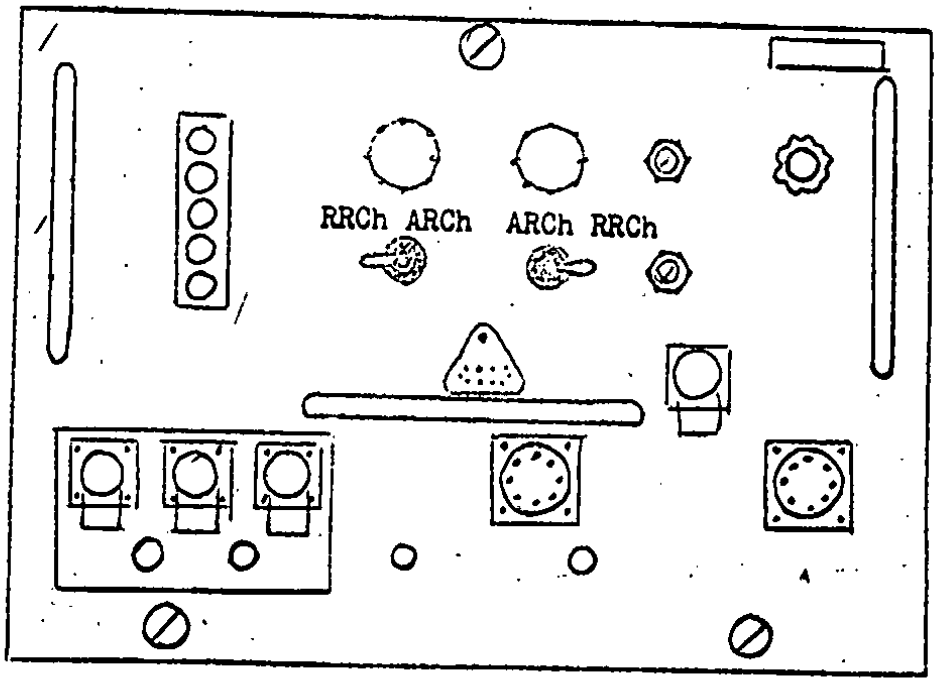
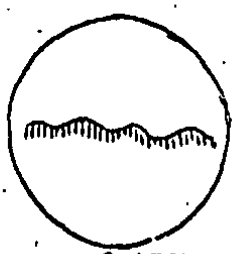


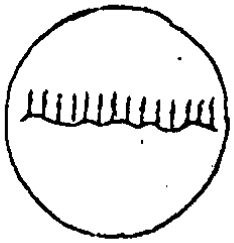
Fig. 6. Front Panel of the YeE-02 Receiver [markings illegible]

Fig. 7



Oscillogram of APCh Negative Pulses

Fig 8.



Oscillogram of APCh Positive Pulses

precisely at a frequency which is 30 megacycles off that of the magnetron; read the micro-ammeter indication; throw the ARCh-RRCh switch over to position ARCh, which should cause no change in the indication of the micro-ammeter; if the indication is different, adjust the klystron by means of the plunger; after this adjustment, check once more by the above-described method and obtain the same micro-ammeter indication for both positions on the ARCh-RRCh switch on the receiver.

7. Check the reliability of the klystron setting.

The klystron frequency should be above the magnetron frequency in channels 2, 3, and 5, and below the magnetron frequency in channels 1 and 4.

This check can also be made without using the frequency meter. The oscillograph with direct scan is connected to the receiver receptacle marked IMP APCH, and the oscillograph control knobs are manipulated to get a clear image of the APCh pulses on the screen (oscillograph gain control at maximum).

With the ARCh-RRCh receiver switch on position RRCh, rotate the RRCh potentiometer knob clockwise and observe the pulses on the screen.

If the klystron is properly tuned, then, when the RRCh knob is rotated slowly in a clockwise direction, negative pulses (Fig 7), and then positive pulses (Fig 8), should be observed on the screen.

If the positive pulses are observed first, and then the negative, this means that the klystron is not properly tuned, i.e., in channels 2, 3, and 5, f_{kl} is less than f_{magn}, and in channels 1 and 4, f_{kl} is greater than f_{magn}.

NOTICE: 1. The absence of the thickening at the end of the positive pulses is an indication that the L-14 thyratron is out of order.

2. If, when the RRCh knob is rotated, the pulses of similar polarity (positive or negative) appear double, the APCh gain control on the front panel of the receiver must be turned down. If this does not eliminate the doubling, the magnetron will have to be replaced.

If there is an appreciable difference between the frequencies of the klystron and magnetron, the klystron cannot be tuned by the method described above. The tuning must be done with the RT-10 instrument, as follows:

1. Transmit-receive equipment on normal operation;

2. Measure the frequency of the magnetron oscillator with the RT-10 instrument (See Section 4, Chapter I).

3. Measure the frequency of the klystron oscillator. For this, the 100-microamp ammeter is hooked up to the connection TOK KRISTALLA APCh, and the ARCh-RRCh switch is on position RRCh. Manipulate the RRCh knob to get maximum APCh crystal current.

Connect the radar-tester cable to the tee (receptacle 1268) on the AP section, and disconnect the APCh mixer cable leading to receptacle 1268.

Further steps in the measurement of the klystron frequency are analogous to those for measuring the frequency of the magnetron.

After taking a reading from the scale and the vernier of the frequency meter, use the same tables to determine the value of the klystron frequency (See Fig 5).

4. Compare to ascertain the extent and direction of the difference between the klystron and magnetron frequencies.

5. Using the screw-driver-key, either advance or back-off the plunger of the klystron and again measure the klystron frequency.

If a 30-megacycle difference cannot be obtained by manipulating the plunger, the following steps are necessary:

Place the klystron-circuit plunger, which extends through the front panel of the receiver, in approximately the middle position.

Pull the receiver out of the section without touching the RRCh tuning knob or klystron circuit plunger which extends through the panel; advance or back off one or several of the plungers along the periphery of the klystron circuit and lock their nuts. After measuring the frequency of the klystron, connect the cable to receptacle 1268.

NOTICE: Advancing the plunger increases the frequency (shortens the wavelength) of the klystron, whereas backing-off the plunger reduces the klystron frequency (increases the wavelength).

6. Put the receiver back into position, hook up cable 1039 to it, connect the voltage source to the receiver (receptacle 1605), and once more measure the klystron frequency (See Fig 6).

This operation is repeated until the magnetron and klystron frequencies are 30 megacycles apart in the desired direction (as shown in Table 1). Then the fine-tuning is done as described above.

The klystron frequency in channel 4 can be measured with the ER-10 instrument, the obtained klystron wavelength being converted into frequency according to the following formula:

$$f(kc) = \frac{3 \cdot 10^7}{\lambda\,[cm]}$$

Table I

Channel No.	Channel Marking	Receiver Classification	Magnetron Freqency (Kilocycles)	Klystron Frequency (kilocycles)
1	G	N	2905 - 2935	2935 - 2965
2	D	B [V?]	2995 - 3025	3025 - 3055
3	B [V?]	V [B?]	2725 - 2755	2755 - 2785
4	A	N	2695 - 2725	2655 - 2685
5	B [V?]	B [V?]	2815 - 2845	2845 - 2875

WARNING: In retuning the klystron plungers, pay particular attention that the klystron resonator housing shows plus 230 volts with respect to receiver ground. This voltage must be removed by disconnecting receptacle 1604 on block VK-01 (voltage supply block). After the klystron is tuned, all the cables connecting the receiver with the AP must be hooked up again.

Complete Testing of the Operation of the Automatic Frequency Tuner (APCh)

A complete testing of the operation of the APCh system requires hooking up the receiver jack marked VYKHOD (output) to an oscillograph (oscilloscope) with slave sweep.

Switch the ShchU-02 [local control] mode switch on position POLNOYE VKLYUCHENIYE (full power). Turn the cockpit by hand until the oscilloscope screen shows a clearly visible reflection of the local objects (selecting the most distant local objects is desirable). Switch the MRU-DRU switch on the receiver panel to position MRU.

Switch the ARCh-RRCh switch on the receiver panel to position RRCh, and turn the potentiometer RRCh to tune the klystron until the amplitudes of the pulses from the local objects are maximum. Then throw the switch over to position ARCh, which should cause no change in the pulse amplitudes.

NOTICE: The gain controls of the receiver and the oscilloscope must be set at such values where no limitation will be set on the pulse amplitudes.

If there is a change of amplitudes of the pulses, a more precise tuning of the klystron is required.

Stable operation of the APCh indicates that the magnetron oscillators are functioning properly. Thus, if the APCh is not correctly tuned, the magnetron must be replaced, and the entire test must be conducted again from the beginning.

4. Connecting the Local Oscillator With the Signal- and APCh-Mixers

The connection between the local oscillator and the mixers is checked by means of the 100-microamp ammeter plugged in at the receiver-panel position marked TOK KRISTALLA APCh (automatic frequency tuner crystal current) or TOK KRISTALLA SIGNALA (signal crystal current).

These crystal currents are established by corresponding connections in the AP-block and should be within the following ranges:

signal crystal current:	20-35 graduations
APCh crystal current:	60-80 graduations.

NOTICE: The values of these graduations apply only for the 100-microamp instrument. Since the internal resistances of the 100-microamp and 300-microamp instruments are different, the obtained current values would be different also.

Keep in mind:

Before any connections are made, it is necessary to warm up the radar for at least 20 minutes. Connections are made only when the radar is on FULL POWER, i.e., only when the choke coils are off. If the desired crystal currents cannot be obtained, then a crystal replacement must be made.

NOTICE: If the choke coils are on (closed), the crystal currents will be different from those indicated.

If the crystal currents of the signal mixers and the AFC are absent (in both control connections), the klystron must be replaced, with care exercised in order not be bend the coupling loop.

NOTICE: If the high voltage is absent at the receiver, the micro-ammeter needle will deviate; in such a case, the instrument reading will not give the value of the crystal currents.

5. Testing the Crystal Detectors of the Signal Mixers

Receiver input noises are made up of noises fed from the antenna, and noises of the crystal detector, local oscillator and first UPCh stages, and determine the sensitivity of receivers. The crystal detector should be tested on the basis of the noises it causes. This is done by setting the ShchU-02 mode switch at position PRODUV, the ARCh-RRCh switch to position RRCh, and the MRU-DRU switch to position MRU, connecting the 100-microamp ammeter into the test receptacle marked DETEKTOR on the front panel of the receiver, and manipulating the RRCh knob to get maximum needle deflection on the microammeter. Turn the receiver gain all the way down and, with the instrument stop, set the DC component of the detector at 10 or 20 scale graduations for the sake of convenience in reading. Set the receiver gain so that the micro-ammeter will show readings about 50 graduations above the original setting when indicating noise. Then loosen the nut on the crystal-detector holder and separate it from the holder. The crystal detector can be considered satisfactory if the noise level drops no more than 7-9 scale graduations as a result.

If the reduction amounts to some 10-20 graduations, the detector should be replaced, and the entire test conducted again from the beginning. / Crystal detectors must not be quality-checked on the basis of a test in any one channel. In addition to resistance, they also have a certain reactance, the value of which can vary appreciably in detectors of the same type, which impairs the tuning of the mixer. For this reason, with certain detectors the desired mixer current values are obtained only by increasing the coupling between mixer and local oscillator, which can lead to increased noises from the local oscillator, since the crystal detector itself can have a low noise level. In another channel, the same detector might be used with better results. The ultimate choice of the crystal detectors for signal mixers should be made on the basis of receiver sensitivity.

6. Testing Amplification of the Intermediate-Frequency Stages (UPCh)

(Testing the Noise Level at Detector Load)

The specific noise level at a detector load in the receiver reflects the amplification factor, since the noises of the electron tubes in the first amplifier stages always have approximately the same level.

Testing is done as follows: Set the ShchU-02 mode switch on PRODUV; into the DETEKTOR receptacle on the front panel of the receiver hook up the 300-microamp ammeter (which is connected to the detector load through resistances 50 and 51 and, at the indicated value, acts as a voltmeter with a 3-volt scale); set the ARCh-RRCh switch on RRCh; the DRU-MRU switch on MRU; and turn the MRU potentiometer knob clockwise to the stop. This should cause the instrument to deflect no less than 50-60 graduations (not counting the DC component [caused by the DC] current of the detector). Thus the noise level at the detector load should be no less than 1.5 volt.

A reduction of the noise level below that indicated reflects an emission loss by one of the intermediate-frequency amplifiers (most frequently responsible is the 6Zh3P tube, tube No 8). In this case, a 6Zh3P tube known to be good should be tried successively in stages 1, 3, 4, 5, 6, 7, 8, and 9 (but not the second) of the intermediate-frequency amplifier (UPCh).

NOTICE: The second stage has a 6N15P tube. If this tube is replaced by a 6Zh3P tube, resistor 29 heats up, which reduces the receiver sensitivity by about 6-8 decibels.

Table 2

Electron Tube Operations

Number of Tube	Type	VOLTAGE V — Anode max	Anode min	Control Grid max	Control Grid min	Cathode max	Cathode min
1.	6Zh3P	115	105	115	105	1.5	0.5
2.	6N15P	105	95	-	-	1.5	0.5
3.	6Zh3P	110	95	120	105	1.5	0.5
4.	6Zh3P	110	95	120	105	1.5	0.5
5.	6Zh3P	115	100	120	105	4.0	3.0
6.	6Zh3P	110	95	120	105	1.5	0.5
7.	6Zh3P	110	95	120	105	1.5	0.5
8	6Zh3P[?]	3..?	300	120	105	2.0	1.0
10.	6Zh4	105	90	55	40	-	-
11.	6Zh4	110	95	125	110	2.0	1.0
13.	6Zh4	150	90	120	105	4.0	2.0
14.	[?]	-	-	- 250	- 230	- 250	- 230
15.	[?]	-	-	-	-	- 250	- 230
16.	[?]	- 32	- 27	-	-	-	-
17.	[?]	320	300	320	300	5.0	4.0
18.[19?]	[K-11?]	[??]					

[Last 3 entries and two footnotes illegible]

C-O-N-F-I-D-E-N-T-I-A-L

Noise voltage at a detector load can be absent as a result of the failure of the following:

tube 16 (6N9S) of the MARU stage;
one of the tubes (1-8) of the IF amplifier stages; tube 9 of the detector;
one of the resistors through which voltage is fed to the plates of the IF amplifier tubes.

If the failure cannot be detected by external inspection, then the tubes must be tested and checked with Table 2 (TT-1 tester used with electron tubes).

When readings are taken of the operation of the IF amplifier tubes, the control grid of tube 4 should be grounded in order to eliminate interference from the exposed bar. The plate voltages supplied to the tubes from the plus 300-volt bus are measured at minimum noise voltage (MRU-DRU switch on position MRU, and the amplifier potentiometer all the way to the left).

7. Measuring the Sensitivity of the Receivers

Measuring the sensitivity of the receiver is done in two steps: balancing the RT-10 instrument and measuring the sensitivity.

Balancing the RT-10 Instrument

Turn on the power (220 volts) and heat up the instrument for 10-20 minutes.

Switch 1 (See Fig 3) at position NEZATUKHAYUSHCH. (undamped, or continuous); switch 4 at position INDIK UROVNYA (indication of level); switch 6 in position OTSCHET (read-off) and manipulate knob 9, USTAN NULYA (zero setting) to set the needle of instrument 14 at zero (right-side of scale); throw switch 6 to position PROB NULYA (test for zero), and by manipulating knobs 3 and 5 (GRUBO- "coarse" and TOCHNO - "fine") set needle of instrument 14 on zero (right side of scale); then set switch 6 at position UST BAL (balance setting) and manipulate knob 5 marked TOCHNO (fine), to bring the needle of instrument 14 of the RT-10 to the red line on the left side of the scale; set switch 7 at position IZMERENIYE (measure) and manipulate knob [?], USTAN UROVNYA MOSHCHN (power level setting), to bring the needle of instrument 14

to the red line on the left side of the scale; set the attenuation of the oscillator attenuator of instrument RT-10 at approximately 20 decibels; connect the cable running from the receptacle VYKHOD GENERAT (oscillator output) on the side of the RT-10 to the control coupler on block AP (See Fig 4).

Measuring the Sensitivity

1. Switch on the transceiver and heat up for 10-20 minutes in normal operation.

2. With the 100-microamp ammeter, test the crystal current values and the operational reliability of the APCh (automatic frequency control).

3. Set the ARCh-RRCh switch on position ARCh.

4. Connect the micro-ammeter to the receiver connection marked DETEKTOR.

5. Set the MRU-DRU switch on position MRU and turn the MRU knob (potentiometer) all the way to the left; the microammeter will show a low current (the current of detector L_2).

6. With the instrument (100-microamp) stop, set the needle of the instruments on the closest multiple of five graduations on the micro-ammeter scale, either to the right or to the left. For example, with the MRU turned all the way, the needle points to 7. Set it at 10.

7. With the MRU potentiometer knob set the noise at one volt (for example, 30 graduations on the 100-microamp ammeter). Thus the micro-ammeter needle will point to 40 (10 for the closest multiple of 5, plus 30 = 40).

8. By turning knob 12, marked CHASTOTA GENERATORA (oscillator frequency), obtain a fine-tuning of frequency by reaching maximum needle deflection on the 100-microamp ammeter hooked up to the connection marked DETEKTOR.

   Do not let the needle go beyond the scale. To prevent this, change the frequency of the radar-tester slowly and, if the ammeter deflection is large, immediately increase the attenuation of the RT-10 by means of knob 11, marked ATTENYUATOR GENERATORA (oscillator attenuator). After this is done, knob 12, marked CHASTOTA GENERATORA (oscillator frequency) must be manipulated to get a fine-tuning according to maximum micro-ammeter needle deflection.

Obtain a signal from the RT-10 higher than the receiver noises by a factor of about 1.5, measured in volts. To do this, the RT-10 oscillator attenuator is set for an attenuation whereby the microammeter needle deflects another 15 graduations (10 plus 30 plus 15 [for the RT-10] = 55 graduations).

9. To the scale indication of the ATTENYUATOR GENERATORA (oscillator attenuator) must be added the attenuation value of the directional coupling which controls it and of the cable running from the RT-10 to the directional coupler. The total sum of the attenuation of all these elements gives the receiver sensitivity value in decibels.

NOTICE: 1. The RT-10 instrument is calibrated with a cable [5 meters] long [6 words illegible] during the calibration of the instrument. The standard cable for the measurements is 3 meters long. Consequently, in determining the sensitivity, it is necessary to add the attenuation for two meters of cable, which is 1.7 decibels.

2. When a change of position is made with the knobs marked ATTENYUATOR GENERATORA, CHASTOTA GENERATORA, and USTAN UROVNYA MOSHCHN (oscillator attenuator, oscillator frequency, and power level setting), indicator 14 of the RT-10 changes its position. In order to get accurate measurements of sensitivity, it is necessary that the indicator of the RT-10 instrument at all times be set at the red line on the left side of the scale or within the limits 0-5 graduations on the upper scale. Setting the needle on zero is done with the knob 2, marked USTAN UROVNYA MOSHCHN (power level setting).

If the sensitivity is below that on the rating plate, the gas dischargers must be tuned.

Conducting sensitivity tests during a heavy cloud cover, fog, and the like is not recommended. It must also be kept in mind, that, when sensitivity measurements are made with a radar tester which is not part of the equipment of that particular radar, the indications will differ from those given in the logbook for that radar. An admissible

sensitivity reading should not deviate from the data plate rating by more than plus-minus 1.5 decibels. In order to obtain correct data in sensitivity measurements, it is necessary to account for the irregularity of the amplitude-frequency characteristic of the instrument, as shown by the graph attached to the RT-10.

8. Tuning the Gas Dischargers

Connect up the transceiver and the RT-10 just as for the measurement of receiver sensitivity (Section 7 of this chapter). Perform all the necessary operations and, after adjusting the attenuation of the RT-10, tune the gas dischargers according to a maximum indication of the 100-microamp ammeter by rotating successively the control screws of the two dischargers. When turning the control screw of the circular discharger of the signal mixer of the antenna switch, be sure to go through its entire range. The discharger is tuned at the largest maximum.

When turning the control screw of the circular side (secondary?) discharger of the antenna switch, be sure to go through its entire range, whereby three possible cases can be encountered:

1. in the tuning with the control screw, only one maximum is detected; the minimum is very far away from the maximum;

2. in the tuning with the control screw, only a minimum is detected;

3. in the tuning with the control screw, a minimum is observed, but on each side of it is a maximum, one of which is larger than the other.

In the first case, tune at the maximum; in the second case, tune away from the minimum; and in the third case, tune at the larger of the two maxima.

In tuning the dischargers, remember that the correct frequency setting on the RT-10 must be obtained in order to avoid tuning the gas dischargers to the frequency of the image channel. It must be remembered that the image frequency for the receivers of blocks B, V, and D (3, 5, and 2) is higher than the main frequency, and that the image frequency for the receivers of blocks A and G (4 and 1) is lower than the main frequency.

NOTICE: Although the receiver sensitivities measured with the RT-10 during a tuning of the gas dischargers to the mirror frequency differ only slightly from the receiver sensitivities measured during a tuning of the dischargers to the fundamental frequency, the signals reflected from the target will pass through the dischargers with greater attenuation, and no target pip will appear on the indicator screens.

There are three methods of tuning the gas dischargers to the fundamental frequency.

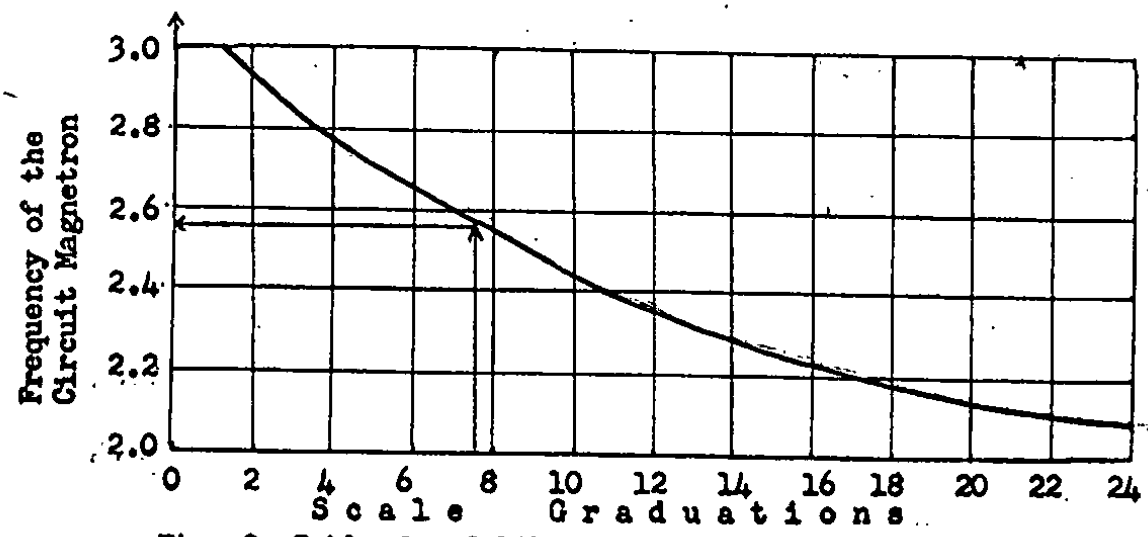


Fig. 9. Table for Calibrating the Oscillator of the RT-10 Radar-Tester

First method: Using the graph (Fig 9) supplied with the RT-10, find the desired scale graduation of knob 12 (CHASTOTA GENERATORA (osillator frequency)) corresponding to the frequency of the magnetron of the given channel.

In tuning the frequency of the oscillator, find the maximum deflection of the needle of the 100-microamp ammeter in the vicinity of this scale graduation. Then tune the dischargers.

Second method: By manipulating knob ATTENYUATOR GENERATORA (oscillator attenuator) set an attenuation of approximately 10-20 decibels and, by rotating knob 12 (CHASTOTA GENERATORA) find two maximum tuning positions on the 100-microamp dial (if the needle deflections are small or absent, it will be necessary to reduce gradually the attenuation until the instrument needle deflection is noticeable).

For example, there are two maxima at graduations 15 and 24, thus two tuning points (See Fig 10).

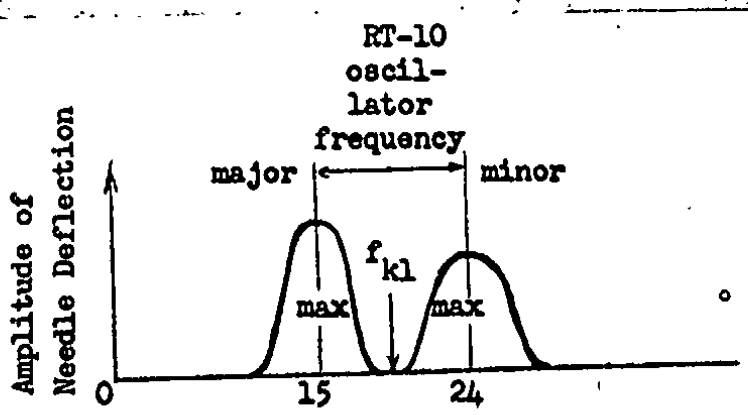


Fig 10. Graph For Tuning the RR-7 Discharger

At these scale points is a maximum deflection of the 100-microamp ammeter needle. The scale graduation at which the RT-10 oscillator frequency is equal to the klystron frequency is found between the graduations representing the maxima.

Tune the RT-10 oscillator to the first maximum in channels 1 and 4, and to the second maximum in channels 2, 3, and 5, to establish the conditions

$$f_{kl} < f_{magn} \text{ (channels 1 and 4), or}$$

$$f_{kl} > f_{magn} \text{ (channels 2, 3, and 5).}$$

Tune the dischargers.

NOTICE: On the scale of the RT-10 oscillator, a reduction in the number of graduations corresponds to an increase in the oscillator frequency.

Third method: Hook up an oscilloscope with slave sweep to the receptacle marked VYKHOD (output) on the front panel of the receiver. With the oscilloscope knobs, CHATOTA (frequency) and AMPLITUDA SINKHRONIZATSII (synchronization amplitude), obtain a stable image of local objects on the oscilloscope screen, and tune the dischargers for maximum amplitude of the signals reflected from the local objects.

Once the gas dischargers have been tuned, measure the sensitivity of the receivers again. If the sensitivity is below that given on the rating plate,

a check should be made of: the crystal in the signal mixer;
the reliability of the gas dischargers;
the receiver input tube, and
the tubes in the IF amplifier.

In the majority of cases, the drop in sensitivity will be due to one of the above components.

LIST OF FREQUENTLY ENCOUNTERED FAILURES IN RECEIVING EQUIPMENT

No.	Nature of Failure	Probable Cause	Remarks
1	Scanning stage does not function	a) Thyratron out of order (tube 15; TT-1-0.1-0.2) b) Faulty resistors $R_{??}$ or $R_{??}$	
2	AFC circuit not operating [8 1/2 lines illegible]	a) If AFC pulses are observed on the oscilloscope (negative and positive) which [illegible] do not have the characteristic thickening at the end, then tube 14 must be [replaced?]	
		[13 lines illegible]	[3 lines illegible]

3. Resistor R_{71} heats up--2.2 kilohms (for radars up to the 1953 models)	The klystron coupling loop tourches the cavity resonator of the klystron.	
4. Absence of noise at receiver output when oscillograph is hooked up to the receiver jack marked VYKHOD (output).	a) Noises at the detector when the 100-microamp instrument is connected to the jack marked DETEKTOR. Check tube 10 (CZh4) and tube 18 (6P3S)	
	b) No noises at detector, then replace tube 16 (6N9S), and check stages 1, 2, 3, 4, 5, 6, 7, and 8 in the UPCh(i-f amplifier); check relay MARU.	Good tubes remain in their places during testing.
5. The level of detector noises is below normal.	Check tubes 1 through 9 in the UPCh (i-f amplifier); check voltage plus 105 v.	
6. Positive pluses are visible on the oscilloscope, no matter what the position of dial RRCh, when the APCh (automatic frequency control crystal current is being tested with the transmitter on.	a) Reduce AFC amplification with potentiometer USIL APCh	
	b) Replace magnetron	

For a successful [adjustment of components in the] transceiver channel, it is well in the [maintenance couses ?] to compile tables for each [2 words illegible] frequency, to use them in the tuning and to enter on the graph all changes in parameters during an exchange of sensitivity. A sample form is given in Table 3.

C H A P T E R III

Checking the Path of Reflected Signals

1. Testing the TK-02 Slip Ring

From the outputs of the receivers, the voltages are fed to the indicator through the TK-02 slip ring. A poor contact between the wipers and rings of the slip ring can cause the target indications to disappear from the displays. The slip ring is tested as follows:

1. Remove the feed voltage from the transceiver.
2. Disconnect cable 1038 from the receiver and connect the neutral wire of the cable to ground.
3. Disconnect the receiver output impedance cable from the PPK cable box.
4. With the TT-1 tester, test the impedance between the neutral wire and ground at the PPK cable box; when the cable is rotated by hand, the impedance should remain constant within the limits of 1-2 ohms.

5. If, when the cable is turned, the impedance drops in value, it is necessary to remove the brushes from the brush (wiper) holder of the slip ring, and to check the smoothness of the copper of both the wipers (brushes) and their contacts (voltage from the outputs of the receivers [fed] to the top of the ring of slip rings 2,3,4,6, and 7). 50X1-HUM

Poor contact can be due to obstructions from chips getting into the holder or the displacement of the brush off the ring and onto the plastic spacer.

2. Testing Block SB-02

The following steps are required in testing Block SB-02:

1. Set the SB-NS switch in block MS-[?] on position SB (power supply cut off).

2. Switch on power.

3. Open the lid on the left side of block SB-02 and throw the switch marked ZAPUSK (start) to the right.

4. At positions VERKHN (upper), SREDN (middle), and NIZHN (lower) of the central switch marked BLANKI (blanks), test the presence of the blanking pulses, NACHALO (beginning), KONETS I (end one) and KONETS II (end two); with the corresponding slits on the lower left side of block SB-02, set the required durations of these blanking pulses.

5. Set the switch marked ZAPUSK (start) to the left.

6. Set the switch marked PERKEKL.KONTR.OSTSILL. (oscilloscope control) to position VERT. (vertical).

7. Set the central switch to position KALIBR. (calibration).

8. With knob USIL.OSTSILL. (oscilloscope gain) set the height of the image of the calibrated voltage on the order of 20 millimeters (two volts).

9. Switch on the receiver.

10. In sequence, set the central switch to positions NIZHN, SREDN, and VERKHN, and manipulate the receiver knobs to establish the noise level of each receiver at approximately 1 volt, which will correspond to half the height of the image of the calibrated voltage.

11. Set switch PEREKL.KONTR.OSTSILL. (oscilloscope control) to position NAKL. (slant) and set the noise level of the receivers of the slant channel also at one volt.

12. Set the central switch to position BYKHOD SBU (SBU output).

13. Switch PEREKL. KONTR.OSTSILL. to position VERT.

14. With the knob marked OBSHCHEYE USIL. VERT. (general vertical amplification), set a noise amplitude equal to 0.7 - 1.0 volt.

15. Set switch PEREKL.KONTR.OSTSILL. to position MAKL. (slant)

16. With the knob marked OBSHCHEYE USIL.MAKL. (general slant amplification), set a noise amplitude equal to 0.7 - 1.0 volt.

NOTICE: Knob OTSECHKA (cutoff) of the vertical and slant [controls?] must be in the far left position.

17. Switch off the receivers.

18. Set switch PEREKL.KONTR.OSTSILL. to position VERT.

19. Switching the SB-02 receivers on in sequence, use the compensators on the horizontal chassis inside the block to achieve maximum receiver noise amplitudes on the oscilloscope screen; turn the compensation potentiometer until the noise amplitude on the screen stops gaining.

20. Set the switch PEREKL.KONTR.OSTSILL. (oscilloscope control) on position MAKL. (slant) and compensate the receivers of the slant channel in the same order.

21. Regulate the block according to the operating instructions.

3. Testing the Reflected Signal Channel on the Display

Testing is done in the following order:

1. Switch on the display.

2. Set normal sweep (scan) brightness with the reflected-signal and scale circuits off. The range scanning traces should be barely visible.

3. Establish normal amplification in the signal reflection channels; at normal amplification, the noise backgrounds should slightly illuminate the screen.

NOTICE: 1. Regulation of the amplification of the reflected-signal channel on the display is done after normal scanning brightness on the oscilloscope screen has been set, and the output noise of Block SB-02 has been set.

2. To prevent signal cutoff, do not put the reflected-signal amplification potentiometer in the far right position.

/

4. Test the equivalent impedances in the reflected-signal circuits (TT-1 tester). The equivalent impedance values should be around 75 ohms.

/

Matching and Tuning the Synchronous-Transmission System Elements

The tuning of all the blocks of the indicator equipment is done in accordance with the instructions. This section gives only the method for tuning the synchronous-transmission elements.

The matching and tuning of synchronous-transmission system elements are done as follows:

1. Switch on block GA-01 in the transceiver compartment, all the panels of the indicator equipment, the remote indicator, and armature switches SL-262 in the US-02 and the KhA-01.

2. Remove the neon lamps in blocks US-02 and KhA-01, and set the slits in the recesses of blocks KhA-01 and US-02 as follows:

   REG USTOICHIV (stability control) all the way to the left;
   USIL TOCHNOGO and
   USIL GRUBOGO OTSCHETA (gain for fine and coarse indication) to the far right

3. Switch the transceiver compartment rotation to three turns.

In blocks KhA-01, PO-02 and PO-03, the scale and scan will begin to rotate. If in any of the blocks the scan rotates counter-clockwise, and the scale moves towards lower graduations, then transpose S_1 and S_2 in the precision selsyn of the BSM servomotor section of the corresponding cabinet. If in all the blocks used, PO-02, PO-03, KhA-01, the direction of rotation of the scan and scale are opposite, then exchange terminals R_1 and R_2 in the selsyn-transducer of the fine indication in Block FD-01.

4. If the rotation is correct according to the precision tracking channel, plug in the neon lamps. If in one of the blocks, the scan or the scale begins to rotate in the opposite direction, exchange the positions of terminals S_1 and S_2 in the coarse selsyn of the corresponding BSM. If counterrotation begins in all blocks, exchange the positions of terminals R_1 and R_2 of the coarse selsyn-transducer in Block FD-01.

5. Lock the transceiver. Loosen the locking device on the di50X1-HUM ential in Block FD-01, and by rotating the FD-01 differential, bring the KhA-01 dial to zero (signalling the moment of concidence of scale and graduation mark is possible with the signal preventing the rotation of the (transceiver) compartment).

6. Loosen the linkage of the stators of the coarse and precision tracking selsyns in block KhA-01, unplug the neon lamp and, by rotating the stator of the precision tracking selsyn in one direction or the other, set the scale of the fine reading to zero (scale of coarse reading also at zero) and tighten the selsyn.

7. While controlling the voltage with the oscilloscope (or with the tester at about 10 volts) in receptacle 115 of block KhA-01, turn the selsyn of the coarse tracking in the direction of reduced voltage until a minimum reading is obtained. Tighten the selsyn and replace the neon lamp.

8. In blocks PO-02 and PO-03, loosen the stators of the fine and coarse-tracking selsyns in the BSM.

If the scan line does not coincide with the North line (off by more than 10 degrees), then, by turning the stator of the coarse-tracking selsyn, transpose the scan and North line (first set the beginning of the scan on the center of the graphic scale).

9. Remove the neon lamp from Block US-02 and, by turning the stator of the precision-tracking selsyn, set the scan on the North line. Tighten the selsyn.

10. While controlling the voltage with the oscilloscope (or with the tester at about 10 volts) in receptacle 115 of block US-02, turn the selsyn (coarse tracking) in the direction of lower voltage until a minimum reading is obtained. Lock the selsyn and replace the neon lamp.

11. If the scan line is out of coincidence with the North line by not more than plus-minus five degrees, correct as indicated under No 8. above.

12. Release the transceiver cabinet from the locked position and switch on rotation. If the blocks have been correctly adjusted, the neon lamps should not light. If the adjustment is correct, and all of the lamps still light up, then the slit (screw) marked USIL.GRUBOVO.OTSCHETA (coarse indication amplification) should be rotated 1/4 turn to the left.

13. Shut off transceiver-cabinet rotation and put it on lock. The scale of block KhA-01 should be at zero, and scan should be on the North line. Remove the cover from block FD-01; loosen the screws which hold the selsyn dials of the precision-and coarse-tracking transducers; set the dials at zero and tighten them; replace the cover of the FD-01.

14. Release the transceiver cabinet from the locked condition and switch rotation on six revolutions per minute.

15. Set the block VO-01 indicator sector in such a way that the scan (sweep) will traverse the screen of the indicator of that block at the instant the scan (sweep) of block PO-02 passes through the North line.

16. Follow the same procedure for the indicator of NO-02.

17. Stop the rotation of block KhA-01 by means of switch YAKOR' SL-262 at the instant the sweep traverses indicators VO-01 and NO-02.

18. Pull out block KhA-01 and, by turning the reduction gear behind the drive sleeve, increase the scale indication of Block KhA-01 to five degrees.

19. The sweep of indicators VO-01 and NO-02 should shift upward. If one or both should shift downward, then the selsyn terminals S_1 and S_2 of the corresponding indicator (upper selsyn BST in indicator NO-02) must be exchanged.

20. If terminals S_1 and S_2 must be exchanged, then switch YAKOR' (armature) SL-262 of Block KhA-01 must be turned on, and the operations given under 15, 16, and 17, above, must be repeated.

21. By turning the reduction gear of block KhA-01, behind the drive sleeve, set the KhA-01 selsyn scales to zero.

22. Loosen the screws which hold the scale USTANOVKA SEKTORA (sector adjustment) of the VO-01 indicator.

23. By slowly turning the USTANOVKA SEKTORA knob of indicator VO-01, obtain minimum deviation of sweep when the knob MASSHTAB AZIMUTA (azimuth scale) is turned.

24. With the MASSHTAB AZIMUTA knob in this position, set the dial at zero and tighten.

25. Follow the same procedure for indicator NO-02. Instead of manipulating the dial MASSHTAB AZIMUTA[turn the knob marked MASSHTAB VERTIKAL'NOY RAZVERTKI (vertical sweep scale), and set both the precision- and coarse-tracking dials to zero at the same time. The control marked SMESHCH LINII GOR (shift line horizontal) superposes the NO-02 indicator sweep on the lower exponential line on the graphic scale.

26. With the KhA-01 dial at zero, brighten up the lines on the screens of the VO-01 and NO-02 indicators. 50X1-HUM

27. Set the NO-02 indicator switch UGOL-AZIMUT (angle-azimuth) on position AZIMUT.

28. By means of switch YAKOR' SL-262, switch on the block KhA-01 rotation.

29. Turn on the scale switches of VO-01 and NO-02.

30. By turning the (preciously drawn out under the slit) axis of the rotor TOCHNYY ST. (precision-[stabilization?]) in block KhA-01, superpose one of the five-degree marks on the earlier illuminated zero lines of the VO-01 and NO-02 indicator screens. Fasten the holder of slit TOCHNYY ST of block KhA-01.

31. By turning the (previously drawn out under the slit) axis of the selsyn GRUBYY ST (coarse-[stabilization?]) of block KhA-01, superpose the thirty-degree mark with the north (zero) five-degree mark on the PO-02 indicator screen. Fasten the slit(screw) GRUBYY ST of block KhA-01.

32. In block NO-02, set the switch on position UGOL (angle), and wait until the scale marks on the screen are well illuminated (brightness can be turned up).

33. Turn the knob marked VYBOR SEKTORA (sector selector) of the NO-02 indicator one degree and notice whether the five-degree marks shift vertically; if the shift is on the order of two degrees, then terminals S_1 and S_2 of the NO-02 five-degree selsyn (lower selsyn of the block selsyn-transformers BST) must be exchanged.

34. Set the coarse and precision scales of indicator No-02 on zero and, during subsequent adjustments, make sure that the zeros do not move out of alignment.

35. Loosen the stator of the lower BST selsyn of indicator NO-02.

36. By turning the stator knob of the lower BST selsyn of indicator NO-02 bring together the five-degree marks in both positions of the switch UGOL-AZIMUT. In this aligning (matching) operation, alternate the switch positions UGOL and AZIMUT and observe the five-degree marks on the indicator screen. After the matching, put the switch on position UGOL.

37. Follow this procedure whenever entire BSM blocks, or the selsyns within them, are exchanged.

38. When exchanging blocks of the BSM or the selsyns of block KhA-01 conduct the entire adjustment procedure and match blocks VO-01 and No-02 with them as described above.

Matching the SSP during an exchange of a block of main transducers (FD-01) in toto, or their selsyns, must be done as follows:

a) unplug the neon lamp in block KhA-01 and rotate the transceiver cabinet clockwise; if the scale of block KhA-01 begins to rotate in the direction of lower graduations, it will be necessary to exchange the terminals R_1 and R_2 of the fine-selsyn-transducer of block FD-01.

b) replace the neon lamp in block KhA-01 and switch the transceiver-cabinet rotation to six revolutions per minute; if the scale of the KhA-01 block begins to rotate in the direction of lower graduations then exchange the positions of the terminals R_1 and R_2 of the coarse selsyn-transducer of block FD-01.

v) Stop the rotation of the transceiver cabinet; loosen the stator of the coarse selsyn-transducer of block FD-01 and, while controlling the voltage with an oscilloscope (or with tester on a scale of about 10 volts) at receptacle 115 of block KhA-01, rotate the selsyn in the direction of lower voltage, reach a minimum value, and tighten the stator.

g) switch the transceiver rotation on six revolutions per minute, switch the UGOL-AZIMUT switch of indicator NO-02 on position UGOL and illuminate the scale of the azimuth marks.

d) turn the knob USTANOVKA SEKTORA (adjustment of sector) of indicator NO-02 one degree and observe whether the five-degree mark on the indicator screen shifts; if the shift is as much as two degrees from its earlier position, exchange the positions of terminals R_1 and R_2 of the selsyn-transducer of the five-degree marks of blocks FD-01.

e) stop block KhA-01 at the instant its scale reaches zero and, at this position, illuminate the sweeps on indicators VO-01 and NO-02; set the UGOL-AZIMUT switch in NO-02 on the position UGOL (angle).

zh) Loosen the stator attachment of the selsyn-transducer of the five-d gree marks of block FD-01 and, by rotating the stator, superpose the five-degree marks of the indicator screens on these illuminated earlier, then tighten the stator of the selsyn.

z) Set the transceiver cabinet on lock; by means of the differential of block FD-01, set the scale of block KhA-01 on zero; loosen the scales of block FD-01 and set them at zero.

Guaranteed normal military operation of the P-20 radar requires that all paramenters be maintained as given in the logbook of the radar set, plus a testing at least once a month of the levelling and the initial angles of image adjustments (in accordance with the instructions for use). All work conducted must be entered in the technical log.

[redacted]