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PREFACE /3

It is difficult to overestimate the importance of marine radar as a means of safer and better navigation and sailing. In order completely to utilize the technical advantages offered by marine radar, the ship's complement and radio specialists should have a good knowledge of the equipment they use and the rules governing its employment, adjustment, and servicing.

The new Kivach-1 and Kivach-2 radar sets can be used on small seagoing vessels; they differ from older marine radar equipment by the fact that they are more reliable in operation at closer ranges and have automated anti-interference and control systems. They incorporate novel and ingenious engineering concepts which will serve as a source of great interest to radio specialists.

If this booklet is used as a manual for the operation, adjustment, and repair of the radar equipment, it should be borne in mind that with the passage of time new issues of the equipment may embody changes; they will be reflected only in the service manuals that accompany the radar set.

The introduction and Chapters I, III, V, VI, and IX-1, IX-2, and X-1 were written by V. Ts. Fridman; Chapters II, VII, VIII were written by V. M. Malyshev; Chapters IV, IX (except #IX-1, and IX-2) and Chapter X (except #X-1) were written by V. V. Blinov. The project was carried out under the direction and editorship of V. Ts. Fridman.

During the process of working on the manuscript the authors availed themselves of the counsel of B. G. Simanovskiy, A. P. Kreyda, V. K. Illarionov, Yu. B. Kraskovskiy, G. G. Gorman, Yu. N. Ladakin, A. A. Averkiyev, M. S. Novikov, and V. L. Kupchik; for this, the authors extend their sincere gratitude.

INTRODUCTION /4

The Kivach-1 and Kivach-2 navigation radar sets are designed to provide greater safety in sailing and navigating small displacement vessels. The sets can also be used as backup radar units on larger sized vessels.

The set operates as a circular scanning unit. It can be used for observing coastal outlines and surface objects, determining the position of the ship with respect to coastal and sea surface reference points, and for getting the coordinates of objects (range and bearing). The Kivach-2 differs from the Kivach-1 in that when used in conjunction with a gyrocompass it additionally provides automatic orientation and image stabilization on the screen "with respect to the meridian" and makes it possible to determine the bearings of objects and the course of one's own ship.

Basically, the Kivach-2 radar differs from the Kivach-1 in that it contains a device for coupling in the gyrocompass and a system for switching the presentation to operate "by course" or "by meridian."

The set is so designed that it can be operated by the ship's crew when under way. These sets are small, have low power requirements, are automated and simple to control and adjust, and can be readily accomodated in the radio shack of a small sized vessel.

In circular scanning short duration transmitter pulses are radiated as a narrow beam into space. Objects encountered in the path of the beam reflect a portion of the energy as pulse signals which are used to determine the range and direction of an object.

The time of transit of radio pulses to a target and back depends on the distance ($Д$) to the target. Since the speed of propagation of radiowaves (C) in space is constant ($C \approx 3 \times 10^5$ km/sec), the time of pulse travel is described by the following formula $t = 2Д/C$, from which we get the formula for range $Д = Ct/2$. Thus, the range of an object is proportional to the time t. On the radar indicator this time is measured by a special cathode ray tube which provides the target range information. The radially circular scan on the cathode ray tube screen of the indicator rotates in synchronism with the rotation of the antenna and, therefore, with the movement of the radio beam in the scanning field. During the instants when the objects are illuminated by the radio beam corresponding brightness markers appear on the CRT screen. The distances of the markers from the center of the presentation, depending on the scale selected, represent the range from the radar set to the objects detected. The directions to the target markers on the screen relative to the ship's course(course reference markers) or to the meridian provide information concerning the relative bearing or the true bearing of a target. 15

The following abbreviations have been adopted in the test of the booklet and in other technical documentation.

- РЛС - radar set
- СВЧ - superhigh frequency
- ВАРУ - automatic time gain control
- УПЧ - intermediate frequency amplifier
- ГК - control oscillator
- ВСК - built-in control system
- ЭЛТ - cathode ray tube
- ОК - course marker
- КУ - relative bearing
- РЗП - ATR tube
- МД - range markers
- ВД - range sighting ring
- СК - self control
- ПЧ - frequency tuning
- КСВН - voltage standing wave ratio
- КЭХ - power characteristic control

- эдс - electromotive force
- U - voltage
- F - pulse repetition frequency
- τ - pulse duration
- ЗИП - kit of spares, tools and accessories
- T - pulse repetition period
- f - frequency of oscillations /6
- Δf - passband
- ППП - semiconductor devices
- ЭВП - electrovacuum device

The following positional designations of elements are used on the schematic diagrams: Л - tube; R - resistor; C - condenser; L - inductance; Др - choke; Тр - transformer; ПП - semiconductor triode; Д - semiconductor diode; Р - relay; Г - control socket; ИП - metering device; М - electric motor or selsyn; В - changeover switch, tumbler switch, blocking contact; Кн - button; Ш - plug type connector; П - contact plate; РИ - discharger; М - electromagnetic shutter, electromagnet; У - junction point.

Each electrical circuit in the set has an assigned number indicated on the electrical circuit diagram and on the end of the corresponding lead. The leads from the various instruments with similar voltages and part of the same circuit are designated by the same numbers.

CHAPTER I /7
PRINCIPLES OF SET DESIGN. STRUCTURE, CHARACTERISTICS, AND OPERATING PRINCIPLES

I-1. STATEMENT OF THE PROBLEM

The conditions for operating the navigation radar unit on small ships are extremely unfavorable and include the following: limited space for housing the equipment; low output capacity and instability of the onboard power supply; insufficient height of radar antenna system, a fact that reduces the range of target pickup; a greater degree of rolling and pitching by the ship with resultant lowered tactical characteristics of the radar equipment; use of the equipment in port areas with dense marine traffic in narrow passages and restricted channels which requires images of sufficiently large scale with minimum dead zone and high resolution; unfavorable conditions for housing the apparatus contribute to difficulties of operation, especially in rough weather with attendant salt water spray, wind, rolling and pitching, rain, vibration, etc; operation of radar at sea is under the direct charge of the deck officer who oftentimes lacks specialized training in electronics.

In view of the foregoing, the radar equipment should be characterized by the following qualities: ruggedness of design with proper shielding; reliability and economy of electric power supply; simplicity and convenience of installation, control and adjustment of operating efficiency, and servicing; and efficient operation when the ship is rolling heavily, especially in the near radar zone.

Inevitably, contradictions such as the following arise in developing a radar set of this type: between small dimensions and equipment reliability; between automation of control, operating efficiency control, and equipment shielding on the one hand, and small dimensions and economy of power supply on the other hand; between the increased requirements for equipment ruggedness and stability with respect to mechanical and climatic influences on the one hand, and small dimensions and reliability on the other.

The most important requirement of the apparatus -- small dimensions -- excludes the possibility of utilizing large sized reliable elements and /8
and units that have been tested in practice; it limits the possibility of greater dependability through reserves in mechanical strength, electrical and temperature relief of radar elements and their redundancy, all of which contribute to a more complicated piece of equipment, i.e. more elements and stages.

The number of elements per unit volume increases in small-dimensioned equipment. Here, the temperature inside the unit assemblies and instrumentation increases. Consequently, the reliability and operating stability of radar element, especially semiconductors, deteriorates. To overcome this situation, cooling ventilators are used in the large-dimensioned apparatus, as well as a variety of operation stabilizers and automatic tuning devices. In small-dimensioned equipment measures of this kind not only make the apparatus more complicated by introducing additional, unreliable elements, but also contribute toward increasing its dimensions, make for poorer economy of the electric power supply, and produce acoustic noises. All these things argue against installing the apparatus in the navigation compartment.

The lack of a specially trained operator on the ship (the radar gear is used by the navogator) calls for the use of automated controls, checks on equipment operating efficiency, and protection of gear against overload, all of which leads to greater complexity of the apparatus and, consequently, larger dimensions and bigger power requirements.

The very considerable mechanical loads (operating and limiting wind load velocities of 50 and 70 meters per second, respectively, and vibrations with an amplitude of up to 2.5 mm) call for greater antenna rotating motor power and increased strength of equipment design. This, too, leads to increased dimensions, greater weight, and bigger power requirements.

The low antenna height of about five meters and the greater degree of ship's motion are responsible for the considerable losses in range and target detection probability owing to distortion of the antenna radiation pattern in the vertical plane, smaller zone of direct visibility, and fluctuations in reflected signals because of oscillations in the antenna beam when the ship is rolling and pitching. To compensate for these losses it is essential to increase the power characteristics of the power unit, which, as we know, involves a more complex piece of equipment; it means increasing the power, and the dimensions and weight, as well as lessened reliability.

Taking into account the vast number of small ships in the fleet as a whole, the radar equipment should be developed with a view to the economic and technological requirements of large scale production, including the necessary unification of instruments and units performing similar functions in the Kivach-1 and Kivach-2 radar sets, reducing the total number of types and lowering the rated values of the constituent parts, maintaining normal access to the various elements, units, assemblies for /9 convenience in replacing or installing elements and in control and adjustment work. All these factors limit the possibility of developing small-sized equipment.

Therefore, each of the foregoing contradictions could not be fulfilled in their entirety, and individual compromising solutions are in order.

I-2. PRINCIPLES OF DESIGN AND BASIC RADAR PARAMETERS

Maximum range of detection. To obtain the necessary range of target pickup (up to 24 miles with an antenna height above the water surface of 5-10 meters) the radar unit should have a power characteristic of about 170 db. Such a characteristic is achieved, for example, in the Donets-2 radar set by using a large antenna and a relatively powerful (15 kw) transmitter, a magnetron, and modulator which is cooled by a special blowing system.

It was found in the case of the Kivach type radar set that it is desirable to decrease the vertical dimensions of the antenna and lower transmitter power down to 7 kw after eliminating the need for cooling; and to compensate for losses in pulse power by increasing the frequency of pulsing in the far zone, decreasing the receiver noise factor, providing a better match between the receiver passband and the transmitter pulse spectrum, as well as by optimizing the antenna beam in the vertical plane with allowance for rolling and pitching.

Experimentation with radar models at sea demonstrated that when the main pulse is prolonged the reflecting capacity of targets increases somewhat more than is generally accepted. For example, when the duration of the main pulse is increased from 0.12 to 0.5 usecs the peak power of the reflected signal at the receiver input increases an average of 3 db for a point target and 7 - 10 db for an extended coastal target. This clearly demonstrates the desirability of increasing the duration of the main pulse on the range scale where range resolution is limited only by the resolving power of the indicator CRT. To get additional gain in the signal-to-noise ratio in this case it is necessary to decrease the receiver passband correspondingly.

For known radar equipment parameters, given a certain amount of ship motion and a certain coverage zone, there is a particular optimal antenna beam width in the vertical plane at which maximum target detection probability is insured. In developing the Kivach radar set for a mean square value of ship's roll of $\pm 10^{\circ}$ and a pitch of $\pm 3.5^{\circ}$, a relationship was set up between the probability of detecting a target in a given detection zone and the width of the beam. It was found here that the optimal width of the pattern in the vertical plane is about 25°. This is greater than

the figure for known domestically produced radar equipment -- in the /10
Donets and Don radar sets the width is 20°. In order to get a beam
widened to 25° it is necessary to have a smaller antenna dimension in
the vertical plane; this decreases the wind load, making it possible
to reduce the power of the drive mechanism.

<u>Blind zone.</u> This characteristic is a function of many parameters:
duration of the main pulse base, CRT indicator resolving power, image
scale, antenna height, width and inclination of its beam in the vertical
plane, decoupling between transmitting and receiving circuits during
the generation and radiation of the main pulse, the passband and shape
of the amplitude and frequency characteristic curves of the receiver in
the input signal dynamic range, the recovery time of the receiver-amplifier
circuit (including the discharger) following the effects of a powerful
main pulse, the length of the waveguide channel and its voltage standing
wave ratio, synchronization stability of the scan relative to the main
pulse, and the power characteristics of the radar set (pulse power of
transmitter, antenna gain, and losses in the superhigh frequency channels).

In selecting a sufficiently short duration main pulse (0.1 usec at
the 0.5 amplitude level and 0.35 usec base) one of the obstacles to any
reduction in the blind zone is the fact that the powerful videopulse of
the modulator is trained toward the receiver, which produces an inter-
ference at the receiver output of up to 0.6 usec duration. Careful shield-
ing of the modulator and blocking all its couplings with filters made
it possible to eliminate this interference in the radar set. Another reason
is insufficient decoupling between the transmitter and receiver on the shf
channel, chiefly in the antenna switch (it does not exceed 25 db).
Accordingly, the leakage of the main pulse (about 15 watts of power)
ignites the discharger, whose regeneration time lasts several microseconds,
and thereby impedes reception of the signal. After clipping by the dis-
charger this pulse of about 40 microwatts goes to the receiver input, over-
loading it, and, as a consequence, it is lengthened considerably (up to
0.5 usecs). To decrease this elongation a pulse of special form is fed
to the receiver input in order to temporarily control the gain; this
decreases the gain during the effective time of the main pulse following
which it restores the gain for the period of the paralyzing effect of the
discharger.

Since the range to the target is measured in the radar set from the
moment of radiation of the pulse by the antenna (after the time of passage
of the pulse through the waveguide channel), the waveguide channel may be
regarded as a delay line capable of reducing the blind zone somewhat.
However, it has not been practically possible to get a travelling wave
coefficient in the circuit over 0.8 - 0.9; hence, when the main pulse /11
travels through the waveguide it is repeatedly reflected by the ends of the
channel and the interior discontinuities. This tends to elongate the
main pulse at the receiver input and therefore increases the blind zone.

It was determined through experimentation that the use of a 10-12
meter long waveguide channel permits reduction of the dead zone. In
this sense there was found an ideal channel length of five meters at

which the dead zone is reduced by approximately six meters. Contributing to the reduction of the dead zone to less than 25 meters were the following: expansion of the antenna beam in the vertical plane to 25°, use of the new type 18ЛМ5B CRT with better resolution (about 400 spots per diameter), enlarging the image scale on the screen-- off-centering the image on the 0.4 mile range scale (fig. I-1) -- to 30 mm on this scale (fig. I-2), and developing a non-overloading logarithmic type receiver.

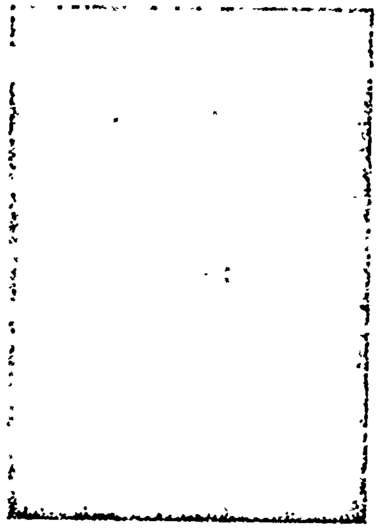

Fig. I-1. Image on the 0.4 mile scale (water area of Kerch fishing port - interference suppression switch on)

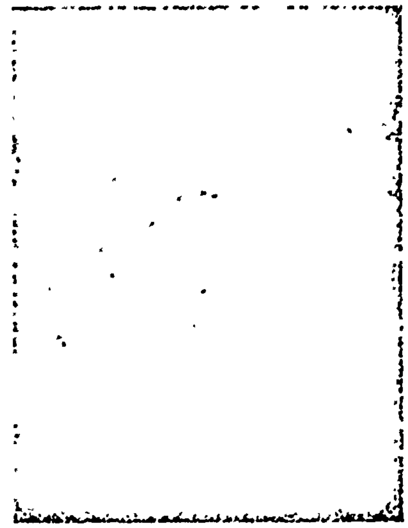

Fig. I-2. Presentation off-centered in the 0.4P mile scale (water area of Kerch fishing port - interference suppression switch on)

Resolution. The measures employed to obtain a small dead zone include: a short probing pulse, wide passband and non-overloading receiver, high CRT resolution, and large scale image; all these insure sufficiently high range resolution not in excess of 25 meters.

Bearing discrimination is determined, basically, by the antenna beam in the horizontal plane. Its width in the Kivach-1 radar set is 1.7° and side lobe attenuation is not less than 25 db. The image center is off-centered on the 0.4 P mile scale to improve the resolution in the near zone; by means of this off-centering procedure the angular dimensions of the target markers observed near the center can be reduced. An operating regulator of the salient point of the discriminator video amplifier amplitude curve is provided to improve resolution and make for better observation of signals against an interference background. This device makes it possible to sharpen the peaks of target echoes. /12

Target determination accuracy. In the case of small vessels a sufficiently high degree of accuracy is necessary to determine the coordinates, especially in the near zone.

In the Kivach radar set the spacing accuracy (standard deviation) of the range scale markers is within 0.5%. An adjustable range sighting ring operating between zero and the maximum range of 24 miles is used to provide greater accuracy in range measurement in the markers and to establish the boundaries of danger zones on the screen when the vessel is sailing through narrow passages.

The radial-circular sweep shaping circuit is designed with two fixed deflecting coils with permanent magnets for centering and focussing the sweep. This insured quiet operation, improved indicator stability and reliability of operation, and contributed toward reducing its dimensions. In this case, the maximum error in the transfer of bearing angles from the antenna and of the ship's course from the gyrocompass to the indicator do not exceed one degree. The accuracy (standard deviation) of determining directions of the target is also not over one degree. Offsetting the image center on the maximum scale allows of greater accuracy in measuring directions by visually halving the target marker and thus reducing the error factor.

Space scanning. The equipment is capable of scanning space in a circular manner within the limits of 0 to 24 miles. The largest image size, which conforms to the conditions of use of radar equipment on small ships, is provided on the 0.4 mile scale. The moderate scan rate of 17 turns per minute used in the Kivach set is adequate to provide information in time in the case of slow-speed, small displacement vessels. Taking into account the wind loading, such a scan rate is convenient for the small radar units. It permits the use of low power motors of about 50 watts for rotating the antenna, and it allows of a greater number of pulses accumulating on the indicator when a target is illuminated, thereby increasing target detection probability.

The new type 18ЛМ5B cathode ray tube produces a clear image with improved brightness (over 300 nits). /13

Invulnerability to interference. One of the most important characteristics of this radar set is its invulnerability to sea clutter and atmospheric precipitation. Efficient radar equipment functioning is especially important in rough seas and in poor visibility.

Automatic time gain control is widely used in foreign and domestically manufactured marine radar sets as an interference killing feature. However, this system has some considerable drawbacks which hinder its use by the navigator. ATGC is a programmed system and is not automatically regulated. It operates independently of the direction of the antenna beam, whereas the intensity of reflections from surface waves is governed by the position of the wave front to the direction of the beam; during a single turn of the antenna this intensity may change 5 to 10 db or more. Depending on the intensity of the sea clutter, the automatic time gain control is set manually. It requires that the operator have a certain amount of skill and that he have some knowledge of the approximate position of the targets obscured by the clutter. The operator must exercise extra care and attention since there is the chance of suppressing useful reflected signals with an amplitude only slightly above that of the clutter level. Therefore, the gain control requires constant tuning while in operations and calls for a highly skilled operator. Also, there is every danger of getting a poor quality echo even where sea clutter is not present. Furthermore, automatic time gain control does not insure against interferences due to atmospheric precipitation.

In searching for ways to improve on invulnerability to interference, much work was done on comparative evaluations of the following interference suppression systems: automatic time gain control and other automatic gain controls such as high speed automatic gain control, noise automatic time gain control, and instantaneous automatic gain control; polarization methods and logarithmic receivers.

Calculations and experiments for determining the effectiveness of polarization methods of protection against interference at sea and during rainstorms demonstrated that circular and lateral polarization (cross polarization) of radiation in marine radar sets can offer a gain of from 5 to 10 db in the signal-to-noise ratio with respect to rain compared with linear (horizontal) polarization of radiation, but actually it does not provide protection against reflections from ocean waves and snow. In that case there is a reduction in the effective radar operating range owing to decreased reflecting capacity of targets and losses in the polarizer (by 4-5 db for circular radiation and 6 to 9 db for lateral polarization in the effective radar operating range), and the antenna system tends to become more complicated. Of the remaining automatic systems, the most accepted and efficient means of protection against interference by sea /14 waves and atmospheric precipitation is the logarithmic receiver with a dynamic band of logarithmic amplitude characteristics within the limits of from -20 to + 80 db relative to the inherent noise level of the receiver.

Experiments carred out in the Sea of Azov and the Black Sea during rainstorms confirmed the efficiency of the logarithmic receiver with a differentiator as a means of protection against ocean clutter and atmospheric precipitation interferences even in a radar set with relatively high resolution (like the Kivach), but in this case the contrast of the overall image and the visibility of elongated sloping objects (shorelines) deteriorated. In order to increase the amount of image contrast in the Kivach radar set the logarithmic characteristic following the differentiator is restored approximately to that of linear with the aid of a special anti-logarithmic video amplifier. The amplitude characteristic of such a video amplifier produces an antilogarithmic effect in the dynamic band by 0 - 10 db relative to the level of the inherent receiver noises (it corresponds to the dynamic band of the brightness indicator). Deterioration of the image of elongated objects in the absence of interference can be eliminated by disconnecting the differentiator with the switch on the radar set control panel. In this case we preserve the advantages of a linear receiver with respect to range of target pickup and insure operational effectiveness and automation of control (the radar set is switched to automatic interference suppression by means of a single tumbler switch).

To attenuate false echoes from the antenna side lobes and to reduce the dead zone, the Kivach radar set has a stationary time gain control (of a special form), when operating on interference suppression, which excludes extra gain in the near zone; this extra gain is present even when receiving signals from objects with minimum reflecting surfaces (boats and the like).

Radar control. Since the officer in charge of a small ship cannot devote much time or attention to the matter of tuning and operating the set, it is important to simplify to a maximum and automate the process of control. It is essential to reduce the total number of operating control elements, especially those calling for tuning, which require the constant attention of the operator, in addition to special qualifications and the requisite time to do the tuning work. Instead of tunable regulators it is desirable to use "Yes-No" type switches or push buttons.

By automating the process of control (switching the interference suppressor, automatic frequency tuning, etc) and stabilizing the operating modes to get better quality images on the screen, it was possible in the Kivach equipment to reduce the overall number of operating control elements down to five (not counting the bearing and range cursors or coupling to gyrocompass); only one of these elements -- the discriminator -- is tunable. The radar system and control panel (scales, control and signalling elements, sighting systems, image scales, etc) were designed with an eye to engineering psychology and technical aesthetics. For example, through the operation of sighting to determine the direction of a target marker on the Kivach-2 /15
radar indicator, the operator can simultaneously read off his own course, the relative bearing, and the true bearing of the target.

Instruments contained in the ship's radio shacks do not contain structural sources of acoustic noises. The light signals in the controlsystem give the operator information about the voltage in the electrical system, whether the power converter and transmitter are switched on, the type of range scale set, and the intervals between the range markers.

Control of radar set operating efficiency and its reliability. A small ship handler without special radio engineering training cannot perform quality service repair work on a radar set with standard metering equipment as it is done in the case of other navigational radar sets. Furthermore, in the smaller sized sets access to the various elements and units that have to be checked for electrical and operating characteristics is difficult and unsafe, especially since the checks have to be made with the set in operating condition. This impedes the work of the base specialist. In this case only two structural solutions are possible: either do not plan on repairing the apparatus while at sea, or develop an uncomplicated, though automated, built-in system of control, which would allow the ship's officer readily to seek out and correct a malfunction.

As a result of a marked reduction in time dedicated to search of malfunctions, the automated system of control has the effect of increasing equipment reliability inasmuch as its readiness factor increases (the probability that at any given moment the equipment is ready for operation).

According to results of factory tests the Kivach radar set has a 0.99 readiness reliability factor and a 0.95 reliability during any eight-hour watch.

On the basis of information contained in the radar screen even in the absence of targets, by taking into account the limiting conditions of their detection in the scanning zone, the criteria for resolution, and accuracy in determining coordinates, it is possible to formulate the requirements of a control signal to insure complete automated control of radar functioning. In the general case a ship's navigational radar system should insure the solution of two tactical problems: detection of various objects or targets and determining their position.

The following basic, tactical parameters should be within the limits of tolerance in a normally functioning radar set for the resolution of these problems: the field of view; the maximum range of detection; minimum range of detection (dead zone); range and bearing discrimination; and accuracy in determining range and bearing. /16

It is complicated process to measure these elements directly and calls for special radar testing conditions (a range) and radar targets, reference equipment whose position and radar characteristics are precisely known. In this connection, uncomplicated measurements and checks of engineering parameters of individual parts making up the radar equipment are ordinarily employed both in the equipment fabrication stage and during operational use. Of the several parameters which govern the power characteristics of the radar set and on which the range of target detection depends, the following are checked: mean transmitter power, antenna gain, tuning the receiver to transmitter frequency, the repetition rate and duration of main pulses, sensitivity and receiver passband, stability of automatic frequency control, scanning speed, etc. Control of one complete parameter such as the radar power characteristic is accomplished indirectly means of a post-operational check of a multiplicity of individual parameters. This is not convenient inasmuch as it increases the production control cycle, raises the probability of missing the defect, increases the overall control error, and calls for highly specialized servicing.

Therefore, in the concluding stage of production control, in periodic and acceptance tests of radar equipment, as well as during operational use it is desirable to check the radar set for system functioning as a whole. In this case, it is necessary to control, at least approximately, the basic tactical parameters of the radar set on the "within-not within" standards basis, using some equivalent target which can simulate the solution of a radar problem, namely, detecting and determining the position of a target. This problem should be resolved with a radar indicator, i.e. under conditions of observation which are identical with operating conditions when observations are made of real targets.

A circular scanning visual brightness display unit is usually employed as the indicator in surveillance radar equipment, hence the general information as to the functioning conditions of a radar unit can and should be obtained by observing the display unit screen. Given these control conditions, it is possible, even in the absence of external objects of information i.e. targets, to obtain control information about the following: circular scanning of space by the radial circular motion of the sweep on the screen and the uniform illumination of the whole screen by noises; about the range image scale by the presence and number of scale markings used to read off the distance; about the direction scale by the presence and position of the bearing marker of own ship and the absence of ellipticity in the range scale circles. /17

To obtain complete information on the display unit screen as to the functioning of the radar system in all of the above tactical parameters, the control system should, in addition to the information available on the screen (in the absence of targets), simulate a point equivalent of the target with a control signal that should satisfy definite criteria.

To check the maximum range of detection, the control signal should satisfy the following requirements.

1. It should have main pulse parameters (pulse duration, wavelength, repetition frequency, number of pulses per packet) such as to produce power conditions equivalent to real conditions in the reception, amplification, and accumulation of the control signal. This makes it possible to control the tuning of the receiver channel by the automatic frequency control system, the gain, receiver and video amplifier passband, and the storage capacity, resolution, and the indicator capacity of the CRT.

2. It should disappear (or diminishbelow tolerance) when the power characteristics of the radar system are reduced below set tolerance values, i.e. it should depend on the ratio of pulse power radiated by the antenna to the threshold sensitivity of the receiver.

As a control of the minimal range of detection, the control signal should satisfy the requirements set forth under points 1, 2, and 3.

3. It should be located and picked up near the bounds of the radar system dead area adjacent to the main pulse.

To control the range resolution and accuracy of determining the range, the control signal should satisfy the requirements of points 1, 3, and 4.

4. The range (delay) of the control signal should be known precisely beforehand and recorded. The requirements of points 5 and 6 should be met to control bearing resolution and accuracy in determining bearing.

5. The shape of the control signal pulse packet envelope should be determined by the radar antenna radiation pattern, i.e. the width of the control signal marker on the screen should be a monotonic function of the width of the antenna pattern in the horizontal plane.

6. The control signal should produce a marker on the display unit the direction of which should be fixed relative to zero (course marker) and known beforehand.

In the Kivach radar set the "point" equivalent of the target and its position with respect to range and direction is simulated by means of a control device the schematic diagram of which is shown in fig. I-3.

The control device consists of the fixed control antenna 2 for receiving a portion of the energy from the radar main pulse (in accordance with points 1 and 5) when the antenna beam 1 of the surveillance radar is directed toward the control antenna, the high frequency delay line 3 for the fixed delay of the control signal for the time (range) corresponding to the radar system dead area (according to points 3 and 4), a techological attenuator 4 for setting (calibrating) the necessary threshold attenuation of the control signal (in accordance with point 2) and the directional coupler 5 for feeding in the control signal to the common signal input of the receiver. /18

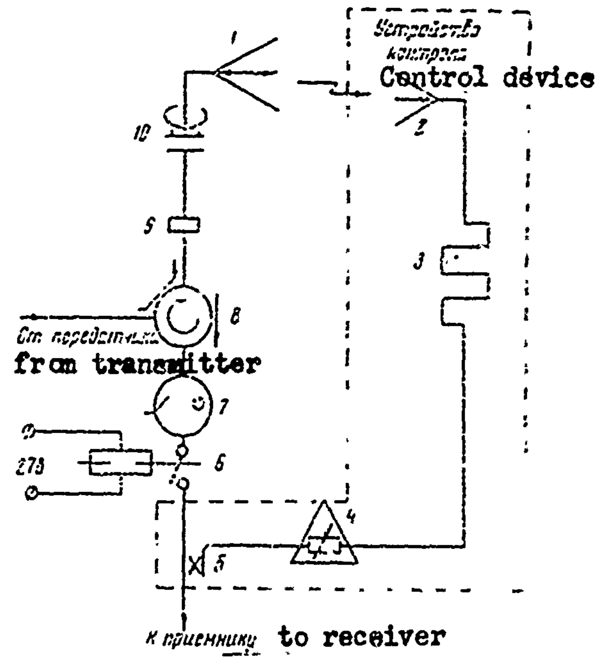

Fig. I-3. Schematic diagram of device for control of radar system power characteristics

The control antenna is set at a certain fixed bearing angle (according to point 6). Its radiation pattern and distance from the circular scanning radar antenna is so selected as to insure the necessary radio communications with the control antenna and to exclude the distorting influence of the latter on the radar antenna radiation pattern.

In a properly functioning radar system the received control signal is observed on the radar screen as an arched brightness marker with previously known coordinates. In the absence of a control marker on the screen (if the power curve and radar dead area have extended outside permissible limits), and changes in the position or shape of the control signal marker, the operator obtains information about any impairment in the functioning of the radar set from the appropriate tactical parameter. /19

The radar antenna, the waveguide channel 9, and the rotating junction 10 are controlled only in the direction of transmission of the main pulse, but this has no theoretical importance in the quality of control since the efficiency of these elements in transmitting and reception are the same. The control signal is fed to the receiver, bypassing antenna switch 8 and receiver discharger 7. This excludes signal attenuationin the discharger during its period of regeneration and makes it possible to utilize a small sized cable with relatively low specific attenuation as a delay line 3. The receiver circuit is protected during control with an electromagnetic screen 6 which is usually present in a radar set to attenuate the radar signals or interferences.

In the method of control discussed, conformance of individual radar parameters that determine the power characteristics (transmitter power, antenna gain, etc) to a standard has no significance, as is also true in operation. It is important that the power characteristics of the radar set as a whole correspond to a standard (it is possible that deterioration of some power parameters are compensated for by the presence of a reserve in others).

Since the operator utilizes the visual brightness indicator for controlling the power characteristic as he does in operation, in both instances the operator, as a recorder of information, is part of the "operator-radar" ov rall system of signal detection. In this control mode it is possible to ignore the error of the operator in detecting the threshold control signal, i.e. the error of solving the problem: "Signal present - Signal not present" (this error can be as much as 2 db). If changes in conditions of observation (screen luminance, indicator brightness capacity, ship's motion, noise, vibrations, etc) make for less favorable detection of the control signal and thereby reduce the power characteristics of the radar set, these very same conditions make less favorable the detection of a signal from a real target when the radar set is in operating condition.

For repairs at sea the radar set is designed with unit construction and a kit of spare parts and accessories which includes all the replaceable units and the most vulnerable elements such as the magnetron, klystron, discharger, crystals, and the CRT. The radar system is tuned and adjusted when under way by a built-in system of control instruments.

The control system provides for the issuance of visual information of the "yes-no" type about the extension beyond permissible limits of controllable output parameters of replaceable units and elements of the radar set. In this case, the following are checked in order: functioning and power /20 characteristics of the set; condition of all power sources; state of control (auto-control) system units; condition of all radar operating units; state of all the more unreliable replaceable radar elements (magnetron, klystron, discharger, and crystals).

The operating time, from the moment the radar set is first switched on, is recorded by a special counter.

Equipment reliability is improved by taking the load off the electrical and radio elements. In this case the electrical load factors in the Kivsch radar set do not exceed 0.5 in power for resistors, 0.7 in voltage for condensers, 0.7 in voltage and power for send-receive switches, 0.6 in power for vacuum tubes, 0.5 in power and current for relays and commutator and adjusting devices, and 0.8 in current density for transformers, chokes, and inductance coils.

To improve reliability and economy of electric power supply, all electronic devices used in the set (with the exception of the magnetron, Klystron, CRT, and discharger) are semiconductors, and the intermediate frequency amplifier consists of nuvistors (metallo-ceramic tetrodes). The line converter (static) also consists of semiconductor devices. Printed circuits are used in most units.

For better reliability and to reduce the time and cost of repair and service work, provision has been made in the radar set to protect the feed source and power consuming units against short circuits, temporary overloads, and jumps in current and voltage when the radar set is switched on and off; it is also provided with automatic protection for the line converter, modulator, scanning devices, and electrovacuum equipment, such as the magnetron, CRT, and klystron, with marked changes in power voltage resulting in inadmissible operating rates. A system of signal lights indicates whe fuses have burned out in feed source circuits.

I-3 COMPOSITION OF SET

The set is made up of the instruments shown in fig. I-4A (antenna rotating system); П (receiver-transmitter); И (display unit); C (line converter); Г (device for coupling in the gyrocompass is used only in the Kivach-2 radar).

Depending on the on-board electrical system for powering the set (24, 110, 220 volts, 400 cycles), instrument C is supplied in appropriate /21
versions such as: C/24 volts; C/110 volts; C/220 volts; C/~ 220 volts-400 cycles.

If the set is powered by a three-phase 220/380 volt, 50 cycle current through an АЛА-1.5М type assembly, the radar set is additionally equipped with the C/~ 220 volt, 400 cycle device. In this case, the current of ~220 volts is set at the output end of the АЛА-1.5М unit. Depending on the type of gyrocompass coupled in, device Г is also supplied with the НЭД-101ТВ differential selsyn (when coupled to the Kurs-4 type gyrocompass) or the СДСМ-1А selsyn (when coupling to the Amur type gyrocompass).

Instrument A is supplied with a receiver selsyn БС-404АН for the Kurs-4 gyrocompass, or the СС-150 selsyn for the Amur gyrocompass.

In addition to the basic instruments the outfit includes the following: installation set (waveguide feeder line, calibrated delay cable, and elements for installation); set of operating documents; set of spare parts, tools and appurtenances ЗШ-1 cabinet; stacking outfite, set of containers. Cables necessary for outside assembly of instrumentation are not included as part of the outfit but are delivered by the enterprise that installs the radar equipment on the ship. The dimensions and weight of the instrumentation /22 used in the set are listed in Table I-1.

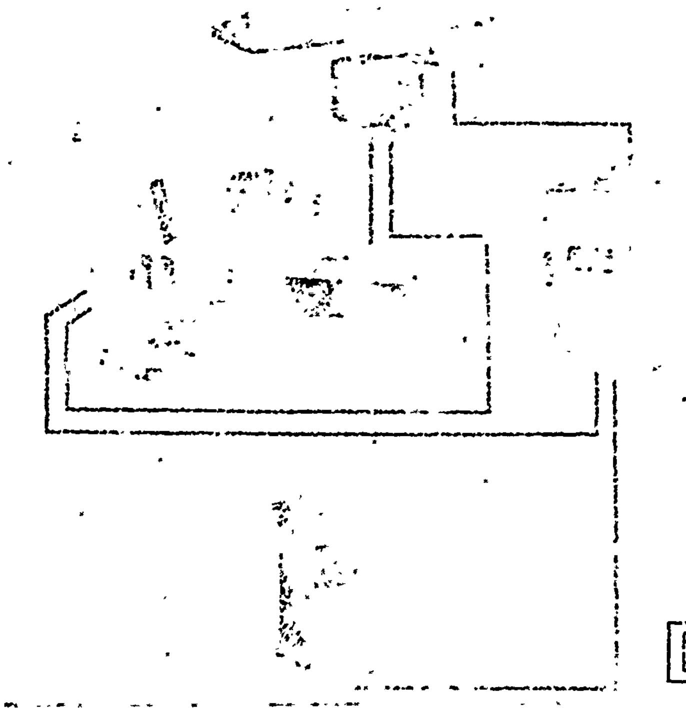

Fig. I-4. Radar instruments: 1 - А; 2 - И; 3 - П; 4 - С; 5 - Т

Radar units are given code numbers consisting of the code assigned to the apparatus or instrument of which it is a part, and codes indicating the number of the unit in the apparatus. Subunits are assigned code numbers consisting of the unit code and digits designating the number of the sub-unit.

Apparatus П consists of the following units: П-1 (modulator), П-2 (superhigh frequency unit), П-3 (receiver), П-4 (automatic frequency tuning unit), П-5 (rectifier ± 110 volts, + 27 volts), П-6 (rectifier - 600 volts, -300 volts, -500 volts), П-7 (rectifier +400 volts, + 50 volts), П-8 (rectifier -12.6 volts, -40 volts), П-9 (rectifier -110 volts/150 volts), П-10 (unit efficiency analyzer), П-11 (control unit).

Apparatus И includes the following units: И-1 (scanning unit), И-2 (ranger marker unit), И-3 (video mixer), И-4 (rectifier +14 kw), И-5 (scale mechanism), И-6 (range sighting ring shaper).

Apparatus A consists of the following units and subunits: unit A-1 (radar antenna), unit A-2 (antenna rotating device), subunit A-2/1 (reducer), subunit A-2/2 (rotating shf junction), subunit A-2/3 (remote transmission of direction device), and unit A-3 (control antenna).

Apparatus C includes unit C-1, the master oscillator.

The radar set kit of spare parts, tools, and accessories consists of the following removable units: П-1, П-3, П-5, П-6, П-7, П-8, П-9, П-10, И-1, И-2, И-3, И-4, И-6, and C-1. It also includes the following spare parts: cathode ray tube, magnetron, heterodyne (klystron), discharger, range sighting ring potentiometer, crystal diodes, dryer, course marker contact assembly, scale and signal illumination bulbs, fuzes, variable discrimination resistor, rotating transformer (phase splitter), electric motor for rotating the antenna, selsyns for coupling with gyrocompass (in the Kivach-2 radar set). The kits of spares also include tools (Ц-57 device, file, wrenches, screwdrivers, etc) and accessories such as solder, lubricant, etc. /23

Table I-1

Dimensions and Weight of Apparatus

Apparatus	Dimensions mm	Wgt of Apparatus Minus Packing kg	Remarks
П.	464x643x304	48	
A (Kivach-1 radar)	1430x344x350	24	
A (Kivach-2 radar)	1430x384x355	27	
И	380x800x660	33	Dimensions for bulkhead version
Г	234x93x168	3	
C/=24 volts	501x503x245	35	
C/=110 volts	413x560x239	30	
C/=220 volts	413x560x239	30	
C/~220 volts, 400 cycles	290x428x198	15	

I-4 OPERATING CHARACTERISTICS AND SPECIFICATIONS

1. Target detection range with a 0.5 probability and antenna mounted 10 meters above sea level:

a ship of 1,000 tons displacement with superstructure height of 12 meters -- not under 8 miles;

average type ocean buoy 3.2 meters high without corner reflector -- not under 1.8 miles.

2. Minimum detection range (dead area) at 0.5 probability and antenna mounted at a height of 10 meters above sea level -- not over 25 miles.

3. Resolution at a probability of 0.5; range resolution on 0.4 mile

scale not over 25 meters, bearing resolution on 1.6 mile scale not over 2°.

Mean square error in target bearing measurement (within 360° limit) -- not over 1°. In this case the maximum error in the transfer of angles from antenna and gyrocompass to the indicator is not in excess of 1°.

5. The set contains seven range scales, to wit: 0.4, 0.8, 1.6, 4.0, 8.0, 16, and 24 miles.

6. Fixed range markers for reading off the range on all scales, and an adjustable range sight ring.

The intervals between range markers on the different scales are: 0.2, 0.2, 0.4, 1.0, 2.0, 4.0, and 4.0 miles, respectively, and the instability (mean square deviation) does not exceed 0.5%.

The adjustable range sight circle operates within the limit of 0-24 miles.

Nonlinearity of range sweep on 0.4-16 mile scales -- not in excess of 3%, and on the 24 mile scale -- not in excess of 4%.

7. For greater accuracy and bearing discrimination in the near zone, and for improved observation of signals in the vicinity of the dead area the radar has an image off-centering system on the 0.4P scale.

8. The scanning rate (antenna rotation) is 15-19 rpm.

9. Width of antenna radiation pattern: in the vertical plane 25° ± 2.5°; in the horizontal plane -- 1.7° ± 0.15° with side lobe attenuation not less than 25 db.

10. Diameter of CRT is 180 mm, which is increased to 230 mm by lens built into the radar viewing hood.

11. Transmitter pulse power -- 7 kw.

12. Duration of main pulse -- 0.1 usecs on scales up to four miles, and 0.3 usecs on scales over four miles; pulse repetition frequencies -- 3100 pulses per second and 2000 pulses per second.

13. Pulse sensitivity of the receiver-indicator circuit is 120 db/watt on scales up to 4 miles and 122 db/watt on scales over 4 miles. Automatic tuning of klystron frequency provided.

14. Readiness time of radar set after closing switch -- four minutes.

15. Set accepts power supply from on board dc power circuits of 24, 110, or 220 volts, or from a single phase 220 volt, 400 cycle alternating current. The set can also be fed by an on board three-phase 220/380 volt, 50 cycle current through the АМА-1.5М converter. /24

The permissible limit of deviation in the voltage line is ± 10%; limit of deviation in frequency is ± 5%.

16. The power requirements of the set from the on-board electric power line for the listed voltages are as follows:

24 volts -- not over 500 watts,

110 volts -- not over 400 watts,

220 volts -- not over 450 watts,

~220 volts, 400 cycles -- not over 350 watts.

17. The set is protected against short circuits.

18. The intensity of industrial type radio interferences produced by the set are well within the Union-wide standards of permissible industrial radio interferences for ships with metallic hulls.

19. Superhigh frequency intensity -- radiation from apparatus П with cover closed -- not in excess of 10 uwatts/cm².

20. Apparatuses A, П, and C do not produce acoustic noises in excess of 85 db at frequencies of 50 - 400 cycles or 75 db at frequencies over 400 cycles. In the И and Г apparatuses structural sources of acoustic

noise are not present.

21. The set is so designed that when at sea it can be used readily by navigation section personnel after they have studied the specifications and operating instructions. Technical maintenance and servicing of set at the base should be performed by trained specialists.

22. The set is operated from the control panels of equipments И and Г.

23. Operational checks of the functioning of the radar set and the efficiency of the units and assemblies are effectuated by a built-in automated control system. The operating time from the moment the set is first switched on is recorded by a special counter. The main control panel is contained on apparatus П.

24. The set is tuned during operation by built-in instrumentation.

25. The equipment is capable of 24-hour uninterrupted operation.

26. The equipment is capable of withstanding effects of climatic factors (Table I-2).

27. Set capable of detecting target with ship rolling up to + 12°.

28. Instrument A is watertight; instruments П, И, С, and Г are /25
spray-proof.

29. The set can withstand mechanical effects in accordance with the USSR Rules of Registry (Part XII-1, Radio Equipment).

30. Apparatus A is resistant to wind loads at velocities up to 50 m/sec and is stable at wind velocities up to 70 m/sec. Equipments И, П, and С are provided with shock absorbers.

31. The dimensions of the several apparatuses allow of transfer through hatchways 600 x 600 mm in size.

Table I-2

Effect of Climatic Factors

Affecting Factors	Value of Affecting Factor on	
	Apparatus A	Other Gear
Increased ambient temperature, °C		
operating	+60	+50
maximum	+65	+65
Decreased ambient temperature, °C		
operating	-40	-10
maximum	-50	-50
Increased humidity at a temperature of 40° C, percent	95-100	95-98

I-5 TECHNICAL AND OPERATING DOCUMENTATION

The delivery size of the Kivach-1 and Kivach-2 sets is determined by the general specification of these systems, as well as the order documentation in which the customer indicates the kind of voltage in the on-board circuit and provides a schematic diagram of the waveguide system (applicable to a particular type of vessel), or orders a modification of a typical waveguide system and indicates the type of receiving selsyn unit for the Kivach for coupling with a particular kind of gyrocompass.

All information about the sets necessary for the client and ship designer is contained in the technical specifications in which the following elements are described for a particular set: its purpose, makeup of the set and supplementary equipment, the technical and operating characteristics; the installation area requirements on the ship; size of delivery package; documents governing standards and methods of testing the apparatuses; technical specifications governing the marking, packing, storage and transportation of equipment; customer guarantees.

The following are inclosed with the package of technical specifications: general specifications (systems, containers, waveguide line and assembly kit); list of spares, tools, and accessories and kit of operating documents; diagrams showing the location of apparatuses on the ship and electrical outlets; diagrams giving dimensions of radar set gear and cabinet for spares, tools, and accessories; table of weights, dimensions, and heat release; table of standard waveguide conduits; drawings of individual special elements for assembling and securing the apparatus on the ship such as gaskets, plates, coverings, etc).

Set adjustment during the manufacturing process at the plant is accomplished in accordance with instructions on adjustment and tuning.

The set is tested and accepted at the manufacturer's plant in accordance with specifications govering manufacture and acceptance in which the following elements are stipulated: technical requirements of the equipment, methods of testing, rules for the acceptance of the products and scope of acceptance-delivery and periodic tests of apparatus at the manufacturing plant. A list of the metering instruments and equipment necessary for testing is provided in the appendix to the specifications.

Test results and acceptance of the radar equipment at the plant are formulated at the plant as an official record of the acceptance and delivery tests performed. /26

The testing and acceptance of a radar set on the ship (after the equipment is assembled and installed) is carried out in accordance with provisions set forth in the document "Program, Standards, and Methods of Testing Kivach-1 and Kivach-2 Radar Equipment on Ships," in which the conditions governing the tests at the mooring area and while under way are stipulated. A list of the control and metering instruments and equipment necessary for the tests is provided in an appendix to this document.

The complement of operating technical documentation delivered with the set is determined by the list of service documents. The service documents of the radar set include the following: the list of service documents; technical descriptions; instructions for operation; logbook;

operating diagram; layout of electrical connections; electric power circuits and circuit protection for the on board power lines, both for alternating and direct current voltages; list of spares, tools, and accessories: schematic electrical diagrams of all set equipment; electrical diagrams of all radar electronic units; list of elements for all electrical circuits; element marking schemes in the electronic units and instruments; kinematic diagrams of mechanical diagrams of mechanical units and subunits.

I-6 BLOCK DIAGRAM OF RADAR SET

Structurally, the radar set consists of separate devices containing the following functional equipment.

Apparatus П -- the receiver-transmitter, rectifier and control system. It shapes and generates high frequency main pulses, transforms and amplifies signals reflected from targets and received by the antenna, feeds radar devices with rectified voltages and controls the efficiency of replaceable units and assemblies.

Apparatus A is the antenna rotating mechanism. It directs the beamed main pulse energy and receives signals reflected from objects, threby insuring continuous circular scanning of space. Device A of the Kivach-2 set also connects with the gyrocompass and thereby receives information about the ship's course when orientation is determined with respect to the meridian.

Apparatus И is an indicating device. It indicates signals reflected from objects, provides a reading of its coordinates, and controls the operation of the whole set.

Apparatus C is a line voltage converter. It converts the on board voltage into the 220 volt, 400 cycle feed required for the set mechanisms and stabilizes it. However, the C/220 volt,400 cycle device, in contrast to other versions of apparatus C, merely performs the functions of a stabilizer of the on board line voltage. Also contained in the C apparatus is the automatic radar switching circuit. /27

Apparatus Г is the device which couples in the gyrocompass. In the Kivach-2 radar set it conjugates communication with the gyrocompass and controls image orientation.

Synchronization of operation of radar mechanisms (see appendix 1) is effectuated by synch pulses formed in the modulator (unit П-1). These pulses actuate the scanning unit (И-1), the range sighting circule unit (И-6), range marker unit (И-2) through the sweep unit and the automatic time gain control circuit of the receiver (unit П-3).

The powerful high frequency energy pulses generated by the shf oscillator, whose duration is determined by the length of the modulator pulses, pass through the shf unit (П-2), the waveguide transmission line and rotating shf junction in apparatus A and are then radiated as the main pulses by the directional antenna (unit A-1) into space to illuminate objects in the radar active zone.

A portion of the energy reflected from the objects as echoes return to the antenna and proceed through the waveguide transmission line to the receiver input (into the shf unit) in which the shf pulses are converted into intermediate frequency pulses (in the receiver mixer) and then amplified and detected in unit П-3. The detected video pulses are amplified in unit И-3 and the video pulses from its output go to the CRT to produce the target brightness markers on the screen.

Unit П-4 (automatic frequency control) automatically tunes the intermediate frequency of signals entering the receiver input.

The range scale marker pulses are developed in the И-2 unit. The adjustable range sight ring (marker) pulse is formed in unit И-6. The range scale marker pulse and the range sight ring pulses are fed into the video mixer (unit И-3) and together with the reflected signals are fed to the CRT indicator. The radial circular scan for presenting the terrain on the CRT screen is produced by units И-1 and A-2. Here, the scale markers on the screen are observed as fixed concentric circles; the range sight ring is seen as a circle whose radius (range) changes with the turning of the range sight ring knob; and the course marker is seen as a radial line when the appropriate contact in unit A-2 is closed.

Units П-10, П-11, and the control system of unit C-1, located in apparatus C, automatically control the operating efficiency of the replaceable units and assemblies, while unit A-3 and the delay cable automatically control the functioning and power characteristics of the set. /28

The Kivach-1 radar unit diagram differs from the Kivach-2 unit only in that the Г apparatus is lacking in the former, as well as the elements coupled to it in subunit A-2/3, i.e. the gyrocompass coupling selsyn, electromagnet for switching over orientation of image and mechanical coupling of selsyn (via the differential and electromagnetic contact) to the phase splitter.

CHAPTER II

FUNCTIONAL AND SCHEMATIC DIAGRAMS OF RADAR SET

Functionally, the radar set consists of the following devices: transmitter (unit П-1 and the shf oscillator circuit); the rotating antenna system (unit A-1, A-2, and the waveguide communication line); couplings with the gyrocompass in the Kivach-2 radar (equipment Г and assemblies for the remote transmission of directions to unit A-2/3; receiver (units П2, П3, П-4, and И-3); the indicator (units И-1, И-2, И-5, И-6, and the CRT circuit); power equipment (device C, units П-5, П-6, П-7, П-8, П-9, and И-4); control system (unit П-10, П-11, A-3, control circuit of units П-4, C-1, and the КЭХ assemblies).

The functional diagram of the Kivach-2 radar set is given in appendix 2. This same diagram applies to the Kivach-1 unit as well, but lacking in the latter is apparatus Г and its coupling with apparatus A; unit A-2 is presented in another version (without units for coupling to the gyrocompass).

The functional diagram of the radar set is adaptable to the several kinds of onboard line circuits, but in order to use the 220 volt, 400 cycle power line the circuit of apparatus C lacks unit C-1 and an inverter circuit built with thyristors. The schematic diagrams of the electrical circuits of instruments П, И, A, Г and C/=220 volts are given in appendixes 3 - 7. The electric power diagrams and the protections for the alternating current voltage, direct current voltage, and onboard network circuits are presented in appexidixes 8, 9, and 10, respectively.

The circuit of a typical waveguide transmission line is described in II-2.

II-1 TRANSMITTER EQUIPMENT

The transmitter is designed to shape and generate periodic main shf pulses and video pulses time-related to them which serve to synchronize the operation of other radar units and to form the automatic time gain control pulse.

Structurally, the transmitter consists of the modulator (unit П-1) and the shf oscillator. The modulator is tubeless and is assembled with /29
magnetic elements (saturation choke coil with rectangular hysteresis loop). A type МИ-507 magnetron with an output of 7 kw is used in the shf oscillator.

The transmitter equipment has the following specifications.

1. The transmitter.

Average power on the small scales (0.4P); 0.4; 0.8; 1.6; and 4 miles) not under 1.4 watts, and not less than 2.7 watts on the larger scales (8, 16, and 24 miles).

Duration of main pulse on the small scales $0.1^{+0.02}_{-0.01}$ usecs, and on the large scales it is $0.3^{+0.1}_{-0.03}$ usecs.

Pulse repetition frequency on small scales 3000^{+250}_{-100} pulses/sec, and on the larger scales it is 2000 ± 150 pulses/sec.

Modulating pulse of negative polarity with an amplitude of 5.3 - 6.5 kw.

2. Synchronization pulses.

Duration 4 ± .05 usecs.

Lead relative to the modulating pulse 4 ± .05 usecs.

Amplitude 10-12 volts.

Polarity, positive.

Duration of leading edge not over 0.2 usecs.

3. Automatic time gain control strobe shaping pulses.

Duration on small scales 0.1 - 0.25 usecs, and on the large scales it is 0.25 - 0.6 usecs.

Amplitude 35 - 50 volts

polarity negative.

The transmitter equipment operates as follows. When the set is switched to the master oscillator of the modulator, a -40 volt current is fed in from the rectifier (Unit П-8). The master oscillator consists of a self-oscillating multivibrator built with type Д228B switching diodes Д1 and Д2. Under the influence of the 40 volt current the master oscillator develops rectangular pulses with positive polarity and a duration of 2-3 usecs with an amplitude of about 7 watts which go to the converter and first compression stage of the magnetic modulator. Two pulse repetition frequencies are provided through a relay for switching over the pulse recurrence frequency (P2 type PЭC-22) by cutting in various resistors to the multivibrator of the master oscillator: 3000 pulses/sec on the small scales, and 2000 pulses/sec on the large scales.

The dc modulator power supply of 100-150 volts fed from unit П-9 is changed in the converter (type KY201Л controlled diodes Д7 and Д9) and in the first compression stage into pulses of positive polarity with an approximate duration of about one usec and an amplitude of 8-9 kw. When operating in the small scales, the pulses from the first compression stage go to the second compression stage where they are reduced to 0.1 usecs where they have an amplitude of about 4.5 kw. When the set is operating on the large scales, there is fed to the 0.3 pulse shaping stage from unit П-9 a current magnetizing the switching choke coil and the pulses from the first compression stage coming to this stage and parallelly to the second compression stage are reduced to 0.3 usecs. The pulse /30
amplitude is approximately [illegible] kw. In both operating modes these pulses are fed to the output pulse transformer which is designed to match the load resistance (of the magnetron) with the output resistance of the modulator. These pulses, with an amplitude of 5.3 - 6.5 kw and negative polarity, from the secondary winding of the pulse transformer are fed to the cathode of the magnetron oscillator Л1 (appendix 3) which generates, under their influence, the approximately 7 kw shf pulses.

The magnetron filament is fed from the filament transformer Tp1 through anti-interference filters. The П-1 unit is also fed through anti-interference filters which exclude the effect of the modulating pulse on the receiver unit in the feed and other circuits. The shf pulses go through the circulator of unit П-2 and the waveguide trnsmission line to the antenna rotating device (apparatus A).

The operation of the radar devices is time synchronized by pulses formed in unit П-1. Pulses from the first compression stage are taken off for the synch pulse formation circuit (type Д228B Д12 diode). Pulses of positive polarity, a duration of 4 usecs, an amplitude of 11 volts with a recurrence frequency of the master oscillator go from the output of the circuit to trigger the indicator and the automatic time gain control circuit (into unit П-3). A pulse of negative polarity and an amplitude of about 40 volts, equal in duration to that of the modulating pulse, is taken from the output pulse transformer of the modulator through the pulse voltage divider to form the automatic time gain control pulse in unit П-3.

Uniform control of magnetron current within the limits necessary for the normal operation of the magnetron (current in pulse -- 4-6 amps) is obtained by changing the amplitudes of the modulating pulse. In this case, the time constant of the converter storage circuit is changed by means of a variable resistor. The average current of the magnetron of 1.5 ma, which corresponds to a pulse current of 5 amps, is set beforehand by selecting the modulator feed voltage from unit П-9. Depending on the spread of modulator parameters, this voltage is selected within the limits from 90 to 115 volts in the 0.1 usec operation, and from 136 to 156 volts in the 0.3 usec operation. The required voltage is provided by setting the jumpers in connection III-1 of unit П-1 (cf appendix 3) between contact 2 and one of the contacts 3-8 of the connection in the 0.1 usec operation, and between contact 1 and one of the contacts 9-13 in the 0.3 usec operation. In the process, a number of operating coils in the transformer secondary winding of unit П-9 are commuted and the rectified voltage on contact 21 in the connection changes discontinuously (intermittently) by approximately 5 volts within the previously indicated limits.

In order to prevent the modulator from becoming inoperable due to short circuiting, there is a protective circuit in the magnetron load /31
(relay P3, type PЭC-15, and P1, type PЭC-9). The average current of the magnetron flows through the winding of relay P3, and if it does not exceed the nominal value by less than three-fold, relay P3 is activated. The feed is taken, in this case, from the master oscillator by means of relay P1.

II-2 ANTENNA ROTATING SYSTEM

The antenna rotating system is designed to transmit high frequency energy from the transmitter to the antenna, radiating it directionally into space by circular scanning, receiving the energy reflected from objects, and feeding it into the radar receiver.

The following elements are included in its makeup (cf appendix 2): waveguide transmission line, radar antenna (unit A-1), and antenna rotating drive (unit A-2).

The antenna rotating drive element consists of three subunits: the reducer (subunit A-2/1), rotating shf adapter (subunit A-2/2), and devices for remote transmission of bearings or directions (subunit A-2/3).

The antenna rotating apparatus has the following specifications.

1. The radar antenna.

Width of radiation pattern in the horizontal plane at the half power points is 1.7 ± 0.15°.

Width of radiation pattern in the vertical plane at the half power points is 25 ± 2.5°.

Antenna gain -- about 700.

Radiation pattern side lobe attenuation in horizontal plane not under 25 db.

Specific change in antenna beam direction in the magnetron frequency band not in excess of 0.5 angle minutes/megahertz.

2. Antenna rotation drive unit.

Speed of rotation of drive mechanism output shaft 17 ± 2 rpm.

Voltage standing wave ration of shf adapter not over 1.2.

Change in voltage standing wave ratio during drive mechanism rotation not over 0.15.

3. Waveguide transmission line.

Voltage standing wave ratio of transmission line not over 1.4.

Admissible attenuation introduced by waveguide transmission line at a length up to 6 meters not over 0.2 db/m; with a length up to 8 meters -- not over 0.18 db/m; and with lengths over 8 meters -- not over 0.16 db/m.

The antenna waveguide system operates as follows. The shf pulses from the transmitter are fed via the waveguide transmission line into the antenna rotating device (apparatus A).

The standard waveguide transmission line (fig. II-1) permits mounting the antenna 5-10 meters above the ship's waterline. It consists of special sections that are essential to the installation of the line. The conical adapter insures connecting the waveguide transmission line /32 to the output of the transmitter (they have waveguides of different cross sections), a flexible tube to provide elasticity of connection between the waveguide transmission line and apparatus П. The waveguide section with a settling reservoir safeguards against entrapment of water in the receiver-transmitter in the event the transmission line seal is broken. The dehydrating section in which a silica gel cartridge is placed insures keeping the waveguide dry if moisture should penetrate into the line. In addition to these essential sections the waveguide transmission line includes the straight sections to provide the necessary length of the line.

The radar antenna (unit A-1) forms the radiation pattern in the horizontal and vertical planes. It is a slotted type sectoral horn inside of which is disposed the traveling wave slot radiator with filter array. The radiator forms a radiation pattern in the horizontal plane (fig. II-2). The pattern in the vertical plane is formed by the horn.

The antenna rotates closkwise and is powered by an Ml direct current motor, type СЛ-369 (in unit A-2), which is coupled to the antenna shaft /33 by a reducer (subunit A-2/1). The reducer insures an antenna rotating speed of 17 ± 2 rpm by means of the Ml motor turning at a speed of 4000 rpm. The required antenna turning speed is set by means of resistor R1 (appendix 5), which is inserted into the electric motor turning circuit. The shaft of the 5BT-И phase splitter, which splits the sawtooth voltage proceeding from the indicator to the sine and cosine components to form the radially circular sweep, rotates synchronously with the rotation of the antenna in subunit A-2/3.

The КП-1 course marker contact device mechanically closes contact 1 with every turn of the antenna (the instant the antenna sweeps across the ship's centerline).

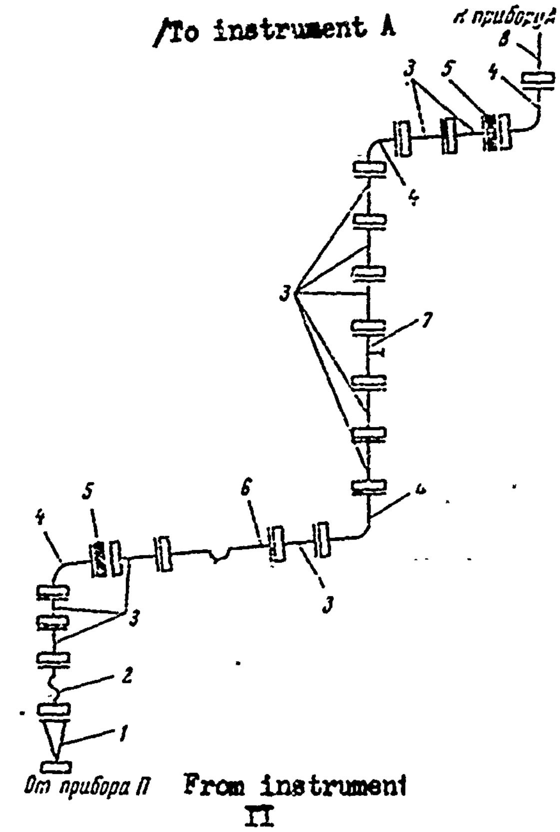

Fig. II-1. Diagram of standard waveguide transmission line: 1. Conical waveguide adapter; 2. flexible tube; 3. straght waveguide section; 4. radial waveguide section; 5. sealing gasket; 6. waveguide section with settling reservoir; 7. dehydration section; 8. straight tubing.

II-3 GYROCOMPASS COUPLING APPARATUS

The device used for coupling in the gyrocompass is designed to stabilize the image with respect to the meridian on the Kivach-2 radar display unit and to switch over to image orientation with respect to the ship's course or the ship's meridian. It can be used for coupling in the Amur and Kurs-4 type gyrocompasses.

Structurally, the coupling apparatus consists of the device for connecting the gyrocompass (device Г) and separate assemblies in subunit A-2/3 of the Kivach-2 set (the selsyn-receiver, mechanical differential, and type orientation changeover switch).

The equipment operates as follows. Then tumbler switch B2 located in instrument Г (appendix 6) is set in the "By meridian" position, a current of + 27 volts is taken from the electromagnet ЭМ-1 in apparatus A and its mechanical switch connects the shaft of phase inverter M3 to the antenna rotating shaft via the tapered differential, which adds course value to the antenna relative bearing value (cf appendix 1). The course value is fed into the differential from the gyroscope by means of the gyrocompass coupling selsyn (M2) with a turn value of 1°. When the Kivach-2 radar is coupled to the Amur gyrocompass, a CC-150 type selsyn receiver is used in subunit A-2/3, and when coupled with the Kurs-4 type gyrocompass, a БC-404AH type selsyn-receiver is installed in the A-2/3 subunit. When Switch B2 in apparatus Г is set in the "By course" position, the +27 volt current is fed to the electromagnet and the mechanical switch connects the phase inverter shaft directly to the antenna rotating shaft. In this case, the phase inverter turns in synchronism and phase with the rotation of the antenna and the image on the scope is oriented with respect to the ship's course. /34

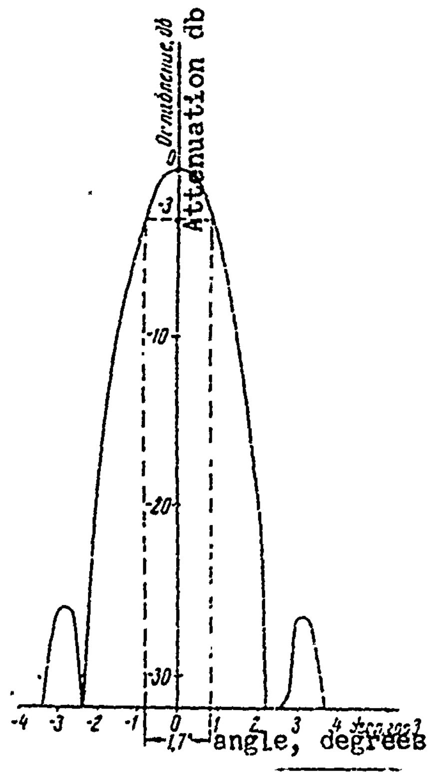

Fig. II-2. Antenna radiation pattern in the horizontal plane.

To initially match the image on the indicator screen with the gyrocompass (after switching the gyrocompass on), there is provided in apparatus Г an M1 differential selsyn which, in this case, is temporarily switched into the circuit between the gyrocompass transmitting selsyn and the M2 selsyn-receiver of the radar set as an intermediate manual data unit (datchik). Depending on the type of Amur or Kurs-4 gyrocompass, apparatus Г contains a corresponding type CДDM-1A or HЭД-101-TB type of differential selsyn. In matching, the gyrocompass coupling switch in apparatus I is set in the "matching" position, and the shaft of the M1 selsyn is rotated with the knob labeled "Matching with gyrocompass"; as a result, the rotor of selsyn M2 in subunit A-2/3 turns. When switch B1 is set in the operating position, differential selsyn M1 in apparatus Г is disconnected from the remote transmission of course and the stator windings of the selsyn receiver in subunit A-2/3 are connected directly to the stator windings of the selsyn-transmitter mounted in the gyrocompass. In the "off" position of the switch, the voltage from the gyrocompass is disconnected from the coupling device circuit. Tube Л1 serves as a signal that a 110 volt, 500 cycle or 110 volt, 50 cycle current is being fed from the gyrocompass to apparatus Г .

П 4. RECEIVER APPARATUS

The purpose of this equipment is to receive and amplify signals reflected from objects and received by the antenna to a magnitude at which they can be observed on the PPI display.

The following elements are structurally a part of the receiver: shf unit (П-2), receiver (П-3), automatic frequency tuning (П-4), and the video mixer (И-3).

The receiver equipment has the following specifications.

1. Input shf device (unit П-2).
Power losses in shf unit in reception not over 1.9 db.
Decoupling between receiver and transmitter circuits not less than 20 db.
Decoupling between automatic frequency control (afc) and intermediate frequency amplifier (ifa) not less than 30 db.
Irregularity in power division by slotted bridges not over 0.15 db.
Direct attenuation of automatic frequency control and intermediate frequency amplifier valves not less than 18 db. 135
Voltage standing wave ratio of mixer sections not more than 2.
Attenuation introduced by shield not less than 50 db.

2. Intermediate frequency amplifier (unit П-3).
Noise factor 12 db.
Amplitude characteristic -- logarithmic in the input signal band from -20 to +60 db with respect to the inherent noise level.
Inaccuracy of logarithmic characteristics not over ± 30%.
Intermediate frequency in the narrow band -- 60 ± 0.7 Mc; in the wide band 60 ± 1.5 Mc.
Passband on small scales 12 + 2 Mc; on large scales 6 ± 1 Mc.
At standard amplification of the ifa the inherent noise level at the output of unit П-3 is set equal to 0.35 volts.
The maximum signal level at the output of unit П-3 is not less than 1.7 volts.
Passband of П-3 video amplifier unit not less than 10 Mc.

3. Automatic time gain control circuit (unit П-3).
Suppression of main pulse not less than 28 db.
Duration of atgc pulse 5 ± 1 usec.
Maximum depth of atgc after strobe 30^{+15}_{-3} db.
Reduction in amplification of ifa in strobe not over 11 db.
In atgc operation the spread in noise amplitude should not change more than by ± 50%.

4. Automatic frequency control (unit П-4).
Automatic frequency control factor on small scales not less than 7.5;

on large scales not less than 15.

Crossover frequency of unit П-4 $60^{+1}_{-0.0}$ Mc.

Frequency spread of discriminator curve voltage maximums relative to crossover frequency ± (5 ./. 7) Mc.

Discriminator curve assymetry not over ± 10%.

5. Video mixer (unit И-3).

Settling time of leading edge of pulse in unit not over 0.055 usecs.

Variation in pulse peaks with duration of 0.5 usecs not over ± 10% .

Duration of range marker and range sighting ring pulses at output of unit not over 0.1 usec.

A receiver apparatus operates as follows. Target reflected signals received by a radar antenna in the pauses between the main pulses proceed along the common receiver-transmitter waveguide transmission line (cf appendix 2) to the shf unit. The receiver is built on the superheterodyne principle with automatic tuning of the heterodyne frequency.

The shf unit performs the functions of a "receive-transmit" switch (insures operation of the set by an antenna common for transmitting and receiving), a converter of received shf signals into 60 Mc intermediate frequency signals, and a converter of shf magnetron pulses into difference frequency pulses for the automatic frequency control system which controls the klystron heterodyne frequency.

A ferrite circulator is used as a "receive-transmit" switch; it is made in the form of a T-piece with the arms disposed at an angle of 120°. /36
In the center of the circular there is a ferrite rod with a permanent magnet on the outside. The direction of power circulation is so selected that the energy coming from the transmitter is practically all directed to the antenna, and that reflected away from the objects and received by the antenna goes to the receiver mixer through the circulator.

The type PP-83 wideband РИ1 discharger mounted in the П-2 unit between the circulator and the slotted bridge protects the receiver against overload when the set generates powerful shf pulses and when it is irradiated by other radar sets located in the near vicinity. At a power exceeding the ignition threshold of the discharger (200 mwt) gas ionization occurs in the latter as a result of which the energy passing through it is limited at approximately 40 mwt. The power of reflected signals is considerably below the discharger ignition threshold and they pass through the discharger practically without loss. To increase the effectiveness and stability of operation of the discharger as a power limiter there is fed a continuous auxiliary -600 volt current from unit П-6. Protection of receiver mixers against strong signals from other radar set is insured, when the set is switched on, by a special electromagnetic shield which provides an attenuation in the receiver circuit of not under 50 db. When the radar set is switched on the shield is opened by an electromagnet to which a +27 volt current is fed from unit П-5.

The slotted bridge insures dividing the power in half, and it insures the necessary phase relationships of signals and heterodyne oscillations in a balancing mixer.

The heterodyne circuit includes the type K94 klystron oscillator, power divider, attenuators, and ferrite rectifiers of the afc and ifa circuits. The klystron has a waveguide output and a frequency tuning screw. The klystron is tuned to a frequency which is 60 Mc higher than the magnetron frequency. The power divider distributes klystron power between the ifa and afc mixers. The operating power of the klystron necessary for optimum operation of these mixers is set by attenuators Y4 and Y12. The necessary decoupling between circuits is insured by installing ferrite valves in the ifa and afc circuits.

Reflected signals and local oscillator oscillations go to the balanced mixer, which consists of two waveguide sections soldered together. One of them contains a crystal high frequency type Д-405Б diode and a Д-405БП type in the other. The intermediate frequency pulses go from the ifa mixer to the input of the receiver (unit П-3). The input circuit, which is tuned to a frequency of 60 Mc, matches the receiver ifa with the mixer. The if pulses transformed by the input circuit go to the low noise stage (Л1 type 6С51Н-В) and are then amplified by two linear stages of intermediate frequency (Л2, Л3 type 6Э12Н-В). A time regulation of the atgc amplifier is made in the linear stages (Л1, Л2); the intermediate frequency amplifier passband is also switched over from the narrow band (5./.7 Mc) to the wide band (10 ./. 14 Mc). The passband is switched by shunting the band elimination circuit with diode Д1 type Д-223А (in the Л2 linear stage) of the amplifier to which is fed a triggering direct current voltage from the contacts of the P1 type РЭС-10 relay when the set is operating on the low scales. /37

Further on, the if pulses go to the logarithmic ifa input (Л4 ./. Л13, type 6Э12Н-В). The logarithmic ifa is built on the principle of the successive addition of detected voltages in the summation line. The if pulses are amplified in each stage of the logarithmic ifa and simultaneously detected in the cathode circuits of the amplifiers. The detected pulses from each stage go to the summation line. The time delay value of each element in the summation line is so selected that the pulses enter the line output simultaneously and their amplitudes are integrated on the line load. In this case, in the range of input signals from -20 to +60 db relative to the inherent noises of the intermediate frequency amplifier, the output voltage of the latter is proportional to the logarithm of the input voltage. Signals of positive polarity from the summation line output proceed to the two stage video amplifier (ПП1, ПП2, type П 416 Б) and, after amplification, are fed through the emitter follower (ПП4, type 1Т308Б) by cable to the input of unit И-3.

The leading edges of the prolonged signals are produced with the aid of a differentiator switched to the "Interference suppression and signal differentiation" operating position by feeding the voltage to relay P2, type РЭС-10. The duration of the differentiated signals is approximately equal to the duration of the main pulses. The emitter follower (ПП3, type 1Т-308Б) insures a sufficiently low resistance of the differentiating circuit.

The positive polarity video signals traveling via cable from unit П-3 are fed to the antilogarithmic video amplifier of unit И-3 (ПП1, type 2Т301Д) which, in a certain sector, linearizes the amplitude characteristics of the receiver circuit as a whole, thereby creating normal conditions of observation of signals above the noises in the dynamic range of the CRT. Formation of the antilogarithmic characteristic is achieved by using non-linear feedback.

The negative video signals on the load (ПП1) are mixed with the negative pulses of range and range sighting ring markers and proceed to the /38 limiting amplifier (ПП2, type 2Т301Д). The mixed signal is clipped to a maximum achieved by cutting off the collector current of transistor ПП2. The purpose of limiting is to match the dynamic range of the signals with the dynamic range of the CRT. Further on, the signals and markers go to the output stage (transistors ПП3 ./. ПП6, type 2Т301Д) in which they are amplified to a magnitude necessary for normal observation on the CRT. The level of clipped signals with an amplitude of up to ?0 volts is necessary for the CRT is established by the limit regulator.

The automatic frequency tuning circuit insures uniformity of intermediate frequency signals (60 Mc) formed in the ifa mixer. Automatic tuning of the frequency is achieved through the electronic adjustment of the klystron oscillator frequency by changing the voltage on its reflector when altering the frequency of the magnetron or klystron. To do this, shf pulses from the magnetron go to the afc mixer through the slotted bridge from the directional coupler У-8. The necessary shf power of approximately 1 mwt required for the normal operation of the afc is established by the У-7 attenuator.

The difference frequency pulses go from the afc mixer to the ifa stages of unit П-4. The ifa consists of three stages (ПП3 ./. ПП5, type 1Т313В) with band filters tuned to the if and has a wide passband (about 20 Mc). The phase discriminator with capacitive coupling (Д2, Д3, type Д18) is the third stage load. If the heterodyne and magnetron frequencies vary from the nominalintermediate frequency, which is equal to 60 Mc, an error video signal appears at the discriminator ouput; its magnitude and sign will correspond to the amount of frequency difference with the normal. The video signal at the discriminator output is expanded and, after passing through the emitter repeater (ПП6, type П416Б), which serves to match the high output resistance of the discriminator with the low input resistance of the video amplifier, proceeds to the preliminary video amplifier. This pre-amplifier is built with transistors ПП7, type П416Б. Further on, the video signals are amplified, depending on polarity, by one of the video amplifiers (ПП8 or ПП9, type МП 25Б) and converted into direct current error voltages in the peak detectors (Д9, Д10, type Д223А). The amount of dc voltage is proportional to the amplitude of the error pulses taken from the discriminator. The error voltage is fed directly to the klystron reflector, changing its frequency until the difference frequency of the magnetron becomes equal to the intermediate frequency.

II-5 DISPLAY UNIT

The indicator device is designed to produce a bright image of a surface object on the screen of the CRT and to provide a means of reading target /39
coordinates by bearing and range

The radar set control panel is combined with the display unit.

Structurally, the indicator consists of the scanning unit (И-1), the range marker unit (И-2), the scale mechanism (И-5), the range scale sighting ring shaping unit(И-6), cathode ray tube circuit, course marker circuits, and radar operation control panels.

The display unit has the following specifications.

1. Indicator.

The radar image is reproduced on the CRT screen, type 18 ЛМ5B with an operating diameter not less than 148 mm, which is increased about 1.5 times by a lens.

Range scales: 0.4P, 0.4, 0.8, 1.6, 4, 8, 16, and 24 miles.

Length of sweep on all scales 71± 5 mm.

Repetition frequency: on 0.4P, 0.4, 0.8, 1.6, and 4 miles scales is 300 pulses per second; on the 8 and 16 mile scales it is 2000 ± 150 pulses per second; on the 24 mile scale it is 1000 ± 150 pulses per second.

The distance between range markers (fixed rings):

on the	0.4P	mile	scale --	1	ring	every	0.2	miles
" "	0.4	"	"	2	"	"	0.2	"
" "	0.8	"	"	4	"	"	0.2	"
" "	1.6	"	"	4	"	"	0.4	"
" "	4	"	"	4	"	"	1	"
" "	8	"	"	4	"	"	2	"
" "	16	"	"	4	"	"	4	"
" "	24	"	"	6	"	"	4	"

Maximum instability of the range marker period, allowing for temperature effects, not greater than 1.5%.

Non-linearity of sweep: on the 0.4, 0.8, 1.6, 4, 8, and 16 mile scales not over 3%; on the 24 mile scale not over 4%.

Range sighting ring permits measurement of distances from 0 to 24 miles.

2. Sweep unit.

Duration of sawtooth current sweep ulses (in usecs), illumination and starting unit И-2:

on 0.4P, 0.4, and 0.8 scales --		14± 1
on 1.6	scale --	28 ± 3
" 4	"	65 ± 5
" 8	"	135 ± 15
" 16	"	235 ± 15
" 24	"	370 ± 20

Amplitude of positive pulses for illuminating the foward motion of the sweep 20 ± 3 volts.

Amplitude of negative pulses for triggering unit И-2 not less than 9 volts.

3. Range marker unit.

Duration of range marker pulses 0.03 ./. 0.05 usecs.

Pulse repetition period:

on 0.4P, 0.4, and 0.8 mile scales -- 2.47 usecs ± 1.5%
" 1.6 mile scale -- 4.94 usecs ± 1.5%
" 4 " " 12.35 " " "
" 8 " " 24.7 " " "
" 16 " " 49.4 " " "
" 24 " " 49.4 " " "

Amplitude of negative pulses of range markers -- not less than 2 volts.

4. Range sighting ring shaping unit /40

Duration of range sighting ring pulse 0.03 ./. 0.05 usecs.

Amplitude of negative polarity range sighting ring pulse -- not less than two volts.

Interval of uniform travel of range sighting ring pulse relative to the main pulse 0 - 296.4 usecs.

The indicator equipment works as follows. Positive polarity synch pulses of 4 usecs duration with an amplitude of 10-12 volts go from the П-1 unit to the display device to the units И-1, and И-6 (cf appendix 2). In the И-1 unit the pulses are fed to the delay line ЛЗ-2, type ЛЗТ which coincides the beginning of the sweep with the main pulse on the CRT in all scales except the off-centering scale (o.4P). Switching the leads of the delay line on this scale insures leading the sweep (offsetting the center) relative to the main pulse by 1.6 - 2 usecs. From the delay line the pulses go through the emitter follower (ПП1, type 2Т301Д) to the driven multivibrator built on a circuit with emitter coupling on transistors ПП2 and ПП3, type П416Б Negative polarity pulses are taken off the multivibrator (equal to sweep duration); they have an amplitude of 11 volts and are fed to the power amplifier.

The power amplifier is built with parallelly connected transistors ПП6 and ПП7, type П605 on a transformer circuit from the output of which positive polarity pulses of about 20 volts and equal in duration to that of the sweep duration proceed to the sweep generator starter (sawtooth current oscillator), which is built on a two-line circuit. On the 0.4P and 0.4 mile scales the sweep current pulses are formed according to a circuit with a control diode (Д20, type КУ201Л). In this case, the sawtooth pulse is formed by the discharge of the storage element through the control diode. The sweep generator is switched to the power amplifier on the 0.4P and 0.4 mile scales by feeding the -40 volt current to the generator with the aid of relay P5, type РЭС-9. The contacts of this relay alternately (depending on the scale set) cut in the output circuits of the oscillator in each channel to the beginning sweep registration circuit.

On the other scales the sawtooth current generator channel on powerful transistors is switched to the power amplifier (when relay P3 is de-energized).

The generator is designed on a bridge circuit, the arms of which are formed by transistors ПП8 and ПП9, type П210А and diodes Д17 and Д18, type Д231.

Positive pulses with an amplitude of about 1.5 volts are taken from the multivibrator to trigger unit И-2; these pulses are then amplified by the triggering pulse amplifier (ПП4, type МП10А) and go via delay line ЛЗ-1, type ЛЗТ to the emitter follower input. The zero range /41 marker is caused to coincide with the main pulse on the small scales (0.4P, 0.4, and 0.8 miles) by switching the delay line leads when selecting the different range scales.

The emitter follower ПП5, type П416Б serves to match the low input resistance of unit И-2 with the line delay. From the emitter follower output the negative 9 volt triggering pulse goes to unit И-2. The 20 volt positive illumination pulses are taken from the power amplifier and go to the CRT modulating electrode.

The sawtooth pulses of current from the sweep generator go via apparatus A to the CRT circuit. The latter consists of type 18 ЛМ5В CRT, circuits for fixing the initial sweep position, deflection coil, centering system, and the preliminary focusing of the CRT beam system.

The following are fed to the CRT electrodes to insure operation of the CRT and a normal radar image: to the cathode -- video signals mixed with range marker pulses and range sighting ring pulses, and the course marker pulse; to the first anode -- focusing voltage whose magnitude is set by the focus control; to the modulator -- pulses for illuminating the sweep motion and a negative voltage for blanking the CRT in pauses between illuminating pulses. The magnitude of the voltage is established by the brightness regulator.

The deflection system consists of a stator type core with slots containing sine and cosine type coils whose axis is shifted 90° to insure a rotating magnetic field.

The centering system consists of a permanent magnet and a magnetic conductor which surrounds the neck of the tube. The system of preliminary magnetic focussing is similar to the centering system.

The sine and cosine windings of the phase splitter (in unit A-2) are connected to appropriate windings of the deflection system through the bridges for fixing the starting point of the sweep (diodes Д2 ./. Д9, type Д231).

The course marker circuit consists of resistors R15, R16, R18, R20, and R21, condenser C4 and diode Д13, type Д223А (cf appendix 4). Until the instant the antenna axis passes through the ship's center line, the mechanical contacts of the course marker in apparatus A are open and condenser C4 is charged by the -300 volt source current. The instant the antenna axis coincides with the center line, the contacts in unit A are closed and condenser C13 is discharged through R18. The negative pulse of the discharged condenser goes to the CRT cathode, causing radial illumination for several sweep periods i.e. creating a course marker on the indicator screen.

The range scale markers are formed by unit И-2. The triggering pulse from unit И-1 goes to the shock excitation generator of the range marker unit (ПП1, type МП10А). It develops sinusoidal oscillations of about 4 volts. The oscillating frequency is determined by the circuit parameters (in the emitter circuit) and, depending on the range scale, is selected such as to insure the necessary number of markers on each of the scales. Uniformity of amplitudes of sinusoidal oscillations is insured by the magnitude of the positive feedback of the additional charging stage (ПП2, type МП10А) built on the scheme of an emitter follower, which also insures decoupling the oscillator from the following stages of the unit. From the emitter follower the sinusoidal oscillations go to the limiter (Д1, type Д311А) which passes the negative half periods of the oscillations and limits the positive ones. The limited pulses are fed to the trigger (ПП3, ПП4, type П416Б) which shapes the rectangular 12-volt pulses of about one usec duration going to the differentiating circuit. The negative 0.1 usec pulses of two volts go from the differentiator output to trigger the blocking oscillator (ПП5, type П416Б). /42

The blocking oscillator is designed on the scheme of a driven oscillator with a load in the emitter circuit. Negative range markers with a duration time of .03 - .05 usecs and an amplitude over two volts are taken from the blocking oscillator output; they are fed into the video mixer (unit И-3).

The range sighting ring is formed in the И-6 unit. The synch pulse from apparatus П for starting unit И-1 is fed simultaneously to the differentiator of unit И-6. The differentiator accentuates the negative pulses which activate the trigger, and the positive overshoots are limited by diodes Д1, type Д311А. The trigger (ПП1, ПП2, type 2Т301Д) forms negative pulses of 9 volts which go to the sawtooth voltage oscillator designed on a charging capacitance circuit with a ПП3 type 2Т-301Д transistor. The duration of the pulses is a function of the distance measured. The positive sawtooth voltage is taken from the oscillator output and fed to the comparator. Also fed to the comparator is a direct current range sighting ring delay voltage from the linear range potentiometer R26 type ППМЛ-М (cf appendix 4). The magnitude of the voltage is set by turning the range sighting ring knob; the voltage is proportional to the range counter readings. The comparator is built with transistors ПП4 (2Т301 I) and diodes Д7, Д9 (Д 223А), and operates as an amplifier with negative feedback or as a blocking oscillator. When the sawtooth voltage on the comparator reaches the delay voltage, a strong positive feedback is formed in the circuit and a blocking process takes place. /43
As a result, there is formed at the comparator output a negative voltage pulse for a particular range with a duration of 0.1 usecs and an amplitude of 2 volts, which triggers the output blocking oscillator. The latter (ПП5 type П416Б) is designed on the scheme of a driven oscillator with collector-base coupling. After leaving the blocking oscillator the not less than two volt pulses of 0.03 - 0.05 usec duration go to the video

mixer (unit И-3) as a range sighting ring pulse. The required amplitude of the output pulses is controlled by potentiometer R32.

A five volt, 2 usec negative pulse is taken from the collector of transistor ПП4; this pulse goes to the trigger (ПП1, ПП2) and returns it to the original position, thereby preparing the circuit for receiving the next starter pulse.

The scale mechanism (unit И-5) makes it possible to read bearings, course angles, and to measure distances to objects. It consists of two scales: the fixed scale with graduations from 0 to 360° (reference lines every degree) and a movable scale with graduations from 0 to 180° (right and left). The bearing sight or cursor is attached to the movable scale. Unit П-5 contains a linear range potentiometer and a reducer which activates this potentiometer and a range sight counter.

II-6 POWER SUPPLY EQUIPMENT

The radar power supply equipment serves to convert the onboard line circuit into an alternating, stabilized, sinusoidal current of 220 volts and 400 cycles, and to produce direct voltages necessary for powering the units and assemblies in the set. In taking power from the onboard 50 cycle network we use an А ЛА-1.5М type outfit; stabilization is provided by the С/~220 volt, 400 cycle apparatus.

Structurally, the power equipment consists of apparatus C and rectifying units (П-5, П-6, П-7, П-8, П-9, and И-4).

The power supply equipment has the following specifications.

1. Supply line converters.

Effective output -- 220 volts.

Output voltage frequency 400 ± 10 cycles.

Instability of output voltage when changing the onboard supply line voltage ± 10% is not over 1%.

Second sequence voltage cut in between three and five minutes after switching equipment on.

2. Master oscillator (unit C-1).

The unit gives off two pulse sequences which have a 180° phase shift and the following parameters:

pulse amplitude not under 10 volts, a current of not less than 250 ma, pulse recurrence frequency of 400 ± two cycles, and pulse duration of 300 - 500 usecs.

3. Rectifier ± 110 volts and + 27 volts (unit П-5).

Input voltage of unit when feeding with sinusoidal current of 220 volts 44
from unit C is: ± 110 volts ± 2%, +27 volts ± 2%, and 115 volts ± 5%.

Ripple voltage at rectifier output not over 0.75 volts.

4. Rectifier -300 volts, -500 volts, -600 volts (unit П-6).

Output voltages of unit when fed with sinusoidal, 220 volt current from instrument C is equal to -300 volts ± 2%, from -420 to +500 volts ± 2%.

Ripple voltage at rectifier output from -420 to -500 volts not over 0.5 volts; -300 volts -- not over 0.3 volts.

5. Rectifier +400 volts, +50 volts (Unit П-7).

Output voltages of unit when fed with sinusoidal 220 volt current from apparatus C is +50 volts ± 50 volts ± 2%, +400 volts ± 2%.

Ripple voltage at rectifier output +500 volts -- not greater than .075 volts; +400 volts -- not greater than 0.4 volts.

6. Rectifier -12.6 volts, -40 volts (unit (П-8).

The output voltages of the unit when fed with a sinusoidal 220 volt c current from apparatus C is -40 volts ± 0.3%, and -12.6 volts ± 2%.

Ripple voltage at rectifier output -12.6 volts -- not over .003 volts; -40 volts -- not over .06 volts.

7. Rectifier -100 volts/-150 volts (unit П-9).

Output voltages of the unit when fed with a sinusoidal 220 volt current from apparatus C, depending on the position of the jumper in unit III-2, are as follows:

jumpers	2-3 in position	-- 90 volts	± 2%
	2-4	-- 95 "	"
	2-5	-- 100 "	"
	2-6	-- 105 "	"
	2-7	-- 110 "	"
	2-8	-- 115 "	"
	1-9	-- 136 "	"
	1-10	-- 141 "	"
	1-11	-- 146 "	"
	1-12	-- 151 "	"
	1-13	-- 156 "	"

Ripple voltage at the output of the unit with a current of -105 volts not over 0.5 volts, and with a current of +146 volts it is not over 0.75 volts.

8. Rectifier +14 kw.

Output voltage of unit when fed with a sinusoidal current of 220 volts from apparatus C +14 kw ± 3%.

Ripple voltage not over 22 volts.

Static line voltage converters for dc onboard power lines of 24, 110, and 220 volts are functionally similar and operate as follows (the operating principle of apparatus C/=220 v is considered here).

When the set is switched in by the tumbler switch from the control panel a +24 volt current obtained from the onboard power line through a voltage dropping resistor in apparatuses C/=220 volts and C/=110 volts is fed to the master oscillator. In apparatus C/24 volts the current to the master oscillator is applied directly from the onboard power line. In the process (cf appendix 7) the multivibrator of the master oscillator (ПП1, ПП2, type МП14А) working in self-oscillation generates pulses with a duration of 300-500 usecs and a repetiation frequency of 800 cycles. /45
These pulses go to the formation stage (ПП3, type МП25Б), designed on the principle of an amplifier-limiter circuit. Negative pulses with steep fronts and an amplitude of about 6 volts are taken from the output of the pulse shaper; these go to the differentiating circuit. From the latter, sharp pointed positive pulses (the negative pulses are cut off by the diodes)

are taken off to activate the trigger (ПП4, ПП5, type МП14А); this element activates and gives off from the two arms voltage pulses of different polarity with an amplitude of 6.5 volts and a frequency of 400-500 cycles. Pulses from the trigger go to two coincidence circuits (Д4, Д7, and Д6, Д8, type Д223А). At the same time, pulses directly from the shaping stage enter the coincidence circuit. With the simultaneous presence of negative polarity pulses from the trigger and shaper on diodes Д5, Д7 and, accordingly, Д6, Д8, a series of negative pulses, time-shifted by exactly 180°, are taken from their loads. These pulses are then amplified by the amplifier-limiter (ПП6, ПП7, type МП25Б), built on a circuit with a common emitter and transformer as load, and powerful output stages on transistors ПП8, ПП9, type П214В. Pulses of not less than 10 volts go from the output to the inverter circuit. As the power is fed to unit C-1 the onboard power line voltage is fed to the winding of the contactor of apparatus C. In apparatus C/=24 volts there are two contactors (one for each phase of the onboard net) of the TKД201Д type. Contactor P1, type KH-153 is mounted in apparatus C/=220 volts. The contactor will trigger and switch in the onboard power line to the inverter, which is built on the bridge system and is transistorized. Depending on the power line voltage, thyristors Д3 and Д4, types ПТЛ-100-2, ПТЛ-50-5, or ПТЛ-50-7, respectively, are installed in the 24, 110, and 220 volt converters. Powerful pulses are taken from the inverter output with a frequency of 400 cycles, which are then fed to the voltage stabilizer.

The stabilizer is built with a saturation choke Др10 with positive feedback effected by diodes Д20 and Д21 (type Д 233Б). If the network voltage or load current is changed, the voltage at the output is held constant. A pulse voltage of truncated form is taken from the stabilizer output, which is increased by the autotransformer (Tp5) to values up to 240 volts (effective), and fed to the first harmonic filter. The filter is tuned to resonance (Др12, C11, Др13, C12) (cf appendix 7) and separates the first harmonic component frequency of 400-500 cycles with an effective current of 220 volts from the truncated pulse voltage. This sinusoidal voltage goes directly to the rectifier units П-5, П-6, П-7, П-8 and to the filament transformers of the magnetron, klystron, ifa tubes, and the CRT. At the same time, the sinusoidal 115 volt current from the transformer Tp1 is fed to the winding of thermorelay P3 of the automatic circuit. When the thermorelay is activated (3 to 5 minutes), the stabilized current of 220 volts goes to rectifier units П-9 and И-4, which are connected into the second series since the high voltage to the magnetron should be fed in after the filament wires have been heated, and the high voltage should be cut into the CRT after the negative voltage has been applied to the control electrode of the tube. When the voltage appears at the converter input, relay P2 is triggered and unit C-1 is switched over to be fed by the ± 24 volt rectifier assembled in apparatus C on diodes Д7, Д8, type Д226. /46

Rectifiers for supplying sets with direct voltage currents are made on the bridge circuit and are not stabilized (except for unit П-8). Stabilization of their output voltages is insured through the general stabilization of the input voltage by apparatus C. Exceptions are the -40 and 12.6 volt rectifiers in which additional electron stabilization occurs. A precise setting of rectifier output voltages is made by means of compensating transformer windings.

Unit П-5 develops a current of ± 110 volts (load current is 0.3 amps) for feeding the antenna rotor and a current of +27 volts (load current 1.2 amps) for feeding the relay and electromagnets. Both rectifiers operate from a common transformer Tpl to increase the efficiency. A 115 volt alternating current is taken off the transformer leads to feed the electric clock contained in device П.

Unit П-6 develops a current of -300 volts (load current 0.05 amps) for feeding the CRT, the klystron, and unit И-6; a current of -600 volts (load current 0.0001 amp) for heating the discharger; and a current of -420 to -500 volts (load current 0.006 amps) for feeding the klystron. The -600 volt current is provided by adding together two rectified voltages of -300 volts.

The rectifiers operate from a single common transformer Tpl. The unit contains a protective circuit which safeguards the klystron when the -420 to -500 volt currents are disconnected, and one for protecting the CRT when the -300 volts on the control electrode of the tube is disconnected. The protective circuit is built on transistors ППП1 and ПП2, type МП25Б and relay Pl, type РЭС-22. When the -600 volt (or -300 volt) current is removed the protective circuit is activated and relay Pl breaks the alternating current 220 volt circuit feeding units П-6 and И-4.

Unit П-7 develops +400 volts (load current 0.007 amps) for feeding the circuits of the CRT and the И-6 unit, and +50 volts (load current 0.215 amps) for feeding units П-3, И-3, and И-6. The +400 volts is obtained by adding the rectified +50 volt and the +350 volt currents taken off a supplementary rectifier. Both rectifiers operate from a single transformer Tp-1. /47

Unit П-8 develops -40 volts (load current 0.6 amps) for feeding units П-1, П-4, И-1 and И-3 and -12.6 volts (load current 0.25 amps) for feeding units П-4, П-10, И-1, И-2, and И-6. Semiconductor compensation type stabilizers with series-connected regulating element are used for stabilizing the rectified current in the -40 and -12.6 volt rectifiers.

Unit П-9 develops -100 volts (load current 0.61 amps) or -150 volts (load current 0.42 amps), depending on the range scale setting in apparatus И, and is used to feed unit П-1. The -100 volts or -150 volt currents are cut in by relay Pl to which is fed a +27 volt current when working with the large scales (8, 16, and 24 mile scales). Setting the voltage within the limits of 96 - 115 volts on the small scales, which is necessary to operate unit П-1, and 136 - 156 volts on the large scales is done by changing the number of turns in the secondary winding of transformer Tpl with the aid of two jumpers. Also mounted in the unit is a circuit for protecting unit П-9 against random short circuits in the load and against overloads. The protective system disconnects unit П-9 from unit П-1 the instant an overload occurs and then automatically cuts in the unit after a certain delay sufficient to avoid overloading due to random pauses in the operation of the thyristor circuit in unit П-1. The protective circuit is built with relays P2, type РЭС-9, and P3, type ТКЕ 16ПДIУ.

Unit И-4 developes +14kw for feeding the secondary anode of the CRT. The rectifier is designed to increase the voltage eight-fold; it contains selenium rectifiers (Д1 ./. Д16, type ТВС-7-19М). Transformers Tp1 (for feeding the magnetron filament), Tp2(for feeding the klystron filament), and Tp3 (for feeding the ifa tube filaments) are assembled in apparatus П for feeding the filament circuits. A filament transformer Tp1 is assembled in apparatus И for feeding the CRT filament circuits. All filament transformers provide a current of 6.3 volts. Appendixes 8 - 12 list the electric power circuits for alternating and direct current voltages and those in the onboard power line. The circuit diagrams indicate the numeration of the wires and contacts of connector units through which the voltages travel to the various consuming units; also given are the numbers of the leads of the various transformers and chokes in the units, as well as the elements to which the different voltages are directly applied.

II-7 CONTROL EQUIPMENT

The control equipment is designed to provide control of required tolerances of the radar equipment power characteristics, as well as the operating efficiency of all replaceable units and assemblies. /48

The following elements are included in the control system: unit effiency analyzer (П-10), control unit (П-11), automatic frequency control oscillator (contained in unit П-4), unit C-1 control circuit (contained in apparatus C), and power characteristic control assemblies.

The control equipment has the following specifications.

1. Unit efficiency analyzer.

Amplitude selection threshold of control pulses of units И-2 and И-6 -- one volt ± 20%.

Amplitude selection threshold of control pulses of units П-1 and И-1 -- one volt ± ;0%.

Direct current selection threshold for control of units П-3 and И-3 -- 0.5 volts ± 10%.

Theshold indeterminacy selection zone of pulse and dc voltages not greater than 12 millivolts.

Self control by analyzer is insured at 0.5 volts $^{+0.02\ v}_{-0.01\ v}$

The unit develops modulating oscillator pulses for controlling the automatic frequency of positive polarity, duration 3 usecs ± 10%, repetition frequency of 4,000 pulses per second ± 10%, and an amplitude of 1.5 volts ± 20%.

2. Control unit.

Normalizer in control circuit of unit П-1 divides by 30 (± 5%) the negative voltage from unit П-1 with over 30 volts of amplitude and a duration of 0.1 usec -- to a level of over one volt.

Point indicator signal ИП-1 serves to indicate the following voltages: 220, 400 cycle, +110, +27, -3, +50, +400, +12.6, -40 volts on the center line of the red sector with maximum error not exceeding ± 5%.

Point indicator signal ИП-1 indicates +24 volts and -3 volts on center line of blue sector with maximum error not over ± 6%.

Point indicator signal ИП-1 indicates current of unit И-4 (23 ma) on middle line of yellow sector with maximum error not over ± 5%.

Point indicator signal ИП-1 indicates crystal currents of ifa, afc, and the discharger (1,200 microamperes, 35 ma, and 62.5 microamperes) on center line of green sector with maximum error not exceeding ± 5%.

Point indicator signal indicates magnetron current (1.25 ma) on center line of blue sector with maximum error not over 5%.

Point indicator signal ИП-2 indicates efficiency of unit П-4 at a current of 120 microamperes on the 50 microampere line of the instrument with maximum error not over ± 5%.

3. Units for controlling power characteristics.

Width of radiation pattern of controlling horn (unit A-3) in vertical plane ≈150°, in horizontal plane ≈180°.

Signal attenuation in air gap between units A-3 and A-1 -- 29 ± 3 db.

4. The control circuit of unit C-1 controls on the presence /49 at its output of two sequences of pulses with an amplitude of about 10 volts with durations of 300-500 usecs.

The analyzer of unit efficiency controls the operating state of units П-1, П-3, И-1, И-2, И-3, and И-6, and gives "good" or "bad" signals to the control unit. The unit also shapes the modulating pulses for the control oscillator of the automatic frequency control.

Units П-1, И-1, И-2, and И-6 are controlled by the amplitude of the output pulses (cf appendix 2). When these units are in normal operation negative control pulses of not under one volt and a duration of from 0.04 to 3 usecs and a frequency of 3,000, 2,000, or 1,000 pulses/sec, depending on the unit controlled and the range scales on which the control is made, proceed from the controlled units to unit П-10. These pulses go via the device for controlling a malfunctioning unit (in element П-11) to the emitter-follower expander built with the ПП1, ПП2, type П416Б element on the scheme of a follower with composite triode. The emitter follower excludes the effect of the input resistance of unit П-10 on the controlled units and extends the duration of the control pulses by approximately 5 usecs. The pulses of unchanged (negative) polarity go from the emitter follower output to the amplitude selector (tunnel diode Д2, type 3 И306КС). The amplitude selector emits output pulses only when the control pulses exceed the efficiency criteria. The duration of the selector output pulses depends on whether the control pulse amplitude exceeds the operating efficiency criteria of the units (from 5 usecs and above).

From the amplitude selector the negative pulses of about 0.6 volts go to the normalizer, which is designed on the scheme of a driven blocking oscillator (ПП4, type МП20А) with a triggering cascade (ПП3, type П416Б). The normalizer develops negative output pulses of 15-20 usec duration of about 6 volts regardless of the duration of the pulses from the selector. These pulses are fed to the integrato.. which is designed on the scheme of an amplifier with negative feedback to ПП5, type МП25Б. The effect of negative feedback in the integrator is to produce a marked increase in the time constant of the circuit charging element, as a result of which the normalizer pulses are converted to a direct current which is increased by the amplifier to the magnitude necessary to activate the relay of integrator P1, type РЭС-15. The relay contacts close the feed circuit of the signal bulb "good" located in unit П-11 (signalling device to indicate the operating condition of units).

In normal operation, units П-3 and И-3 feed a negative dc voltage /50
(proportional to the noise level at the output of the units) not under 0.5 volts. The controlled voltage goes to the converter, consisting of the modulator (ПП7, type П416Б) and video amplifier (ПП8, type П416Б). The modulator consists of a gating circuit with inverse transistor switching controlled by negative pulses arriving from the master oscillator of 1.5 volts, duration of 3 usecs, and a repetition frequency of 4,000 pulses/second. When a dc noise voltage arrives, the modulator gives off positive pulses of approximately 3 usecs duration with an amplitude proportional to the voltage constant of the noises amplified by the vido amplifier.

The master oscillator, built around element ПП9 type П416Б, is made on the layout of a blocking oscillator in the auto-oscillating state. It develops negative pulses which control the operation of the modulator and positive pulses of 3 usecs duration of about 7 volts which are fed to the modulating pulse shaping circuit of the control oscillator of the afc unit. The shaping circuit of the afc control oscillator modulating pulse unit (Д12, type Д311А) consists of the diode limiter, which clips the amplitude of the pulses fed into it down to 1.5 volts. The negative pulses go through the commutation circuits of the device for searching out defective units (unit П-11) to the emitter follower of unit П-10 and then the shaping of the "operating condition" signal takes place just like the control of the pulse units discussed above.

Provision is made in unit П-10 for automatic control operation. A current of 0.5 volts is taken from the automatic control shaping circuit, which is a controlled voltage divider; this voltage is fed through the commutating circuits in automatic control operation to the converter of unit П-10, similar to the check of units П-3 and И-3. The "operating condition" switch signal in this case indicates normal operation of the analyzer.

The control unit is designed to check the system of radar built-in controls (except for КЭХ and unit С-1), as well as to indicate the operating efficiency of controlled replaceable units and assemblies. The front panel of the control unit is contained on the front cover of apparatus II. The control unit consists of the signalling device that indicates a malfunction in the safety devices, a power source tolerance control device, an element for locating a defective unit, a device for controlling unit П-4, and an element for signalling the operating condition of units and devices controlling the tolerances of individual assemblies. In the event of malfunction of the protective devices placed in the feed circuits of rectifier transformer primary windings (units П-5 ./. П-9), ifc filament transformers, and the klystron, signal bulbs Л6 - Л14, type TH-02 will light up. /51

ВПI-1 type protective devices in these circuits are mounted in parallel to the signal bulbs, and in the event the safety devices burn out, there is a circuit to light up the bulbs. The power source tolerance control device includes switch B3, type ПМ, which switches in the appropriate source of power; the point indicator signal ИП-1, type M4206 with special scale containing colored sectors indicating the allowable limits of controlled voltages; and additional resistances and shunts to the metering device. By means of this instrument it is possible successively to check the following power source voltages: 220 volts, 400 cycles (equipment C), +27 volts and ± 110 volts (unit П-5), -300 volts and -600 volts (unit П-6), -400 volts and +50 volts (unit П-7), -12.6 volts and -40 volts (unit П-8), -100/150 volts (unit П-9). If the voltage is contained in the proper sectors the feed sources are in good working order.

The device for locating a defective assembly includes the B1 "Search" type ПМ changeover switch, which successively cuts in the circuits of controlled units (П-1, И-1, И-2, И-3, and И-6) to the efficiency analyzer of the different units (П-10). The proper functioning of these units is indicated by a signalling device consisting of the "good" (Л1, type CM37) and "bad" (Л2 type CM37) signal lights. Depending on the information of unit П-10, and the operating efficiency of the pertinent unit, a voltage is fed to one of the bulbs by relay P1 in unit П-10.

The device for controlling unit П-4 consists of the switch "Unit П-4 control" (B2 type ПМ), which has three positions: "Operation П-4", "Control - I", and "Control - II". In the latter two settings control signals are received from unit П-4. Signals concerning the working order of a unit are obtained from the point indicator (ИП-2, type M4206Г), which contains sectors indicating the normal functioning of units.

The efficiency tolerance control device for the individual units includes the switch labeled "Control of assemblies and currents" (B4, type ПМ) and additional resistances and shunts. This device is used for controlling the currents of the magnetron, dischargers, klystron, and the afc and ifc crystals. Signals describing the operating conditions of the various assemblies are given by the point indicator signal ИП-1 which is switched on when checking some device by means of tumbler switch B5.

The control oscillator of the afc unit is located in unit П-4 and is designed to provide autonomous control over the efficiency of this unit. The modulating pulses from the shping circuit of unit П-10 go to the emitter follower (ПП1, type П416Б) which decouples units П-4 and П-10 on this circuit. After leaving the emitter follower the positive pulses go to the oscillator circuit (ПП2, type 416Б) made on the Hartley oscillator principle with grounded base. The oscillator develops /52 pulses at two operating rates, depending on the position of switch B2 in unit П-11, which directs the power supply to the relay P1 (РЭС-10) of unit П-4. In the first case, the frequency of the pulse is about 66 Mc, and in the second -- about 54 Mc. These pulses are fed to the input of unit П-4, and are used to control its efficiency.

The control antenna (unit A-3) together with the delay cable and control channel in unit П-2 (attenuator Y-18 and directional coupler Y-15) serve to control the power characteristics of the radar set. The control antenna is a pyramidal horn whose aperture dimensions and position insure minimal attenuation in the air interval between the radar antenna and the control antenna (-29db). The delay cable is made of type PK-75-4-22 high frequency cable 60 meters long wound on a circular drum.

The control circuit of unit C-1 includes bulb Л1, type CM-37 and the button KH-1. When the cover of unit C control panel is raised the load from unit C-1 is disconnected by the blocking contact. The signal light at the output of unit C-1 which indicates the operating state of the unit is switched in by depressing button KH-1.

CHAPTER III
INTEGRATED RADAR SYSTEMS

The interaction of all equipments in the set is achieved by electrically integrated couplings. Depending on their functional purpose, integrated couplings are grouped into the following systems: synchronization, control, and built-in systems for controlling the radar set .

III-1 THE SYNCHRONIZATION SYSTEM

The functional diagram of the radar synchronization system is given in fig. III-1.

Time synchronization of the operation of pulsing devices in the set is effectuated by the master oscillator (in unit П-1) which determines (assigns) the pulse repetition period of the set. The time relationship between pulses in the different equipments is shown in fig. III-2.

To produce the necessary lead of 4 usecs for the pulses which synchronize all the equipments relative to the main pulse (generated by the magnetron and beamed by the antenna), the pulses of the master oscillator are branched off immediately after narrowing in the first compression stage into the synch pulse shaping circuit. /53

The synch pulses shaped in amplitude and duration proceed from unit П-1 to apparatus И for starting the indicator equipment and into unit П-3 for triggering the automatic time gain control circuit. Also fed to the atgc circuit from the output of unit П-1 (through the pulse voltage divider) are the pulses for the formation of the automatic time gain control strobes which coincide in time with the modulating pulses arriving at the magnetron.

In the atgc circuit the strobe pulse is delayed by the special delay line for the period of duration of the main pulse, and, after mixing with the exponential automatic time gain control pulse, shapes the complex automatic time gain control pulse (cf fig III-2).

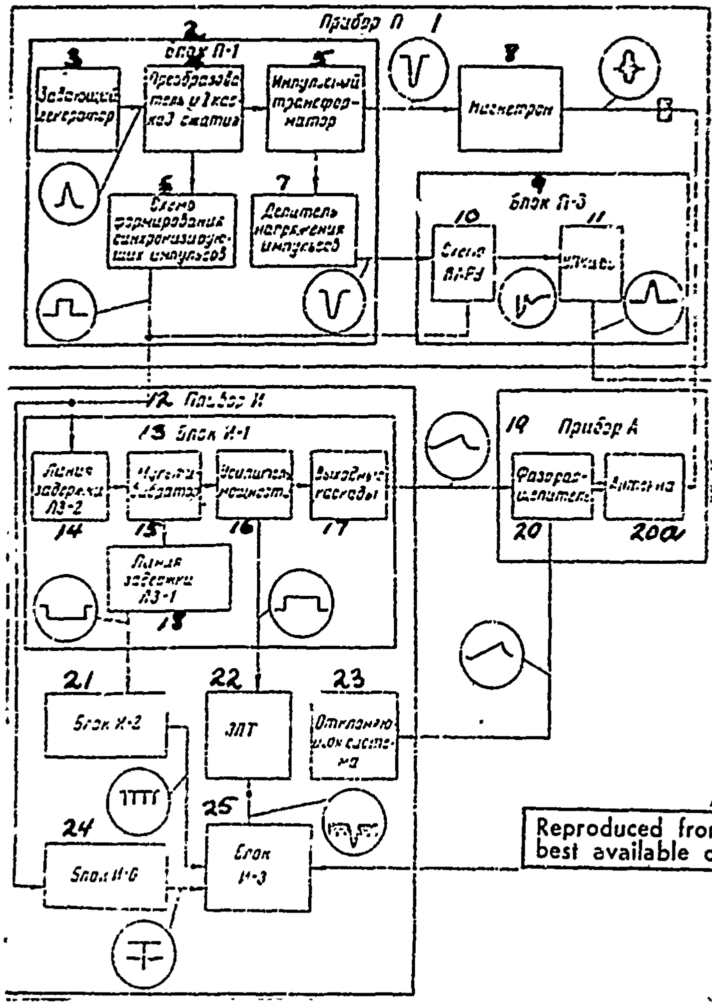

Fig. III-1. Functional diagram of synchronization system
Key: 1. Apparatus П; 2. unit П-1; 3. master oscillator; 4. converter and compression stage I; 5. pulse transformer; 6. synch pulse shaping circuit; 7. pulse voltage divider; 8. magnetron; 9. unit П-3; 10. automatic time gain control circuit; 11. ifc and video amplifier; 12. apparatus И; 13. unit И-1; 14. delay line ЛЗ-2; 15. multivibrator; 16. power amplifier; 17. output stages; 18. delay line ЛЗ-1; 19. apparatus A; 20. phase splitter; 20a. antenna; 21. unit И-2; 22. CRT; 23. deflection system; 24. unit И-6; 25. unit И-3.

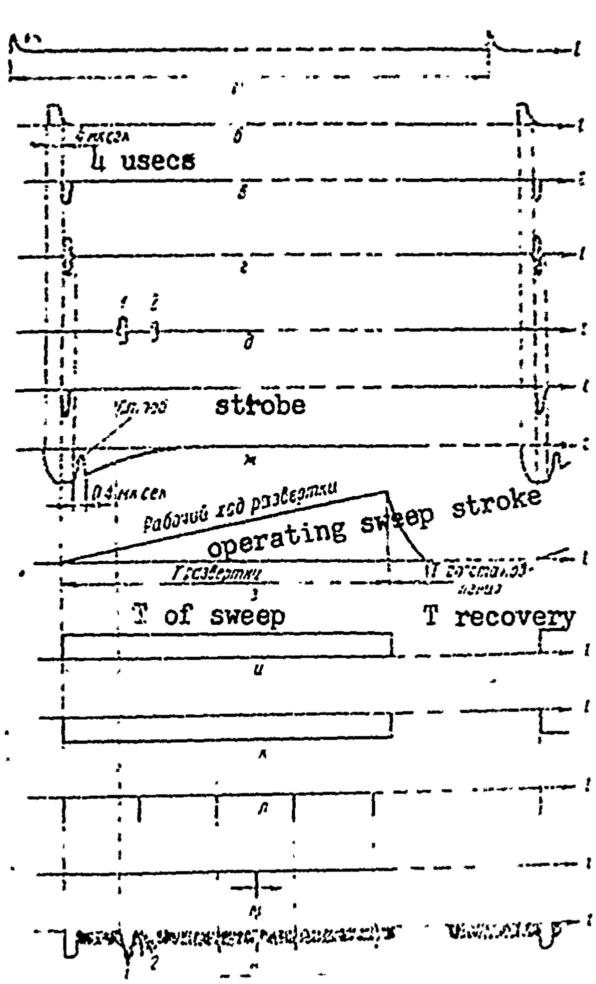

Fig. III-2. Time relationship between pulses.

Pulses: a. master oscillator; b. synchronization; c. modulating; d. main pulse; e. signals reflected from targets at receiver input; f. formation of automatic time gain control strobe; g. automatic time gain control; h. sweep current; i. sweep illumination; j. range marker oscillator starter; k. range marker starter; l. range sighting ring; m. video signals on CRT cathode without "interference suppression"; 1 and 2 -- target signals.

Synch pulses entering instrument И immediately trigger the range metering device (unit И-6) where the range sighting ring pulse is formed and the range sweep device activated (unit И-1). In the latter unit sawtooth sweep current pulses, pulses for illuminating the CRT during the operating period of the sweep, and pulses for triggering the range marker oscillator (unit И-2) are formed. The channel of sweep current pulses arriving at the phase splitter (rotating transformer) in device A are divided in the mutually perpendicular output windings into two lines /55 which are coupled to appropriate fixed deflecting coils in instrument И (also mutually perpendicular). When the antenna and phase splitter rotor turn, the sweep current pulses in both lines are amplitude modulated with the frequency of antenna rotation and a relative phase shift of 90°. Here, the deflecting coils produce a magnetic field turning in synchronism with the antenna, which produces a radial-circular sweep on the CRT.

When the direction of the antenna coincides with the ship's center line the course marker contact is closed in instrument A; as a result, a supplemental course marker pulse that illuminates several sweeps on the CRT and threby produces a course marker on the indicator is fed to the CRT together with the illumination pulse.

Unit И-2 generates a series of range marker pulses when a starter pulse is fed to it from unit И-1 (from the multivibrator). The range marker pulses, range sighting ring pulses, and target signals arriving, respectively, from units И-2, И-6, and П-3, are mixed in the video mixer (unit И-3) and fed to the CRT indicator to be observed. Causing the initial point of range sweep and the first marker to coincide with zero range (the instant of radiation of the main pulse by the antenna) occurs in unit И-1 with the aid of delay lines ЛЗ-2 and ЛЗ-1, respectively. When the off-centering circuit is switched in (scale 0.4P) commutation takes place in delay lines ЛЗ-2 and ЛЗ-1 in such a manner as to cause the beginning of the sweep to lead zero range and thereby insure the first range marker to coincide with zero range.

III-2 CONTROL SYSTEM

The control system insures a check on the operating rates when the radar set is in use, as well as tuning and adjusting various elements during the process of maintaining and repairing of the equipment.

The functional diagram of the Kivach-2 radar control system (appendix 11) also holds true for the Kivach-1 equipment, but the latter lacks the Г gear and the elements related to it in instrument A.

The following operations are performed in the process of controlling the set: switching the radar set on and off; switching in the various scales (image scales) and range markers; switching range and course markers on and off; regulating signal discernibility and image contrast; checking the interference suppression system; checking target distance measurement; checking target relative bearing and true bearing; checking image orientation switching (this is true of the Kivach-2 equipment); checking gyrocompass coupling switch (Kivach-2); matching image with gyrocompass indications (Kivach-2). /56

The following operations are performed when adjusting and repairing the radar equipment: mechanical and electrical adjustments of the klystron; setting the duration of the automatic time gain control and depth of the atgc strobe; regulating the magnetron current; regulating the illumination of the CRT and the brightness of the range markers; focussing the CRT beam; centering the image on the indicator; setting the limiting level of signals; regulating the brightness of the range sight ring; setting the zero position of the range sight ring; and disconnecting the antenna rotor.

Control of the set while in use is accomplished by means of control elements disposed on the control console and the front panel of the indicator (fig. III-3), as well as on the front panel of instrument Г (for the Kivach-2).

The set is switched on and off from the control console by tumbler switch B3 "On-Off" (cf appendix 11). When the tumbler switch is closed the onboard power line voltage (24 volts, 110 volts, 220 volts) goes to the control winding of contactor P in instrument C. After switching in the contactor, the line voltage is fed to the inverter which is built with thyristors. From the inverter the converted 400 cycle alternating voltage goes through the alternating current stabilizer and the first harmonic filter to the consuming elements.

When the set is fed by the onboard electrical system of 220 volts, 400 cycles, the system is switched to the consuming elements directly by tumbler switch B3 labeled "On-Off" through the alternating current stabilizer. Sequence of switching in the feed voltages necessary for the normal operation of the magnetron, klystron, and CRT is insured by the automatic switching circuit contained in instrument C.

The scanning area of the radar set (scales and range markers) is controlled by switches B1 and B2, which are located in unit И-1. The switch shaft is extended out to the control console.

Depending on the operating condition of the radar set in the near or far zones (scales 0.4P, 0.4, 0.8, 1.6, 4.0 miles or the 8, 16, or 24 miles), the following are changed respectively:

Duration of main pulses (0.1 usecs or 0.3 usecs) by means of choke Др7 in unit П-1, which switches over the shaping line, and relay P1 in unit П-9, which switches over the modulator feed voltage (-100 volts or -150 volts); /57

The recurrence frequency of main pulses (3,000 pulses/second or 2,000 pulses/second) by switching over the recurrence frequency of the main oscillator pulses in the modulator by means of relay P2;

The intermediate frequency amplifier passband (12 Mc or 6 Mc) by feeding a negative voltage with the aid of relay P1 in the П-3 unit to the diode, and the shunting circuit in the load of the second linear stage of the intermediate frequency amplifier;

The differentiator time constant with the aid of relay P2 and unit П-3.

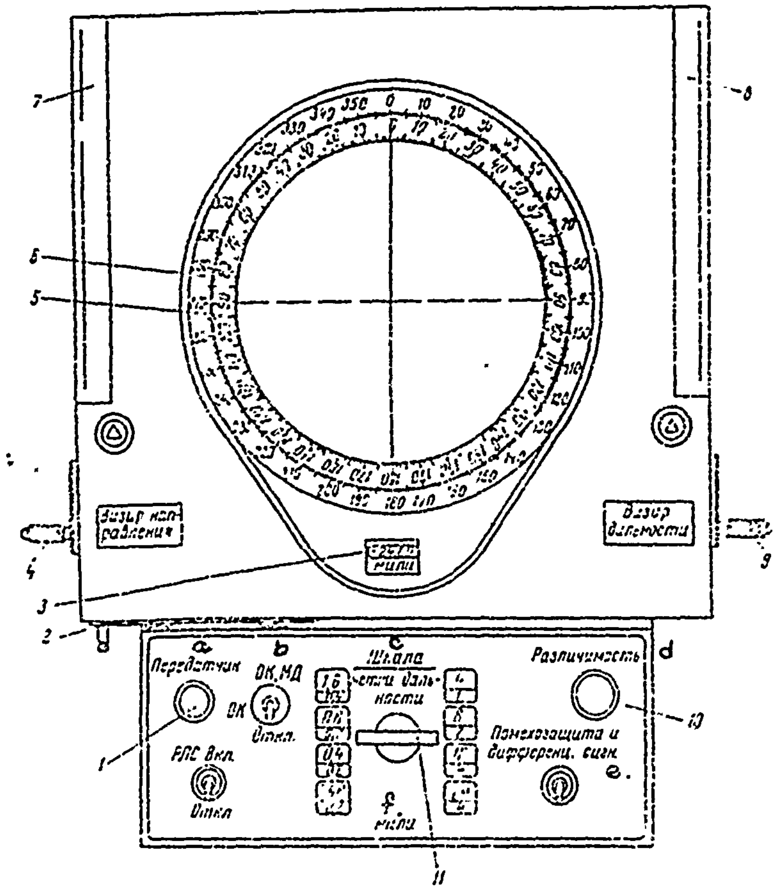

Fig. III-3. Control console and indicator panel with hood removed.
1. Transmitter switch signal light; 2. panel under "Reserve Control" cover; 3. range scale (range counter); movable direction scale; 6. fixed direction scale; 7 and 8 supports; 9. range sighting knob; 10. radar control panel; 11. scale and range marker switch ; a. transmitter; b. course marker, range marker, off position; c. range marker scale; d. discriminator; e. interference suppression and signal differentiation; f. miles.

In addition, upon switching in the 8, 16, 24 mile scales, the automatic time gain control is automatically cut in by means of relay P4 in unit II-3 to decrease the excessive illumination in the center of the CRT screen caused by the main pulse and signals from nearby objects.

The range markers are switched on or off from the control console with tumbler switch B6 by commutating the output circuit of unit И-2. The ship's course marker is also switched on or off by tumbler switch B6 by commutating the discharge circuit of condenser C4 in the course marker circuit in instrument И.

Discernibility of signals against a background of clutter and separation of signals is accomplished on the control console by means of potentiometer R22 "Discernibility" by regulating the position of the anti-logarithmic video signal amplitude characteristic in unit И-3. In the process the operator sets the point of break such as to insure the best signal-to-noise ratio, signal-to-interference ratio, or the best conditions for the separation (resolution) of signals (fig. III-4).

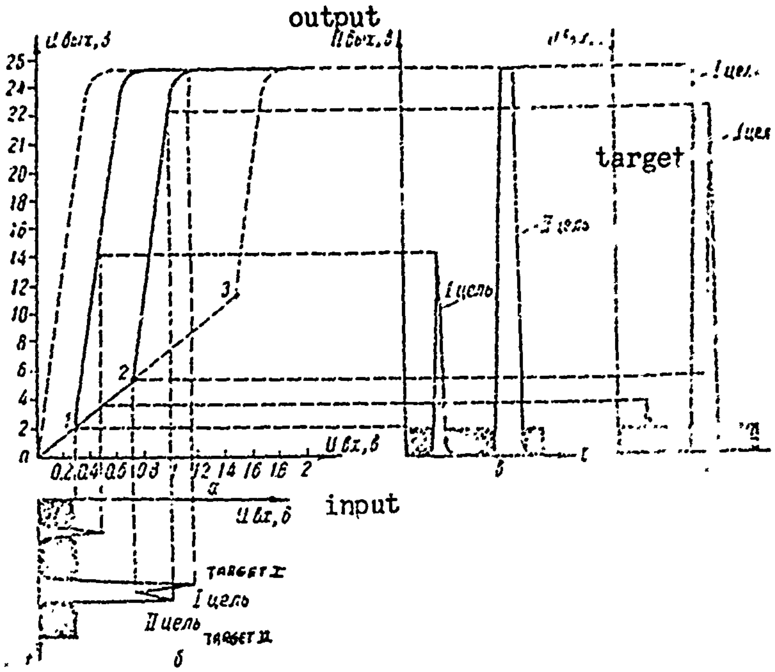

Fig. III-4. Illustration showing the operation of the "Discernibility" regulator: a. amplitude characteristic of the video amplifier; b. signals at the video amplifier input; c. separating out and isolating (discerning) weak signals against a background of clutter (curve 1 fig a); d. resolution (isolation) of signals (curve 2 fig a).

To reduce the interferences on the CRT caused by reflections from rain, snow, or ocean waves, there is an automatic anti-interference system in the logarithmic receiver. The operating principle of the logarithmic receiver in suppressing radar interferences and local clutter caused by ocean waves and atmospheric precipitation is based on certain common properties of interferences and internal noises of the receiver. Both of them are of a random nature and at a fixed range they act like signals whose intensity is determined by the simultaneous operation of a multiplicity of independent, random, elementary sources. Changes of intensity of such signals or fluctuations which recur at point of the range during the course of a rather large number of sweep cycles, are characterized by a common law of probability distribution (Rayleigh's Law). A logarithmic receiver allows of a reduction of the mean power of all interference and noise fluctuations, which changes arbitrarily with respect to range or time, at the receiver input to one level at the output. /59

In this case, regardless of the intensity of the interferences at the input (fig. III-5), the power of the interferences at the receiver input change with respect to range as previously, but the mean intensity of fluctuations remains practically unchanged near the interference component constant.

The interference component constant at the output of the logarithmic amplifier is excluded by the differentiator as a result of which the interferences (their fluctuations) and the inherent noises of the receiver are reduced to a single level along the entire range sweep (cf fig. III-5). This prevents overloading of the receiver and indicator with interferences and creates favorable conditions for observing radar targets against a background of noises and interferences (distributed throughout the entire field of the indicator screen below the limiting level with the same intensity).

The anti-interference system is controlled from the console using the switch labeled "Interference Suppression and Signal Differentiation -- Disconnect," by cutting in the differentiator in unit П-3 off and on. This same switch is also cut in when it is necessary to separate signals (resolution) that are closely disposed in range. In this case, the leading edges of the signals are differentiated (fig. III-6).

As the differentiator is switched on the automatic time gain control circuit is cut in by means of relay P4 to the linear part of the intermediate frequency amplifier at the input of unit П-3. The atgc pulses are optimized: they have a fixed duration, amplitude, and shape that are acceptable for different conditions. The atgc circuit insures attenuation of spurious signals caused by reflections from nearby objects and picked up by the antenna side lobes. /60

Use of a special shape (with strobe) automatic time gain control pulse decreases the area of the radar dead zone. In this case, there is an attenuation and, consequently, a constriction of the pulse in the receiver, as well as increased receiver sensitivity immediately following the termination of the main pulse (the instant the atgc strobe is triggered) /61
in the near zone where the power characteristic of the set is attenuated by the effect of the discharger and the antenna radiation pattern in the vertical plane. In addition, an atgc system excludes excessive receiver gain in the near zone and improves interference suppression characteristics with respect to ocean waves.

The distances to the targets described at point on the screen are measured with an adjustable range sighting ring that is controlled by unit И-5 with a knob labeled "Range Sighting" coupled through the reducer to the range potentiometer R26 and the range counter whose scale is located under the indicator viewing hood. In this case, a direct current voltage proportional to the measured range is fed from the potentiometer to unit И-6, and at the output of this unit there is formed a range sight ring pulse delayed by an appropriate range (or time).

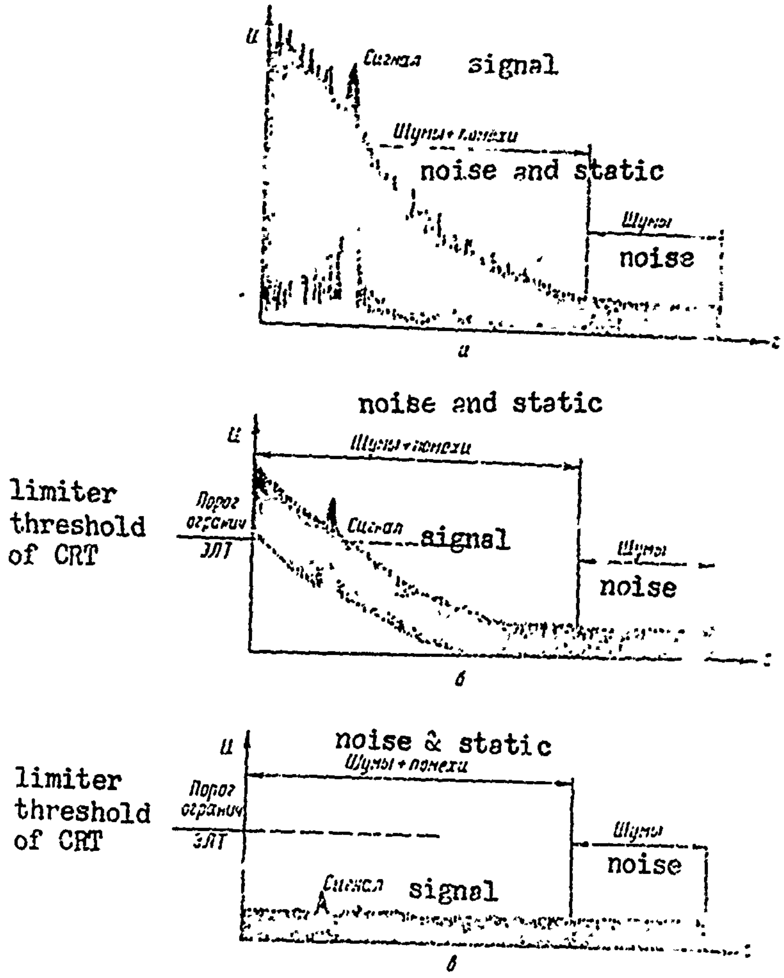

Fig. III-5. Curves of voltages exp.aining the operation of the logarithmic receiver: a. sea clutter at logarithmic receiver input; b. sea clutter at output before entering the differentiator; c. after the differentiator.

Target directions (measurement of relative and true or magnetic bearings of targets) are measured by means of a directional sight line or azimuth marker on the scales of unit И-5; the azimuth marker is controlled by the knob labeled "Azimuth marker" which is mechanically connected to the scale system. Fig. III-7 of a Kivach-2 radar set on the "By Meridian" operation illustrates how direction is determined by a single sighting on a target marker. The target bearing and the ship's course are determined from the external (fixed) scale, and the relative bearing of the target is determined by the inner (movable) scale which is rigidly connected to the sighting line connecting 0° and 180° of the movable scale.

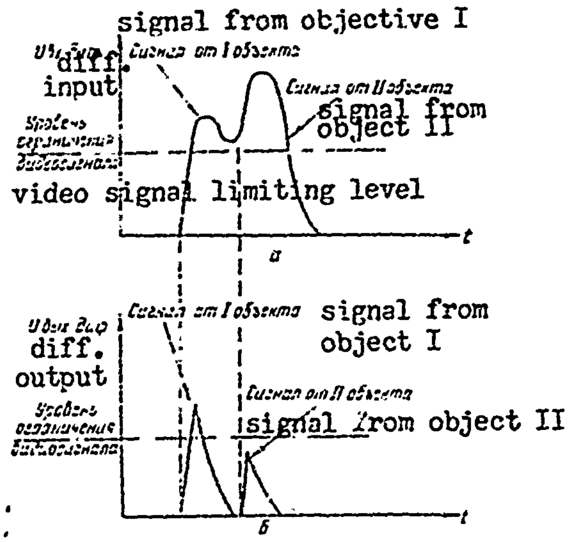

Fig. III-6. Curves explaining the operation of a differentiator: a. signal to differentiator; b. after the differentiator.

In the Kivach-2 radar the image orientation settings on the CRT screen (relative to the ship's course or the observer's meridian) are switched by means of tumbler B2 labeled "Image Orientation" (cf appendix 11) located on the front console of instrument Г and the electromagnetic device ЭМ1 in instrument A. Matching image orientation by meridian with gyrocompass readings is accomplished by turning the knob labeled "Matching With Gyrocompass" via the differential selsyn M1 located in instrument Г with switch B1 set on "Matching Operation." In the process, the differential selsyn M1 in instrument Г is coupled into the remote transmission line between the gyrocompass selsyn sensor and the receiver selsyn (in instrument A). Orientation of the image on the screen in the "Matching" operation can be changed within a limit of 360° by turning the rotor of differential selsyn M1. In the "Operation" setting, the gyrocompass is coupled directly with selsyn M2 (in instrument A), by-passing differential selsyn M1.

Technological control groups are used for making comprehensive adjustments on the sets during the manufacturing process and for repairs and adjustments of the equipment on the ship (cf appendix 11).

The klystron frequency (heterodyne) is adjusted from the "Klystron Tuning Panel" in instrument П by mechanically changing the klystron resonator volume. The maximum power of the klystron in the electron tuning zone is set by the rheostat labeled "Maximum Crystal Current" by changing the magnitude of the negative voltage from unit П-6 to the klystron /62
reflector.

In the event the automatic frequency control unit (П-4) goes out of commission and it is impossible tocorrect the malfunction in the set, there is provided a standby manually operated klystron frequency tuner.

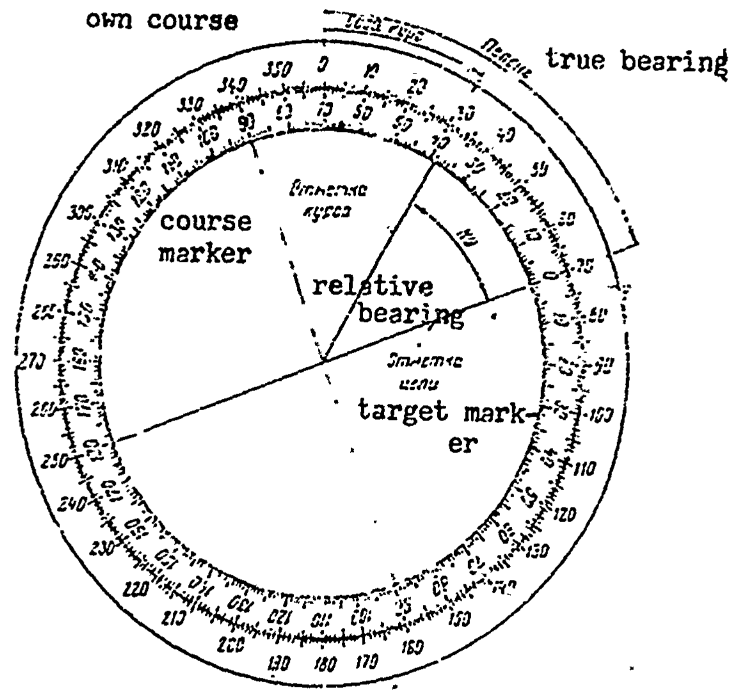

Fig. III-7. Determining the relative bearing, true bearing, and own course when orienting the image relative to the observer's meridian.

This can be operated after setting the B1 switch on the klystron tuning panel in the "Reserve Frequency Tuning" position. The process is carried out by means of rheostat R24 located in unit И-5 under the "Reserve Control" cover, by changing the negative voltage fed to the klystron reflector in small increments.

The magnetron current is regulated by rheostat R9 (unit П-1) "Magnetron Current Regulator" from the front panel of instrument П by changing the amplitude of the modulating pulse in the first compression stage of the magnetic modulator.

The illumination brightness of the CRT screen is regulated inside instrument И with potentiometer R2 "Brightness" in the CRT circuit, which changes the cut-off voltage on the modulator 5 of the CRT. Constancy of image brightness, when changing the sweep speed on the different scales, is maintained automatically by changing the voltage on the modulator of the resistor commutation tube in unit И-1. Commutation is effected by the scale and range marker switch from the control panel.

The CRT beam is focused mechanically by means of the magnetic focusing system located in the neck of the CRT; electrically, it is achieved with potentiometer R8 "Focus" located in the CRT circuit.

The brightness of the range markers on the screen is regulated by potentiometer R22 "Range Marker Pulse Amplitude" in the output stage of the marker unit (И-2).

To match the amplitudes of output pulses of the video mixer (unit И-3) with the dynamic range of the CRT, provision has been made to regulate the signal limiting level with potentiometer R31 "Clipping" in the output stage of unit И-3.

The brightness of the adjustable range sight ring on the screen is regulated in unit И-6 with potentiometer R32 "Amplitude."

Coinciding the range sight zero with radar range zero (instant of radiation of main pulse by the antenna) is accomplished in instrument И by rheostat R3 "Range Zero" by setting the minimal value of the range sight ring delay voltage (corresponding to range meter zero) taken from potentiometer R26 in unit И-5.

The center of the radial-circular sweep on the screen is caused to coincide with the geometric center of the azimuth cursor by means of the magnetic system (magnet and magnetic leads) by rotating it around the neck of the CRT and turning the centering magnet about its own axis. /64

When repairing and tuning the set the antenna rotor can be disconnected from unit И-5 by tumbler switch B7, which is located under the "Reserve Control" cover or from instrument A by means of tumbler B1 "Antenna Rotatation -- Disconnect" by means of which the feed from electric motor M1 of instrument A is disconnected.

A signal indicating to the operator that the transmitter is switched on shows up on the control panel. In this case the pulsating voltage, which is formed on the choke Дp1 in unit П-9 when the modulator is receiving power, goes to the Л6 tube labeled "Transmitter" located on the control panel of instrument И.

III-3 BUILT-IN SYSTEM FOR TESTING RADAR OPERATING EFFICIENCY

A built-in system of testing radar operating efficiency allows of checks on the functioning of the equipment and the operating efficiency control tolerances of all replaceable units and assemblies. This built-in system automatically provides "Yes-No" type of information visually as to the condition of the device checked, and whether the equipment conforms to power characteristics standards.

The schematic diagram of the built-in testing system is shown in appendix 12. It consists of a network of control circuits (links with controlled units and assemblies) and the following self-contained devices: radar power characteristic control (control effectuated from instrument И); check on the condition of instrument C (control by instrument C); tolerance check on unit and assembly operating efficiency (control by instrument П).

The power characteristic control device gives out information about the operating efficiency of the radar set as a whole. In this case, the efficiencies of the transmitter, waveguide transmission line, rotating adapter, antenna, receiving line, automatic frequency control systems, and the indicator are automatically controlled.

The components of this device include the following: control antenna (unit A-3), delay cable, threshold attenuator (Y18) and responder (Y15) in unit П-2.

The control antenna is rigidly secured near the radar antenna at a relative bearing of 180° and receives a portion of the energy of the main pulse which, as a controlling signal, is held up in the delay cable for a period of time exceeding the duration of the main pulse and is attenuated by the cable and attenuator Y18 to threshold level. Following this, the control signal, like the signals received from the targets, is amplified by the receiver and enters the radar PPI.

One criterion of normal radar operating efficiency when checking the power characteristics is the presence of a brightness marker on the PPI screen (on the 0.4P mile scale -- cf fig. III-8). /65

Attenuator Y18 located in unit П-2 is used to calibrate the attenuation of the control signal in manufacturing the set; it is calibrated in a manner as to have the brightness marker visible on the CRT screen so long as the power characteristic of the set is sufficient for operation; it disappears when the power characteristics fall below permissible levels.

In the operating condition the control signal is not usually seen on the screen since it is camouflaged by the main pulse which elongates in the receiver circuit.

To control the power characteristics of the radar set depress the knob labeled "Power Characteristic Control" (KH-1) on the И instrument panel under the cover labeled "Reserve Control". The following operations will then take place by activating button KH-1 and relay P2 located in instrument И:

a. Electromagnetic shutter ЭМ-1 in the receiver channel (unit П-2) between discharger PИ-1 and responder Y15 is switched in and attenuates the main pulse filtering in through the discharger, as well as signals reflected from the ship's superstructures and nearby targets which interfere with the observation of the control signal;

b. The atgc circuit and the differentiator in unit П-3, which reduces the radar set's dead zone, is switched in (the control signal practically coincides timewise with the atgc signal;

c. The 0.4P mile scale (unit II-1) is switched in to improve the observability of the control signal on the CRT screen (by enlargement of the image scale) regardless of the position of the range scale switch /66 on the control panel;

d. The video mixer (unit II-3) is shifted to maximum fixed amplification independently of the position of the regulator "Discriminator" on the control panel.

The device for controlling the operating condition of instrument C is designed for making independent checks on the efficiency of the instrument, indicating the presence of line voltage, and the proper functioning of the line safety element; it also provides control over the efficiency of unit C-1 (for instruments C/=24 volts, C/=110 volts, and C/= 220 volts).

The efficiency of unit C-1 is checked visually by the light bulb Л3 "C-1 Operating". If the unit is in good working order a pulse voltage is fed from the output stages (ПП8, ПП9) of unit C-1 to the signal light Л3 by pressing down in pushbuttonKH-1 and the bulb will light up. To insure stable operation of unit C-1, the feed circuit of the other instruments of the radar set is broken during the instant the efficiency check is made by the locking pushbutton B1 when instrument C control panel cover is opened. In the process, the line voltage is fed automatically only to feed unit C-1.

The device used for making tolerance controls of units and assemblies can check the efficiencies of all removable units and most unreliable sub-units of the radar set.

The following elements make up the tolerance control device: control

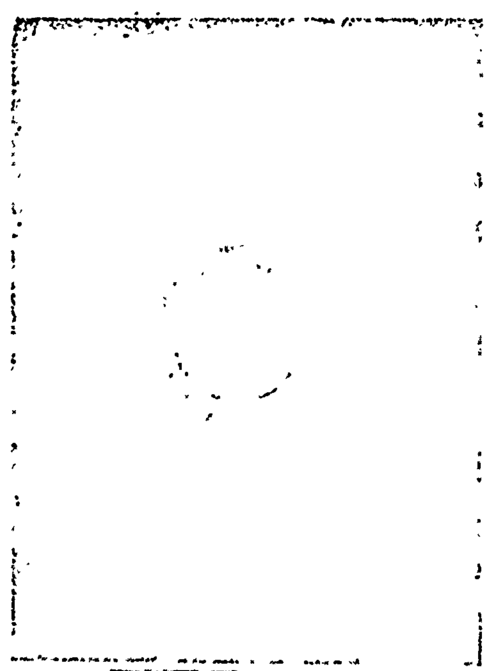

Fig. III-8. Control signal (curved marker) on PPI in checking the power characteristic.

device: control signal sensors in the units and sub-units being checked; control unit (П-11), which checks the operation of the tolerance control device, and indicates whether the item checked is working or not working properly; analyzer of operating efficiency of various unit (unit П-10) which provides automatic threshold control of unit functional efficiency by their input parameters on the basis of a "good-bad" signal, as well as of units П-10 and П-11 proper in the automatic control operation (CK); control oscillator of unit П-4 (ГКАПЧ) located in unit П-4 developing pulses fixed for amplitude and frequency with charging frequencies of 66 and 54 Mc.

When checking the efficiency of the radar set, the units and assemblies are controlled from the panel (unit П-11) in the following order (fig III-9).

1. Control working condition of safety devices.

2. Control power sources and rectifiers.

3. Check automatic testing of controlling devices and controls of operating efficiency of functional units П-1, П-3, И-1, И-2, И-3, and И-6.

4. Control efficiency of unit П-4. /68

5. Control operating efficiency of assemblies.

The foregoing procedure in trouble shooting reflects a definite logical relationship between the units and assemblies controlled, a fact that excludes spurious informationby service personnel who are not qualified specialists.

In case of overload of rectifier units П-5, П-9, И-4, as well as filament transformers of the CRT, Magnetron, intermediate frequency amplifier, and klystron,fuzes of the respective input circuits burn out; this is checked by neon lights Л6 -- Л14 of the safety device malfunction signal unit. In addition, units П-5 -- П-9 and И-4 are controlled by point indicator instrument ИП-1, which provides information concerning the presence of direct fixed voltages at the output of the rectifiers within permissible limits on the basis of "In sector - Not in sector."

Also controlled by the point indicator device ИП-1 are the following power sources: the voltage of the onboard power line and the stabilized alternating 220 volt, 400 cycle current at the output of instrument C.

The controlled power sources and rectifiers are connected to the indicator ИП-1 by means of the manual changeover switch B3.

The efficiency of functional units П-1, И-2, И-1, П-3, И-3, И-6 and П-10 is checked automatically by the output parameters with the aid of units П-10 and П-11 on the basis of "Operating - Not operating." In this process the indications are provided by signal bulbs Л1 "Operating" and Л2 "Malfunctioning", which are contained on the panel of unit П-11. The controlled signals of the functional units are switched to the analyzer on the control panel by the manual switch B1 labeled "Search."

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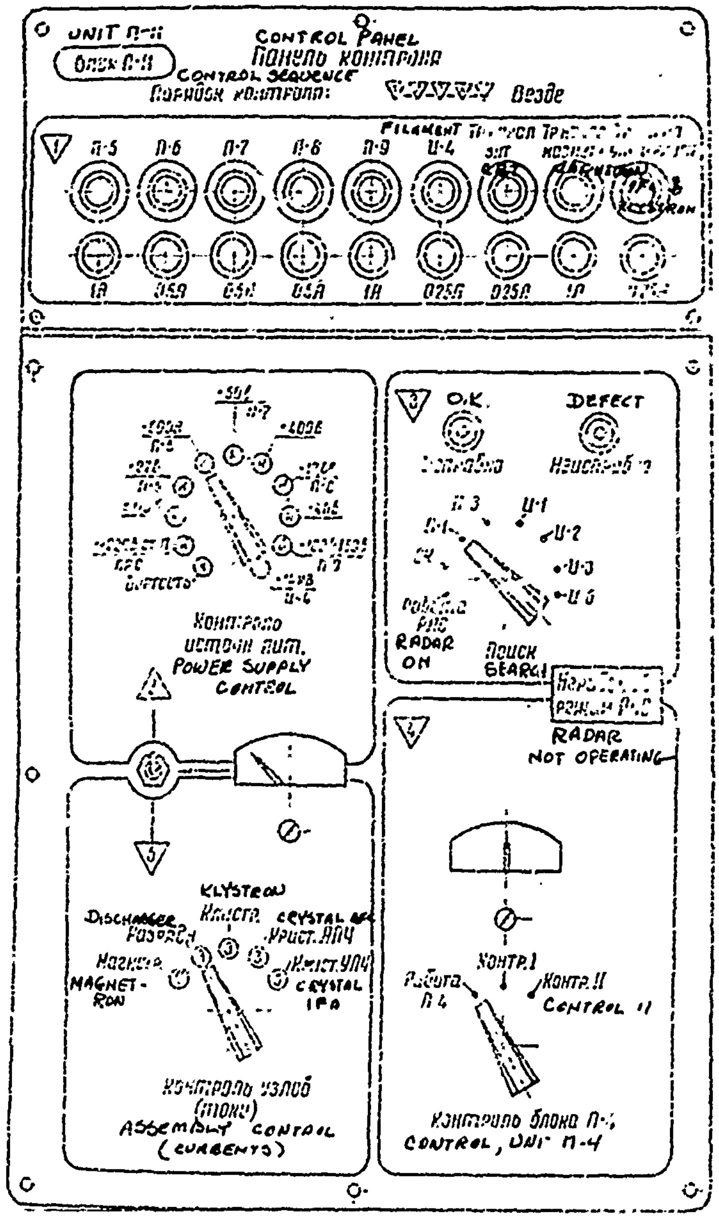

Fig. III-9. Tolerance control instrument panel.

The switches on the control panel are rotated in a clockwise direction and the position of each switch setting designates the controlled item.

The operating principle of the device for controlling the functioning units can be examined on the block diagram (cf appendix 12) in the examples of control of the operating efficiency of units П-1 and П-3.

The control pulses of unit П-1, whose criterion of operating efficiency is the required pulse amplitude (not under 30 volts) , go from the output of unit П-1 to the normalizer (R1, R2) in unit П-11. In the latter, the amplitude of the controlled signal is reduced 30 times, following which an amplitude of not less than one volt is set as the criterion of efficiency of unit П-1. The normalized control signal then goes through switch B1 to the common line for the control of pulse voltages of unit П-10 where the amplitudes of control pulses are compared in the amplitude selector with the standard voltage equal to one volt. /69

In the event the amplitude of the controlled signal is greater than one volt, a "normal" signal appears at the output of unit П-10 (the feed circuit is closed by signal light Л1 with the inscription "Normal"). However, if the amplitude of the controlled signal is less than one volt, there appears at the output of unit П-10 a "defective" signal (the feed circuit of signal light Л1 "normal" is opened and the feed circuit of signal light Л2 "defective" is closed).

A criterion of the operating efficiency of unit П-3 is the presence of a dc voltage of less than 0.5 volts. In checking efficiency, the controlled signal goes as a dc voltage through switch B1 into unit П-10 into the direct current control channel where the dc voltage is converted into a pulse voltage of proportional amplitude. Then, the control pulse signal is again introduced into unit П-10 through switch B1 in a manner similar to the control signal of unit П-1, but this time into the pulse voltage control channel. Later on, analysis of the signal controlled for amplitude and for the formation of "normal" and "defective" signals is made in a manner similar to the control of unit П-1 except for the fact that the converted controlled signal of unit П-3 goes to the input of unit П-10 into a common pulse voltage control channel through switch B1, by-passing the normalizer in unit П-11.

The rectified voltages of the inherent noises in the receiver are controlled by the parameters of units И-3 and П-3. Therefore, to exclude spurious information due to extraneous signals and interferences which have found their way into the receiver channel during the control operation of these units, an electromagnetic gate is lowered by switch B1 in unit П-2 which has the effect of attenuating the signals and interferences, while the video mixer is changed over to fixed, maximum aplification of signals, regardless of the position of regulator R16 "Discriminator" in instrument И.

The operating efficiency of the efficiency analyzer itself and part of the control unit is made in the auto-control operating mode. The check is made in the following manner.

The close to threshold level direct current of 0.55 volts is taken from the auto-control signal formation circuit (in unit П-10) and introduced through changeover switch B1 into the unit П-10 direct current voltage control channel. Analysis of signal CK (auto control) then occurs in a manner similar to the check of unit П-3.

Unit П-4 is controlled as follows. The control oscillator of the automatic frequency control in unit П-4 is switched into the "Control I" and "Control II" positions by means of switch B2 in unit П-11. In the process, a feed current of -12.6 volts and the modulating pulses from П-10 are fed through unit П-11 to the control oscillator of the automatic frequency control element. /70

The control oscillator of the automatic frequency control element develops controlling pulses calibrated for frequency and amplitude with charging frequencies of 66 or 54 Mc (depending on the position of switch B2 and, consequently, contacts of the relay P1) in accordance with the frequencies of the afc discriminator characteristic crests. These pulses are fed to the input of unit П-4 instead of the intermediate frequency signals. To exclude the latter, the radar transmitter is disconnected during the time unit П-4 is controlled. The ~220 volt, 400 cycle current at the input of unit П-9 is switched off and the power source of unit П-1 is thereby disconnected.

After amplification and conversion of the control signal in unit П-4 there is a direct current signal at the output of the latter of definite magnitude and polarity. The magnitude of this voltage is determined by the gain of unit П-4, and the polarity is determined by its discriminator characteristic at a particular frequency of the control signal. This voltage is fed through switch B2 to the point indicator ИП-2 with a zero reading in the center of the scale. Shown on the indicator scale are two operating condition sectors, both symmetrical with respect to zero, for recording pertinent control signals of different polarity on an "in sector -- not in sector" basis.

The operating efficiency of sub-units like the klystron, magnetron, protective dischargers of the receiver and mixers (crystals) of the ifa and afc is controlled by recording their currents with the ИП-1 indicator within the limits of tolerance on an "insector -- not in sector" basis. The ИП-1 indicator is switched to "Control of Sub-Assemblies" with switch B5. The controlled elements are connected to the indicator ИП-1 with a manual changeover switch B4.

In the process of controlling the commutations which cover the receiver waveguide channel, disconnecting the transmitter, cutting in the atgc, differentiator, and switching over the video mixer to fixed amplification during the moment the units are controlled, the radar unit is put into a non-operating condition. Accordingly, an appropriate system of signalling has been provided on the control panel (unit П-11) in which a warning light signal labeled "Radar-Inactive" becomes illuminated.

Control sockets are provided on the front panels of units and in instruments for cutting in metering devices to control and measure the basic input and output parameters of electronic units, as well as to check the condition of connectors and electrical couplings between units when sets are regulated and tuned at the factory or when turned in for repairs.

CHAPTER IV

RADAR EQUIPMENT CONSTRUCTION AND DESIGN /71

Structurally, the radar set is made up of several individual instruments (cf fig. 1-4). All units and the main assemblies are removable. The units are secured to the instrument housings with drop-proof screws or arresting devices. Electrical couplings between units with instruments are usually made with flexible, bunched conductors and plug connectors. Most of the units are built with printed circuits, transistors, and miniaturized electrinic elements.

The main control knobs of operating elements and those used for checking the radar set are disposed on the front panels of the instruments. The tuning elements used in adjusting and fine tuning the set in the process of manufacture, or when it is being repaired or preventive maintenance work is done on it are contained inside the instruments in accessible places or on individual panels.

The housings of instruments П, И, С, and Г are spray proof, and when instrument A is used outside of the inclosed area it is made waterproof. Heat is developed inside the instrument housings while the equipment is operating. The approximate amount of heat developed is given in the following.

Instrument	Heat Generated, watts
A (for Kivach-1 radar)	45
A (for Kivach-2 radar)	55
П	197
И	40
Г	---
C/=24 volts	140
C/=220 volts	140
C/=110 volts	140
C/~220 volts, 400 cycles	55

The instruments are cooled by the natural exchange of heat through the walls of the housings, jalousies, louvers, ventilating ports, and special covers with air slots. Ventilating ports and louvers, which impair shielding integrity, are covered with a metallic screen. Instruments П, И, and C are mounted on shock absorbers which protect them against shock and vibration which may occur during operation. Instruments A and Г do not require shock absorbers.

Instruments И, Г and П do not produce acoustic noises because they do not contain constantly rotating mechanical assemblies. The acoustic noises in instrument A are produced by the rotation of the electric motor, a rotating transformer, selsyn, mechanical assemblies, and a reducer turning at up to 4,000 rpm. The acoustical noises in instrument C are produced by vibrations of the coils of powerful transformers and chokes at the frequency of the converter. /72

Instrument dimensions (cf Chap. I) permit moving them through standard sized entrance ports 600 x 600 mm, doorways, and gangways.

All panels for the operation, tuning, and control of the set (on instruments П, И, C, and Г) are protected by covers or lids which are locked by a single special key carried by the operator. Clamps are provided on the bracket of instrument И for securing the key which is also used to close the covers of instruments П, И, C, and Г .

IV-1 INSTRUMENT П

Instrument П (fig. IV-1) is designed like a wall cabinet and is adapted for attachment to a ship's bulkhead. The instrument housing consists of a stamped base 19, made of thin sheet steel and two light, hinged duralumin covers. The interior of the housing is divided by vertical and horizontal partitions (shields). The partitions form several compartments to accomodate individual units in them. The units inside the housing are located as follows: transmitter is contained on the left side of the instrument in the shielded compartment; the modulatorl, magnetron, filament transformer of the magnetron, and the transformer feed filters are disposed /73
in compartment 3. The receiver 13 is secured on the right side of the instrument. The middle and lower portion houses the rectifiers, units П-5, П-6, 15, П-7, 16, П-8, 17, П-9, 18, and П-4, 2. Unit П-2, 6, which includes the mixing section 4, electromagnetic shutter 9, attenuator 5, klystron 8, discharger 7, and crystal diodes 10, is placed in the upper portion of the instrument between the magnetron compartment and the housing wall.

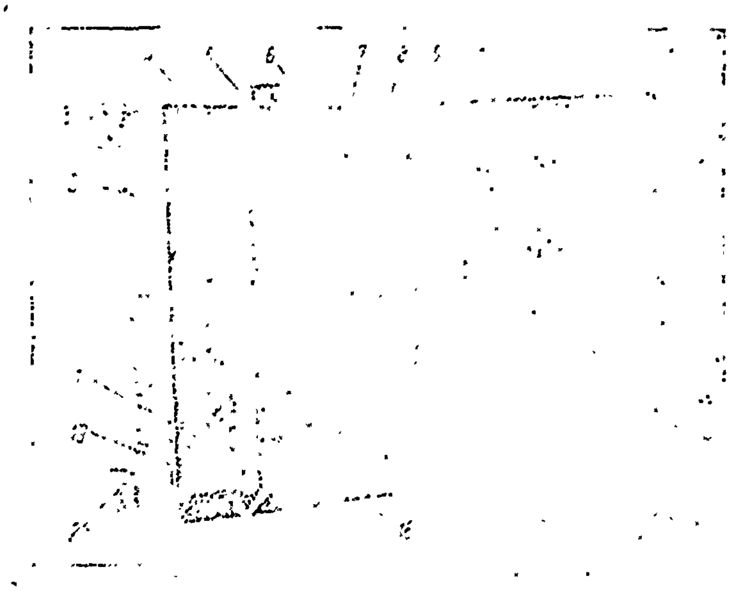

Fig. IV-1. Instrument П with cover open

An entrance port with cover is made in the upper portion of the housing to provide access to unit П-2 when regulating the attenuators and replacing the discharger. Unit П-11 (under the cover) 12, П-10, 11, klystron tuning panel, electric counter of elapsed operating time, a condenser and resistors are disposed on the main cover of instrument П.

The chassis of unit П-11 is made in the form of a plexiglass panel. Mounted on the panel are the indicator instruments of the control, switching, signal light systems and other elements. Externally, the panel is covered with a light duralumin lid with a small transpoarent glass designed for observing the safety device signal lamps.

All replaceable units are electrically coupled with a common type PП10 assembly type plug connectors. The rectifier units are secured with special clamps. All other units are secured by drop-proof screws.

External cables are applied to the instrument through type 2PM and CP-75 plug connectors; they are mounted in the lower portion of the housing. The instrument is mounted on four AПH 20 type shock absorbers.

IV-2. INSTRUMENT A

Units A-1, 12, A-2, 3, A-3, 45 are strcturally a part of the instrument A (fig. IV-2).

Instrument A of the Kivach-2 radar set differs from instrument A of the Kivach-1 in that apart from a pulsing, rotating transformer 41 it has a selsyn-receiver 51, reducer 42, conical differential 24, mechanical switch 22, cable seal 5, and terminal plate 4.

Unit A-2 serves as the base for mounting units A-1 and A-3. The housing 3, covers 17 and 25 and other elements of the supporting structure are made of light cast alloy.

Contained inside unit A-2 is electric motor 26 and sub-unit A-2/3,23. Sub-unit A-2/3 includes the selsyn-receiver for the synchronized transmission of the course from the gyrocompass with a turn value of 1°, a reducer made up of six pairs of cylindrical wheels with a transmission ratio of 1:360, a conical differential, which adds the course value to the antenna relative bearing value, and a mechanical switch for image orientation operation.

Contained on the opposite side of the electric motor is electromagnet 18, the contact group of course marker 2 and antenna rotor reducer 15 /76

In the central portion of the housing we find shaft 36 with a geared cylindrical wheel 30 on two radial ballbearings 29 and 54. Secured to the upper portion of the shaft is bracket 40, unit A-1, and shf rotating adapter 35 (sub-unit A-2/2). The waveguide of sub-unit A-2/2 passes through the center of the shaft and is led to the outside, where it connects to waveguide channel 56. The contact wheel of course marker 1, sector

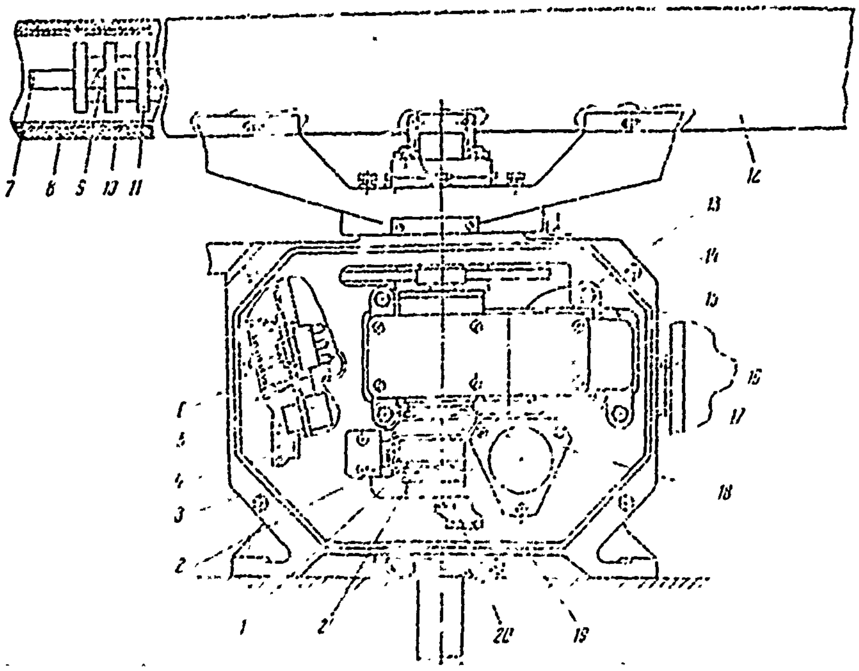

Fig. IV-2. General view of instrument A of the Kivach-2 radar set with cover off: a. from the reducer side; b. from the side of the electric motor and sub-assembly A-2/3.

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with worm 21, and the cylindrical, straight tooth gear 19, serving to transfer the motion from the main shaft to sub-unit A-2/3, are placed on the lower portion of the shaft.

The feed cables are led to instrument A through seals containted on the side wall of housing 3. The ends of the cable are spread and applied to terminal plates 4, 20, and 50. Access to them is insured through the open top. Secured to the top of the seals is switch 6 which is used for cutting in instrument A off and on during repairs or during an internal inspection.

All sub-units and covers are secured by drop-proof screws. The instrument is mounted on the mast without shock absorbers.

Antenna 12 is a sectoral horn 10, made of thin sheet aluminum. Contained at the peak of the horn is a waveguide slotted radiator 9 with filter array 11. A waveguide section, which is connected to rotating shf adapter 35, is located at one end of the radiator, and an absorber 7 made of carbonyl steel is contained on the other. To make it air tight and to provide

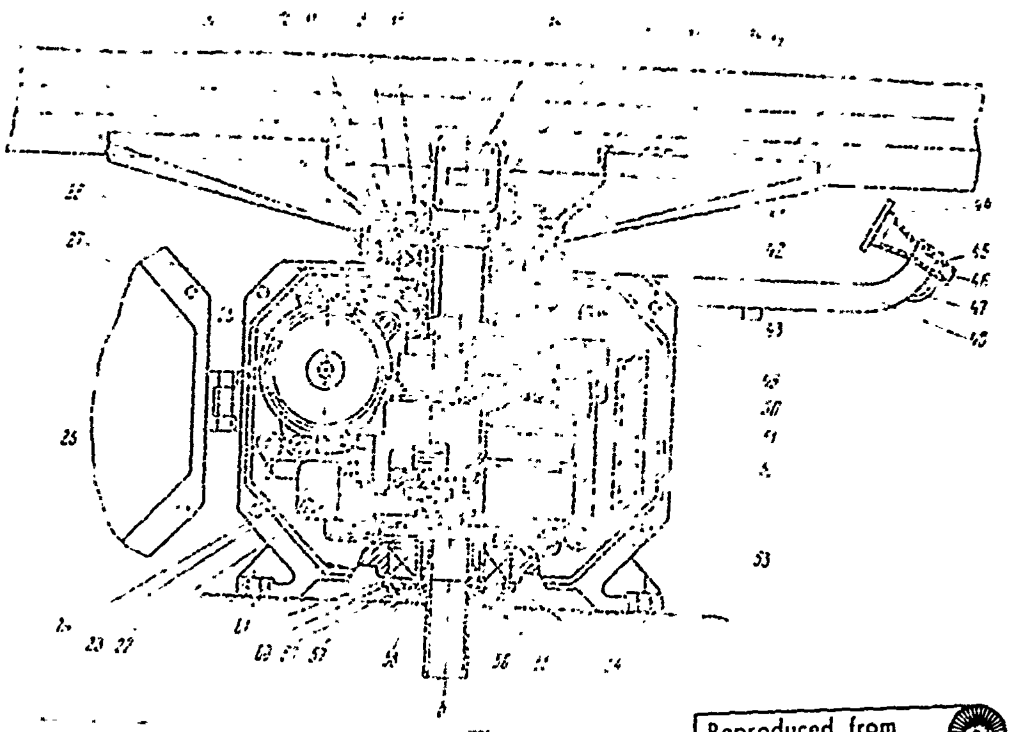

Fig. VI-2. General view of instrument A of the Kivach-2 radar set with cover off.

streamline, the antenna is covered with Ф K-20, a radio transparent material, and a coat of tropics resistant paint is applied.

Monitoring or control antenna 45 is made of thin bras in the form of a pyramidal horn. The aperture is sealed with plug 44 made of radio transparent material Ф K-20. In the lower portion of the horn pin 46 is welded to the straight portion of the wide side of the waveguide. The high frequency delay cable box 47 is connected to it. The unit is attached by means of bracket 48 to the antenna rotor drive base.

Sub-unit A-2/1 (fig. IV-3) is made of conical gears 11, 14 and cylindrical beveled gears 7, 8, 21, 24, and 27. The wheels turn in OKБ -1227T type grease inside cast housing 2, which is covered by a Duraloy lid 1 and secured by nuts 10, 26 and 22. Special protective washers 5, 20 and labyrinth bushings 4, 6, 18, and 19, which seal in housing 2, are installed on the input side of the reducer at the carrier plate 16 and at the outlet of wheel 7. Ball bearings are used in bushings 9, 12, and 23.

The waveguide channel consists of a series of standard waveguide sections (cf II-2) made of brass tubing, 12.6 x 28.5 mm in cross section. /77
A typical waveguide channel is described in fig. II-1. The individual waveguide sections are connected and electrically sealed with special choke and plain flanges. A moisture absorbing cartridge is used to keep the waveguide channel dry. It consists of screen-like transparent housing with silica gel filling and is inserted into a groove in the dehydrating section of the channel.

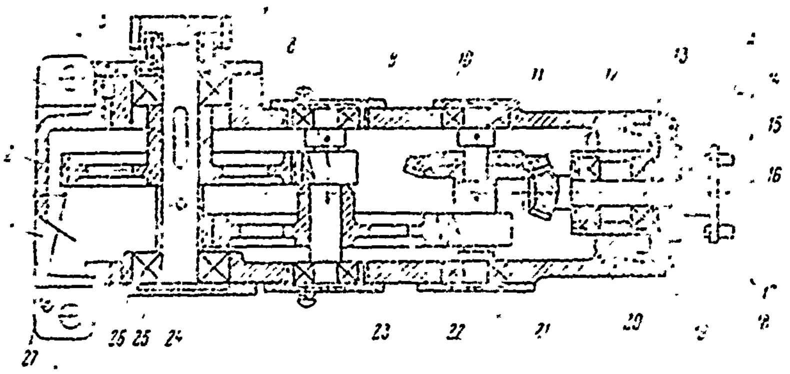

Fig. IV-3. Sub-unit A-2/1 in cross section.

The line is provided with a waveguide section with catchment trap which serves as a drain for any moisture that develops. This section consists of a radially curved tube with flanges at its ends. Secured to the broad side of the conical adapter is a flexible, accordian-shaped waveguide section with flanges welded to the ends. Externally, the section is covered with a piece of leather drawn together with twine. A waveguide conical adapter made of small cross section brass tubing with conversion to a large cross section is installed at the outlet end of the flange in instrument II. Choke flanges and plain flanges are welded to the ends of the tube.

Operating princicle of sub-unit A-2/3. Electromagnet ЭМ1, which is switched in from the panel of instrument Г, controls the mechanical changeover switch. The kinematic diagram of sub-unit A-2/3 is shown in fig. IV-4.

When ch-nging orientation from "by meridian" to "by course", electromagnet ЭМ1 disengages the electromagnetic sleeve 19 from pin 16 of gear 17 and engages it with pin 12 of gear 13. Pins 12 and 14 are caused to engage by their lateral surfaces. If they are not opposite one another at the moment of engagement, shaft A, and therefore the shaft of the rotating transformer M3 are halted for a certain period of time; they resume rotating only after the pin surfaces come in contact with each other on the next turn. The pins are engaged in a position identical to the position of the electromagnetic sleeve relative to gear 13 and at a precise angular position of the rotor turning transformer M3 with respect to the position of the antenna. Therefore, the drive shaft transmits the motion via the wheel of conical differential 9 to the rotating transformer M3 through wheels 13, 10, and 11. The gyrocompass selsyn M2, in turn, transmits the motion to wheel 17 via wheels 1, 2, 3, 4, 5, and 6, the satellites of differential 7 and 8, and wheel 18 without corrections to the rotating transformer M3. /79

When changing the position of the switch to orientation "by meridian", pin 15 of the electromagnetic sleeve engages with pin 16 of wheel 17. If, at the moment of switching, the lateral surfaces of the pins do not coincide, shaft A and the rotor of turning transformer M3 will remain stationary until pins 16 and 15 are in contact with each other. In this case, the angular position of the rotor of the rotating transformer M3 will be uniquely matched with the angular position of the output shaft of the differential, which determines the sum of values of the course and angular position of the antenna shaft relative to the longitudinal center line of the vessel. Transfer of motion to the rotating transformer M3 in this case will also be via the differential from the antenna shaft and gyrocompass selsyn.

The following table of backlashes and moments is given for the kinematic diagram of unit A-2 (cf fig. IV-4).

Table of Backlashes (Play) and Moments

Element		Permissible Backlash		Moments	
Driving	Driven	Reference units, td	Degrees	Driving Element	Maximum static T, dm
M1	I	1.075	15°47'	M1	30
9	I	1.54	0°11'	M2	1.5
9	M3	0.538	0°4'	--	--
M2	M3	2.11	45°30'	--	--

Remarks: The backlash for unit A-2 of the Kivach-1 radar set between the rotating transformer 5BT-И (driving element) and the drive shaft is equal to 0°1'.

IV-3. INSTRUMENT И

Instrument И (fig. IV-5) is made as a hinged structure mounted on a rotatable bracket. The housing consists of a light cast base 6 and two cast covers 7 and 15 on hinges. The housing is secured to the rotatable bracket 12 by means of the two shafts 9. Depending on the desires of the navigator, the instrument can be installed at the necessary angle in the vertical plane within a limit of ± 50° and secured in position by special knobs 10. As a convenience in replacing units and in making adjustments, covers 7 and 15 together with the units are swoung back through 90° and held in a fixed position by stops. Unit И-1, 1 is secured inside the instrument to cover 15 by means of drop-proof screws. Unit И-1 is secured /80 inside the instrument to cover 15 by means of drop-proof screws. Its switching shafts are coupled to the scale switching knob on control panel 16 by a carrier and two gears.

Unit И-2, 13 is secured alongside unit И-1 with three drop-proof screws. Unit И-6, 2 is located above unit И-2. It is secured by special brackets, making it possible quickly to turn and remove unit И-6. The control panel is located in front of cap 15 in a recess. Unit И-3,3 is secured by a screw and wing nut on the left side of base 6. The plate with diodes is secured behind it on the rear wall.

Tube unit 4 is secured to the upper portion of the base 6 in the center of instrument И. Its jacket simultaneously serves as a shield for the /82 CRT and a base for securing the deflecting, centering, and focusing systems. The variable resistors 5 (focus, brightness, zero range), used only in technological adjustments, are contained on a special plate. The high voltage rectifier 11 (unit И-4) is secured on the right side of the base. Unit И-5, with all the assemblies and parts that comprise it, is contained on cover 7 and includes the following: counter reducing gear, range sight ring potentiometer, range counter, gear and scale, shaft and rollers.

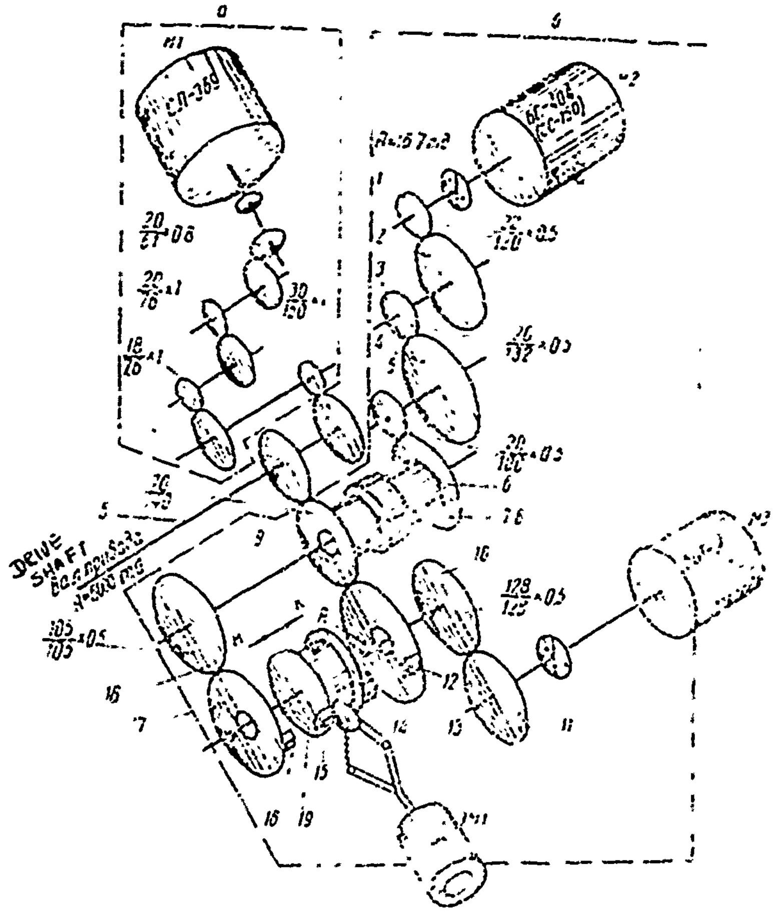

Fig. IV-4. Kinematic diagram of unit A-2 of Kivach-2: a. diagram of sub-unit A-2/1; Ƅ. diagram of sub-unit A-2/3.

Fig. IV-5. General view of instrument И with covers swung open.

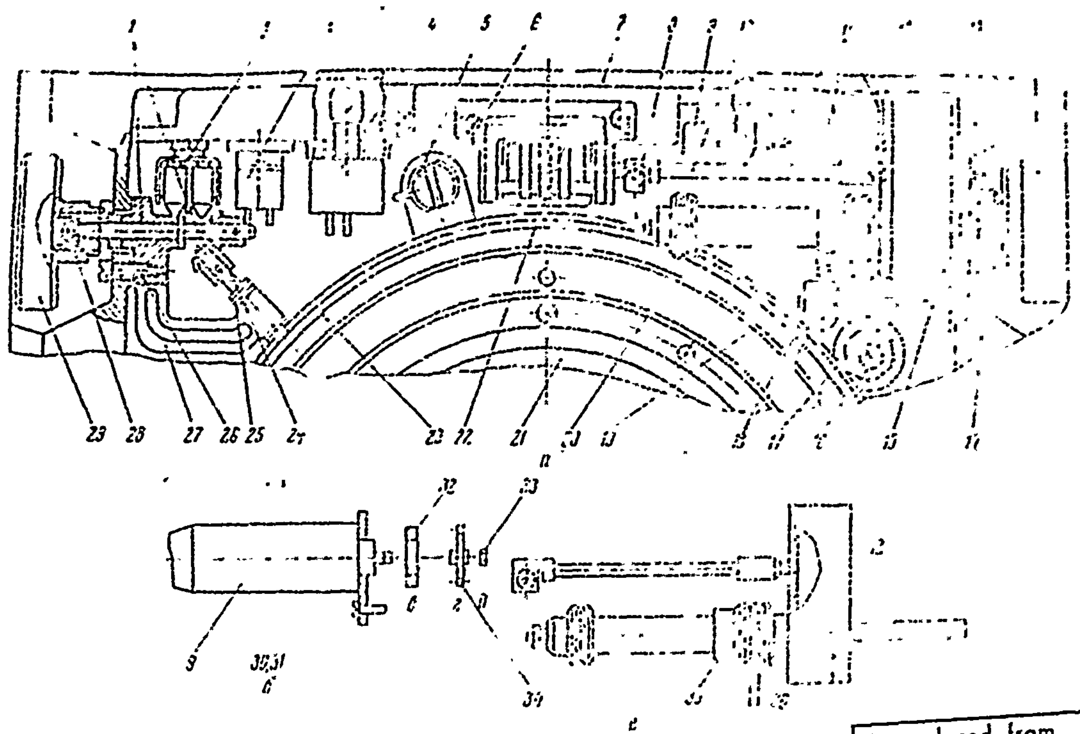

Fig. IV-6. Range potentiometer in unit И-5:
a. general view; b. potentiometer; c and d -- nuts; e. gear; f. reducer.

The following elements are contained in front of unit И-5 (fig. IV-6) fig. IV-6: power characteristic control button 2, tumbler switch "antenna rotation -- disconnect" 3, potentiometer knob "intermediate frequency reserve" 4.

The scale for reading off the directions 20 (relative bearings and courses), as well as the range meter 22, are illuminated by the small bulbs CM-37, 5. All units of instrument И are electrically coupled to the overall assembly with PП10 type plug connectors.

A metallic housing with lens, which increases the image size by about 1.5 times, and a rubber hood 8, which protects against light getting to the CRT screen, is contained on the face side of the instrument (cf fig. IV-5). Externally, the cables are secured to instrument И by plug connectors 2PM and CP-75.

Control panel 16 and covers 7 and 15 are closed with a special key. The instrument is mounted on four shock absorbers 14, type AПH.

IV-4. INSTRUMENT Г

Instrument Г (fig IV-7) is constructed with a cast base and lid 19 on hinges that covers the instrument control panel. The housing is secured to the ship's bulkhead by a special intermediate bracket. The assemblies and parts in the instrument are arranged in the following manner: cast bracket 6 with its two ball bearings 13, shaft 5, and wheel 4 are secured inside the housing. Selsyn 18 and wheel 15 attached to its shaft are secured by screws 3 to cast bracket 2. Matching with the gyrocompass is achieved manually with the knob by rotating selsyn 18 through rollers 5 and 10 with bearings 9 and 13 and cylindrical wheels 11, 7, 4, and 15. Tumbler switch 17 for cutting in image orientation by course or by the observer's meridian, switch 14 "connection with gyrocompass" and light 12 ~110 volts are contained on the front panel 16 which is made of plexiglass. The external electrical coupling of the instrument is effectuated by two plug connectors, type 2PM contained on the rear wall of the base. /83

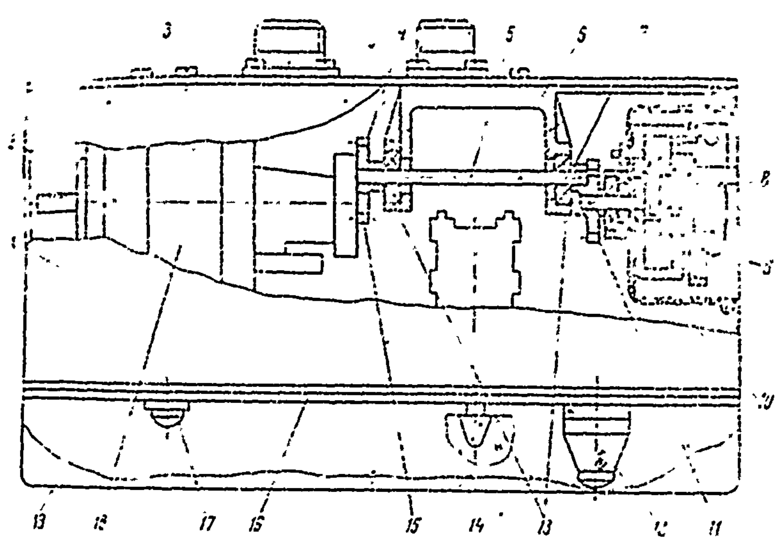

Fig. IV-7. General view of instrument Г .

The front panel is enclosed by a cast cover with a special key.

IV - 5. INSTRUMENT C

Each of the instruments, C/=24 volts, C/=110 volts, and C/=220 volts (fig IV-8), is designed as a low, fixed, cast base 1 and stamped dural cover 10 with hinges. The instrument is secured to the ship's bulkhead. The cast portion of the housing contains units and electrical elements which are very heavy.

Secured to the left side of the housing by four drop-proof screws is the voltage stabilizer 2, contactor 16, and two blocking microswitches 17.

One of these breaks the instrument power supply circuit when the control panel cover is open, and the other breaks it when the instrument cover is open.

Located on the right side of the housing are the following: resistance unit 5, transformer 4, choke 3, and other electrical elements which give off a large amount of heat. The assembly of tubes 14, diode 13, and socket 15 are secured below.

Contained on the instrument cover are the input condensers 12, industrial noise filter 6, main oscillator 11, and control panel 7. Three signal lights, a button switch and safety devices are contained on the control panel. One light signals the presence of a voltage in the on-board line circuit, the second one indicates a malfunctioning safety device, and the third with push button switch serves to check the operating condition of unit C-1. /84

Instrument C/~220 volts, 400 cycles is constructed in the form of wall closet adapted for attachment to a bulkhead. The housing of this instrument consists of a stamped base made of thin rolled steel and a dural cover. The following are contained in the housing: voltage stabilizer, control sockets, relay and blocking device (two microswitches). The power line check light and safety device operating condition control light are contained on the front side of the cover.

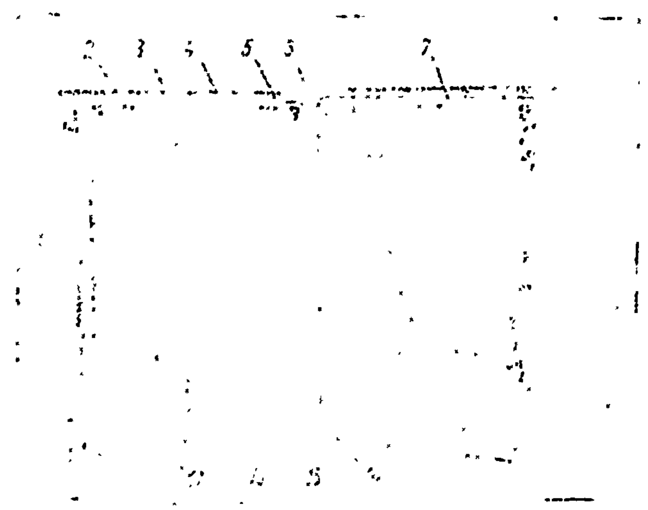

Fig. IV-8. General view of instrument C/≈220 volts with open covers.

The external assembly of all C instruments consists of two type 2PM plug connectors located in the lower portion of the instrument. The instruments are cooled by the natural exchange of heat through the walls of the housings and ventilating ports located in the upper and lower portions of the cover.

All open ports are shielded with metallic grids to improve the interference suppression characteristics. Contact between the housing and the cover is provided by a rubber gasket inclosed in a metallic braid. The cover of instrument C is locked with a special key. Instrument C is mounted on four type AIIH shock absorbers.

IV-6. INSTALLATION OF RADAR EQUIPMENT ON THE SHIP

The disposition of the set on a ship is explained by fig. IV.-9. /85 The equipment is arrange with a view toward maximum convenience in servicing (control, preventive repairs, and service repair work), as well as working with the individual instruments. When the temperature is above 30°C it is necessary to provide ventilation in the compartment in which the main instruments of the set are contained. In order most effectively to divert the heat, all instruments are so disposed as to provide an air gap of not less than 500 mm between the sides of the instruments and other ship gear, and not less than 80 mm of space between the set and the bulkheads. The lengths of the cable connections between instruments A and И is 10 meters, and it is up to 20 meters between other pairs of instruments.

The various apparatuses of the set are disposed in the following manner. Instruments И, Г (when the Kivach-2 is used), and П are installed in the navigator's compartment. Instrument A is placed on top of the pilot house or on a special support. Instrument C and the box of spares, appurtenances, and tools can be placed in any heated compartment.

Instrument И may be secured to the table, the overhead, or to a bulkhead. Depending on the navigator's desires, instrument И can be rotated in the vertical plane within ± 50°. The height of the instrument from the deck to the indicator hood is 1.2 - 1.4 meters. For convenience in observation of targets and course markers on the screen of instrument И, it is so mounted as to have the control panel facing the stern. The light source in the compartment in which the instrument is located should be equipped with special shutters and be so directed as to not interfere with observations on the screen. Light should not be allowed to enter the CRT screen.

It is recommended that instrument Г be secured on the right side of instrument И at the level of the control panel a distance up to 500 mm away. In this case, convenient access should be provided to the control panel of instrument Г and to the gyrocompass matching knob on the right.

For convenient access to the control panel it is recommended that instrument П be so disposed as to provide for a distance of 1.6 meters from the floor to the upper portion of the housing.

Instrument A is set up on the pilot house or on a special support at a height 5 - 10 meters above the waterline in a manner as to provide circular scanning by a 25° wide antenna beam in the vertical plane. The presence of shielding and reflecting obstacles (superstructures, masts, etc) can distort the radiation pattern, cause the appearance on the indicator screen of shaded sectors, spurious targets, and deteriorated accuracy and azimuth resolution. The antenna should not be installed in the vicinity of the smokestack, inasmuch as carbon deposits on the aperature of the radiating portion of the antenna can substantially impair the operating qualities of the equipment. Accuracy tolerance in setting up the servo of instrument A by the "bow" line relative to the ship's centerline is one degree. /87

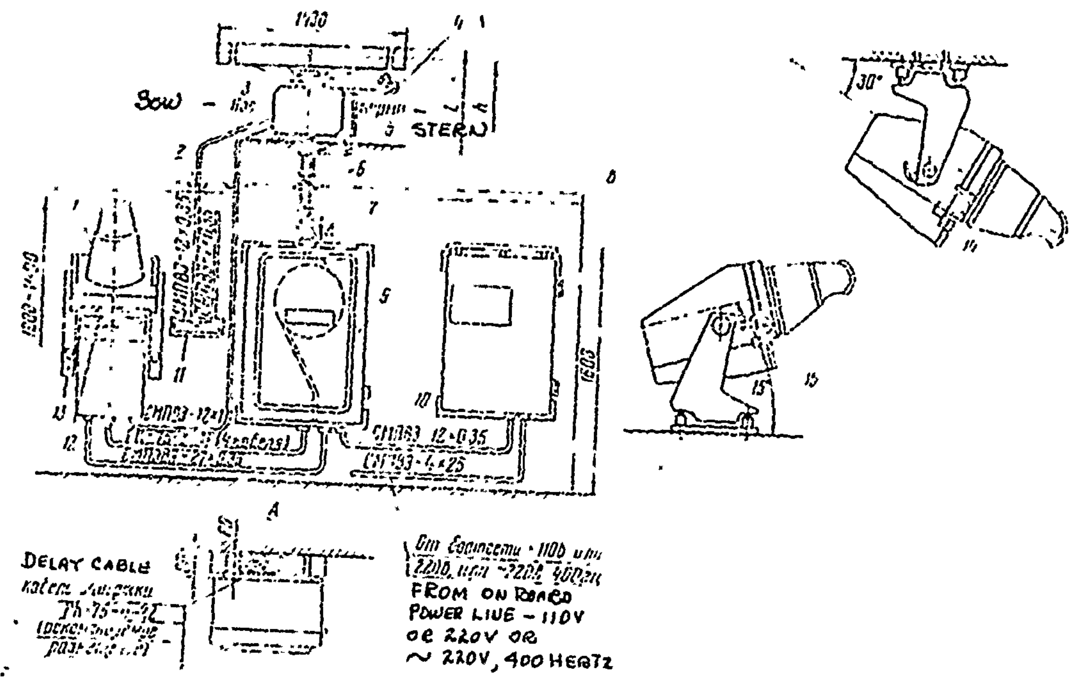

Fig. IV-9. Layout for assembling and installing radar equipment on a ship: 1. Version showing instrument И secured to the bulkhead or a bracket; 2. cable to gyrocompass; 3. instrument A; 4. unit A-3; 5. sealing gasket; 6. gasket; 7. flexible section, conical adapter; 8. pilot house or navigator's compartment; 9. instrument П; 10. instrument C; 11 Г ; 12. control panel of instrument И; 13. instrument И; 14. instrument И secured to overhead in this version; 15. instrument И secured to the table in this version. Length of waveguide channel 3 - 10 meters; length of cable connection between instruments A and И is 10 meters, and between other pairs of instruments it is not less than 20 meters; distance between instruments not less than 500 mm; height of antenna installation above waterline h = 5 - 10 meters; dimension l = 344 (for Kivach-1) and l = 384 (for Kivach-2). It is recommended that instrument Г be secured a distance of up to 500 mm from the right side of the indicator on a level with the control panel of instrument И with convenient access to tumbler switch for "orientation by course" or "by meridian", and matching knob.

The control antenna (unit A-3) is secured to the servo mechanism with a special bracket. Instrument A is installed on the ship with the horn of the control antenna directed along the centerline plane of the ship toward the axis of rotation of the radar antenna and the ship's bow.

For convenience in using the control panel of instrument C it is recommended that the equipment be set up at the same height as instrument П. For free access to the interior assembly of instruments the covers should all swing open by no less than 90°. Instruments И and П are installed not closer than one meter away from the magnetic compass and other devices containing strong permanent magnets.

The cables are connected to the instruments in accordance with the blueprint for cable connections. The delay cable, used for controlling the power characteristics of the radar equipment, should be water-proofed and protected against damage along its entire length (from instrument A to instrument П). A line power switch should be provided in the ship's cable network so that the set might be disconnected while technological servicing is being provided. The entire inter-instrumental cable assembly for the suppression of radio interferences is made of shielded cable, making certain that the shilding is continuous. The various types of cable are described in fig. IV-9.

The waveguide and cable lines should be equipped with jackets at points subject to mechanical action, and asbestos insulators should be used in places subject to heating by hot gases, hot bulkheads, etc. A waveguide transmission line made up of individual sections is assembled in strict accordance with the diagram (cf fig. II-1). If moisture and foreign matter collect inside the waveguide the energy losses keep increasing to the point of complete interruption of energy transmission. Also, corrosion develops on the interior surface of the waveguide tube. For that reason, the waveguide is made as a sealed unit. Rubber rings are placed in special grooves of the choke flanges to provide seals between waveguides, while the flanges proper are drawn tight with screws. A sheet metal plate is set up in a vertical position at points where the waveguide exits from a compartment to the deck area and at the antenna rotor drive mechanism (on the horizontal portion). It prevents the hot air of instruments П and A from entering the cool waveguide and thereby reducing the amount of moisture condensation in it. The waveguide section with settling tank is secured to the horizontal section of the line with a slope of up to 5°.

CHAPTER V

ADJUSTMENT OF RADAR EQUIPMENT ON SHIPBOARD

V - 1. PREPARATION OF SET FOR OPERATION /88

Before switching on the set for the first time the equipment is inspected as follows.

Check instrument C for type, i.e. whether the equipment is properly outfitted to use the on-board line voltage system.

Dry the equipment if instruments have been stored in a moist area.

Check the gear to see if all units are present and correctly installed, and determine whether they have been properly secured with screws and locking devices.

Remove preservation grease with a brush and wipe with a clean dry rag moistened with gasoline or alcohol. All units and instruments should be meticulously cleared of dust with a vacuum cleaner. The mechanisms are lubricated as described under Chapter IX.

Check the security of electrical couplings in plugs and high frequency couplings between units and instruments, as well as the contact between the high voltage lead of unit-4 and the anode of the CRT in instrument И (visually and by touch).

Check to see if the inter-instrument cables and ground leads are properly connected and whether they conform to the electrical circuit diagram. Covers of all instruments should be closed.

Set all controls in the initial reference position:

a. On the control panel of instrument И set the "Radar on - Off" tumbler switch in the "off" position; set the "Antenna rotation - Off" (under the "Reserve Control" cover) switch in the "Antenna rotation" position; and turn the "Discriminator" knob to the extreme left position;

b. On the control panel of instrument П set the "Control unit П-4" switch in the "Operation П-4" position, and the "Sweep" switch in the position "Radar Operation";

c. Set the "Frequency tuning" switch to the "AFCoperation" position on the klystron tuning panel on instrument Д;

d. Set the "Coupled to gyrocompass" switch on the panel of instrument Г (for the Kivach-2 set) to the "Off" position;

e. Set the "Antenna rotation - Off" tumbler switch on unit A-2 of instrument A in the "Antenna Rotation" position.

V - 2. INITIAL SWITCHING OF RADAR UNIT

The set is switched on in the following manner.

1. Cut in the ship's electrical power supply to the set. In so doing, the "Ship's power line" signal light should become illuminated on the face side of the panel of instrument C.

2. Check ship's electrical system voltage with the Ц-57 instrument in service outlets Г 1 and Г 2 which are located under the cover of instrument C (in the case of instrument C/~200 volts, 400 cycles first set the blocking switch). The voltage should not differ from the nominal /89
by more than ± 10%.

3. Switch on the set by placing the "Set on - off" tumbler switch on the control panel of instrument И in the "On" position. The control panel, the scale mechanism of instrument И, and the control panel of instrument П should be illuminated in the process (with the control panel cover open).

4. For the alternate versions of providing power for the set with instruments C/= 110 volts, C/= 220 volts, C/= 24 volts, open control panel cover of instrument C with key which disconnects the set. Depress the "Unit C-1 O.K." button; if the signal lamp lights up it is an indication that the unit is in good working order. Close the cover of the control panel to switch the set on again.

5. Three to five minutes after switching on the set the "Transmitter" light on the control panel of instrument II should light up, indicating that the set is fully switched on (the transmitter modulator and high voltage CRT feed are switched in).

6. The procedures of checking the operating efficiency of the various radar units and assemblies on the control panel of instrument II is described in Chap. VII. If the magnetron current and the ifa and afc systems are not within the sector it is an indication that certain adjustments should be made (cf Chap. VIII-1 and 2).

7. Check the operation of the set by the presentation on the CRT screen of instrument II as follows:

a. Check for radial-circular sweep and threshold brightness on all range scales. If the brightness has to be altered, make necessary adjustment (Chap. VIII-4);

b. Check for coincidence of center of radially-circular sweep on the screen with center of the bearing cursor. The test is made on the 0.4 mile scale. If the centers are more than 0.3 mm apart, make necessary adjustment (Chap. VIII-3);

c. Check the length of the sweep on all range scales and if necessary make adjustment (Chap. VIII-5);

d. Check on the number and quality of range markers. In doing so, set the "Off - Course Marker - Course Marker - Range Marker" switch in the "Course Marker, Range Marker" position and, if necessary, make appropriate adjustment (Chap. VIII-7). If the range markers are not clear (blurred), make necessary focusing adjustment on the 24-mile range scale (Chap. VIII-4);

e. Check for the presence of adjustable range sight marker within the limits of all range scales and for image brightness. To check the latter, move the range sight ring with the range sight ring knob to the center of the range scale, and if the marker is not bright enough or too bright, make appropriate adjustment (Chap. VIII-7); /90

f. Set the "Off - Course Marker - Course Marker, Range Marker" switch in the course marker position. Check for the presence of a course marker. If the brightness is insufficient or excessive, make necessary adjustment (Chap. VIII-7);

g. Set discriminator knob in extreme right position (rotating in clockwise direction). The inherent noises of the receiver and target signals should be observed on the screen in the process. Check for the accuracy of clipping level of powerful video signals. If the target image in the vicinity of the main pulse on the 0.4 mile scale is not bright enough, or if it is accompanied by an extremely intensive halo, make adjustment of the limiting level (Chap. VIII-6);

h. Set the range scale switch on the 0.8 mile position and cut in the "Interference Suppression and Signal Differentiation" tumbler switch.

Make certain that only the leading edges remain of images from targets extended in range. In this case, it is possible to change the noises near the center of the screen and restore them to normal size at a distance of 0.4 - 0.6 miles due to the atgc effect;

i. Repeat the preceding operation on the 8-mile scale, having in mind that on the 8-24 mile scales the atgc system is switched in, regardless of the position of the "Interference Suppression and Signal Differentiation" tumbler switch.

j. Switch in one of the scales up to four miles. Depress the "Power Characteristic Control" button. Make certain there is an arc-shape control signal 90 - 120° wide at a relative bearing of 180° on the screen (cf fig III-8) 3-5 mm away from the main pulse circle (in the power characteristic control operation the 0.4P mile scale is switched in automatically). To improve the visibility of the power characteristic control signal marker it is useful to switch in the range marker.

With a waveguide channel length greater than nominal (5 meters) it may be necessary to adjust the atgc system in unit II-3 to improve conditions for the observation of targets near the radar dead zone and to obtain optimal viewing of the power characteristic control signal on the indicator screen. The delay is increased in this case and the depth of the atgc strobe is adjusted (Chap. VIII-8).

8. Check the operating efficiency of instrument Г (for the Kivach-2). In the process, check for the presence of voltage from the gyrocompass (the ~ 110 volt light on instrument Г should be on); set the "Coupling to gyrocompass" switch in the "Matching" position; when operating the "Image Orientation Switch" make certain the course marker is visible in various positions of the CRT screen; when rotating the "Matching with Gyrocompass" knob (to release the knob pull upwards) be certain that the course marker moves uniformly on the CRT screen.

9. Disconnect set by moving the radar "On-Off" tumbler switch to the "Off" position, and leave the "Matching with Gyrocompass" tumbler switch on instrument Г (for the Kivach-2) in the "Off" position.

/91

V-3. ANTENNA ALIGNMENT

When working with instrument A in the switched on position, it is essential to observe safety rules. To prevent shf irradiation it is necessary to disconnect the antenna rotor after setting the "Antenna Rotation" tumbler switches in the И and A instruments in the "Off" position; set the "Control of Unit II-4" switch on the control panel of instrument II in the "Control 1" position; in this case, it is necessary to make certain there is no magnetron current, according to the point indicator located on the boundary of sectors 2 and 5 (cf III-9), and from the indicator screen determine that there is no sweep.

The procedure in making adjustments is as follows.

1. Before making the adjustment it is essential to check whether the

center of the sweep has been correctly set (cf Chap. V-2, point 7b).

2. When the antenna is adjusted, the ship should be securely moored. In making the adjustment it is enough to have on the indicator screen one identifying marker from the "point" target (better than a corner reflector) located at any direction and at a distance from the center of the screen not less than 2/3 of its radius.

3. Switch the set on.

4. When working with the Kivach-2 the orientation by course operation is set with the "Image Orientation" switch on the front panel of instrument Г . Determine the relative bearing of the target selected by the optical direction finder which is correct to $0^{\circ}.1$.

5. Determine the relative bearing of this same target with the bearing cursor on the indicator screen using ten readings. Determine the mean value of the relative bearing.

6. Compare the results obtained in points 4 and 5, and if they differ by more than 0.2° it is necessary to do the following: set the bearing sight cursor in the position corresponding to the relative bearing of the target determined by the optical direction finder; loosen the locking device of rotating transformer 5BT-И in unit A-2 and after turning the stator try to coincide the center of the target marker with the bearing sight cursor; tighten the rotating transformer hold down device; take thirty readings of the relative bearing on the indicator and check to determine whether the mean value of the relative bearing is equal to the angle determined by the optical direction finder; if necessary, repeat the operations until the error is eliminated.

To average out errors in measuring the relative bearing for any direction, it is necessary to carry out the following operations: /92

Install in unit A-2 the scale mechanism contained in the kit of spare parts, tools, and accessories with two screws; disconnect the waveguide channel from the transmitter and connect an equivalent load to the latter.

Set the sweep trace precisely on zero of the antenna turn indicator scale by manually rotating the reducer wheel of unit A-2 in the direction of rotation of the antenna.

Loosen the drum of the scale mechanism and likewise set it on zero.

Determine a series of errors in transmitting directions from the antenna to the indicator within the limits of 0 to 360°, turning the antenna manually in the direction of rotation through 20° intervals; this is controlled by a scale mechanism. Errors are determined as the difference of indications of antenna and indicator scale mechanisms at the points of measurement.

Compute the mean value of a number of errors, i.e. the systematic error, and eliminate it by turning the stator of the rotating transformer 5BT-И (unit A-2) by the amount of the systematic error but of opposite sign. With this, the adjustment of the antenna should be deemed complete.

V-4. SETTING COURSE MARKER

The following operations are performed in setting the course marker.

Switch on the set and for the Kivach-2 put instrument Г into the "Orientation by Course" operation; set the "Matching with Gyrocompass" switch in the "Off" position.

Using the bearing sight cursor, measure the angular position of the bearing marker on the fixed scale of the indicator.

Set the "Antenna Rotation" swtich in instruments И and A in the "Off" position.

Lift the cover of unit A-2 located to the right of the "Antenna Rotation" switch, turn the antenna manually so that the slot of the worm mechanism (for setting the bearing marker) is directed toward the operator.

Place screwdriver in slot of worm mechanism and, rotating it, turn the slip ring of the course marker until the course marker on the PPI screen coincides with zero of the bearing scale. In the process, the slip ring should be turned in the direction of antenna rotation if the course marker was previously to the left of zero of the fixed scale, and in the opposite direction if the course marker was to the right of zero.

Cut in the "Antenna Rotation" tumbler switches in instruments A and
И and check to determine whether the course marker coincides with zero /93
of the fixed scale. If the discrepancy is not over 0.2°, the course marker adjustment may be considered complete. Otherwise, the operations set forth in the above should be repeated.

V-5. MATCHING THE IMAGE WITH GYROCOMPASS READINGS

This work is performed only on the Kivach-2 radar. The matching operation is carried out while the vessel is at anchor with the gyrocompass power supply unit switched on but with the interior repeater system switched off.

The following operations are performed.

1. Switch the set to operate in orientation by meridian. This is done by setting the "Image orientation switching" tumbler switch on the front panel of instrument Г in the "By Meridian" position. Set the "Coupling with Gyrocompass" switch on the front panel of instrument Г in the operating position.

2. Using the gyrocompass manual starter handle, set any whole number of degrees on the gyrocompass coarse and fine scales. The direction cursor is also set on a whole number of degrees, preferably on the line of the fixed scale of the indicator closest to the course marker.

Loosen the fastening of the receving selsyn M2 in unit A-2 and, turning the selsyn motor, cause the course marker to coincide exactly with the bearing cursor. Tighten the fastening screws of selsyn M2.

4. Set zero on the gyrocompass coarse and fine reading scales and the bearing cursor of the radar set on zero of the fixed scale of the indicator. Set the "Image Orientation Switching" changeover switch o on the front panel of instrument Г in the "Matching" position. Turning "Matching with Gyrocompass" knob (on instrument Г), superimpose the course marker on the bearing cursor on the indicator screen and quickly set the "Image Orientation switch in the operating position. Check to determine whether the course indications on the gyrocompass and the radar set coincide.

5. Setting course values every 2C degrees between 0 and 360° on the gyrocompass, read on the fixed scale of the indicator the corresponding positions of the course marker. The series of course transmission errors from the gyrocompass to the indicator at points of measurement is defined as the difference between indications of scale mechanisms of instrument И and the gyrocompass.

6. Compute the mean value of the error series obtained and eliminate /94
these by turning up the receiver selsyn in unit A-2 by the magnitude of this mean error value but of opposite sign.

V-6. ADJUSTMENT OF RANGE FINDER AT ZERO RANGE

With the cover of instrument И open, cut in the set, and following a two hour period of operation perform the following.

Using the range sight ring knob (on instrument И) set a negative range on the range counter -0.0065 Д cable's length -- in which Д is the length of the waveguide channel in meters. Switch in the 0.4P range scale. Set the operating noise level on the screen with the "Discriminator" regulator.

Observing the range sight ring marker on the screen, cause the leading edges of the main pulse and range sight ring pulse to coincide by turning the "Zero Range" regulator (inside of instrument И).

V-7. SUPERIMPOSING ZERO RANGE MARKER ON ZERO RANGE

With the cover of instrument И open, switch on set and following a two-hour period of operation perform the following.

1. Set the 0.4P mile range scale. Connect the input to oscillograph C1-8 (C1-20) via the remote divider to the output of unit И-3 (socket Г 3). The pulse which synchronizes the oscillograph is taken from one of the leads of line Л 3-2 of unit И-1 so that a clear representation may be obtained of the leading edges of the main pulse and the zero range marker

pulse on the oscillograph.

2. By proper selection, switch in lead No. 137 to the tap of Л 3-2 or Л 3-3 at which the leading edge of the zero range marker pulse will be delayed relative to the leading edge of the main pulse by 0.008 L usecs ; L is the length of the waveguide channel in meters. Solder the wire to the delay line.

3. Switch set to the 0.4 mile scale and carry out steps of point 2, connecting the end of lead No. 136 to the taps of line Л 3-2 or Л 3-3.

4. Switch set to the 0.8 mile scale and carry out steps under point 2, connecting leads 135 to the taps of line Л 3-2 or Л 3-3.

5. Switch set to the 4-mile scale and carry out steps under point 2, connecting lead 140 to taps of line Л 3-1.

CHAPTER VI

DAILY CARE OF RADAR SET

VI-1. SWITCHING AND CHECKING OPERATING CONDITION OF EQUIPMENT /95

Only one operation has to be performed to put the set into operation: set the "Radar on - Off" tumbler switch in the "On" position on the control panel of instrument И. This should illuminate the peepholes with the numbers indicating the scale and interval between range markers. After an automatic time lag of 3-5 minutes, which is necessary to heat the filaments of the magnetron and the CRT, the "Transmitter" bulb should light up on the control panel of instrument И, indicating that the set is fully switched on.

The functioning of the set is checked by observing the presentation on the screen of instrument И in the following order:

a. Check for the presence of a radially circular sweep and its threshold brightness on all range scales.

b. Check to determine the presence of noises and signals on the screen and attempt to alter same with the discriminator adjustment.

c. Check to see if the centers of the radially circular sweep on the screen and bearing cursor coincide.

d. Check on the quality of range and course marker presentations. To make this check set the "Disconnect - course marker - course marker, range marker" tumbler swithch in the "Course Marker, Range Marker" position. The course marker should point to zero of the fixed directional scale (Kivach-2 radar in course orientation).

e. Check for the presence of an adjustable range sight ring and the required brightness of its presentation. To do this, it is necessary to bring out the range sight ring into the bounds of the observed range scale .

f. Select any of the range scales up to the four miles scale. Press down on the "Power Characteristic Control" button and make certain there is an arc-shaped control signal (about 120° long) disposed at an angle of

180° relative to the line of the course marker, 3 to 5 mm away from the main pulse circle. The range markers should first be switched off in checking the power characteristic for better observation of the power characteristic control signal marker.

g. Check the relative accuracy of coinciding the range marker and the range sight ring (cause the range sight ring to coincide with each range marker). In the process, the readings taken from the range sight ring counter should not differ from the distances indicated by the range markers by more than that stimpulated in equipment logbooks. When checking the set for presentation, it is necessary, if signs of malfunction are observed on the CRT screen, to check on the operating efficiency of the set equipment in accordance with Chap. VII.

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The following supplemental operations are performed when checking on the operating conditions of the Kivach-2 set.

a. Set the "Image Orientation Switch" in the "By Meridian" position.

b. Set the "Coupling With Gyrocompass" switch in the "Matching" position.

c. Set the value of the ship's course, which is taken from the gyrocompass repeater, on the fixed scale of the indicator with the bearing cursor.

d. Rotating the "Matching With Gyrocompass" knob on instrument Г (the knob should first be pulled up), coincide the course marker with the bearing cursor after which quickly set the "Coupling With Gyrocompass" switch in the "Operation" position and check to determine if the course marker coincides with the bearing cursor. If the course marker is reflected with a slight lead or lag on the trace of a scan relative to the cursor, the "Coupling with Gyrocompass" switch should again be set in "Matching" position, and using the "Marching with Gyrocompass" knob, set the course marker with approximately the same lag or lead on the scanning motion. Again set the switch on the operating position and check for coincidence. If the course marker coincides with the bearing cursor, lock the control knob (pull back and return control to previous position).

e. Set the required operating condition: "By course" or "By meridian."

If sea clutter or interferences from atmospheric precipitation are present turn the "Interference Suppression and Signal Differentiation" tumbler switch on. This same tumbler switch is cut in also when it is necessary to increase the range resolution of the targets.

Strive to get the fullest and clearest target presentation against the background of noises or interferences with the discriminator control.

The "Radar On-Off" tumbler switch is set in the "Off" position when switching the radar set on.

It should be remembered that in the operating position with the gyrocompass coupled in (even when the Kivach-2 is disconnected) a ~110 volt current is fed from the gyrocompass to the selsyn in device A through instrument Г . To disconnect the voltage from instrument A (but not from instrument Г) it is sufficient to set the "Coupling With Gyrocompass" switch in the "Off" position. However, if the gyrocompass on the ship remains switched in it is not essential to disconnect the "Coupling with Gyrocompass" switch during the short periods when the Kivach-2 is disconnected. In this case, matching with the gyrocompass in the radar is not affected in the "Operating" condition with the set switched off; it simply needs to be checked on the indicator screen each time the set is switched on. /97

VI-2. RADAR IMAGE ON INDICATOR SCREEN

Owing to the relatively low level of image brightness on the screen it is best to view the presentation of the surrounding situation on the indicator screen in a darkened room. Direct rays of the sun should not be permitted to strike against the viewing tube screen.

Detection and presentation of targets and coastlines. Target pickup range depends on radiowave propagating conditions which are affected by temperature, humidity, the relationship between water and air temperatures, and the season of the year.

Target reflectance likewise is not a constant factor. For example, a sandy spit extending into the sea is visible differently on different days, depending on the moisture content of the sand. In the summer season a leafy forest reflects considerably better than it does in the spring when the trees are bare. Metallic roofs of dwellings reflect radiowaves very effectively, but in some instances they are poorly visible owing to specular reflection of incident radiowaves in a direction which might not coincide with the direction to the set. Snow cover greatly changes the reflecting capacity of objects; its degree is governed by the looseness of the snow and its moisture content.

The intensity of weak signals from objects (especially non-stationary objects) can change from one turn of the antenna to another, and for that reason their temporary disappearance for one to three turns of the antenna to another, and for that reason their temporary disappearance for one to three turns of the antenna is not a symptom of antenna malfunction.

Large sized objects like shorelines, cliffs, and large structures are displayed on the indicator screen as contours; small objects such as buoys, channel markers, and small craft appear as dots or short arcs. The shoreline is illuminated on the tube screen as a solid or discontinuous line. If the coastal zone is low, has poor reflecting qualities such as sand, and has tall reflecting objects such as cliffs, high buildings, and metal bridges in the depths of the shoreline, the presentation on the tube screen differs somewhat from the actual shoreline. When observing the surrounding situation it is necessary to take these factors into account. It is also possible that the shore image on the screen lies somewhat closer than the actual shoreline. This phenomenon is observed when radiowaves are reflected from breaking waves.

In observing a shoreline on the screen it is essential to allow for phenomenon of radar shielding (shadowing) of one object by another (fig. VI-1)

The probability of detecting objects increases in all cases if they are observed at the inherent noise level of the receiver; this situation is achieved by setting the discriminator control more to the right. In doing so, the screen field is illuminated by the noises and the image shows a lesser degree of contrast.. /98

The dead zone of the set is minimal on the 0.4P scale when the "Interference Suppression and Signal Differentiation" tumbler switch is on.

Interference suppression features. Reflections from atmospheric precipitation can camouflage useful signals; these are observed on the radar screen as interferences in the form of solid noise flare spots or individual spots. These interferences occasionally screen out the reflecting objects located behind them.

To reduce interferences caused by precipitation it is necessary to switch in the "Interference Suppression and Signal Differentiation" switch on the control panel. It should be borne in mind that in this mode the detection range of elongated objects, especially radially disposed shorelines, decreases owing to the signal differentiation effect.

Interferences caused by reflections from ocean waves depend on the state of the sea (intensity, character, and direction of the waves) and are usually observed in the near zone (up to one or two miles). These interferences cause a flickering of light on the screen, which gradually decreases as the range increases, making it more difficult to observe the nearby objects, especially small objects such as buoys, small craft, and channel markers.

Tor reduce the intensity of the inteferences from ocean waves it is necessary to cut in the "Interference Suppression and Signal Differentiation" switch. Observation of targets against a background of interferences due to ocean waves or atmospheric precipitation can be improved by means of the discriminator.

In observing a radar image it is necessary to take the following elements into account. All types of existing radar antennas radiate and receive a small amount of energy from the sides in addition to radiation and reception in the principal direction. This radiation is not uniformly distributed in direction and is referred to as the antenna side lobes. The amount of energy in this type of radiation is small, but in some cases may be the reason for the appearance of spurious markers on the screen. If the antenna side lobe is incident upon some nearby disposed object with good reflecting properties and if the reflected energy is sufficient to produce a blip on the screen, this spurious signal will be visible at a bearing at which it does not really exist. Spurious signals of this type, unless observed on scales up to four miles, can be reduced by cutting in the "Inteference Suppression and Signal Differentiation" switch. In this case, the weaker reflections from the side lobes are suppressed by the automatic time gain control system at ranges up to 0.4 miles. /99

Signal discrimination. The discriminator control provides for better isolation or discrimination of weak signals against a background of noises or interferences and improves signal resolution (separation) of closely disposed targets.

Optimum contrast and situation presentation quality on the PPI is achieved both with the "Interference Suppression and Signal Differentiation" switch on when interferences are present, and with this switch disconnected in the absence of interferences.

Target bearing discrimination in the near zone (up to 0.3 miles) can be increased by off-setting the center on the 0.4P scale and moving the target markers away from the screen center. Observability of targets located on the bounds of the dead zone is improved in the process. When using the 0.4P scale it is essential to bear in mind that shifting the center introduces distortions in the outline of elongated objects like shorelines, even though the same range and bearing scales remain.

To improve target range resolution quality, the set is equipped with a signal differentiation operation which is switched in by a tumbler switch labeled "Interference Suppression and Signal Differentiation."

Distance and bearing measurements. When measuring range to a target by means of a range sighting ring on the indicator screen it is necessary to employ the method of coinciding the leading edge (inner side of the ring) of the range sight ring with the leading edge of the target marker. /100
To do this, the inside of the range sighting ring on the indicator screen should be caused to coincide with the target marker (fig. VI-2) using the "Range Sighting Ring" knob. As to a point target, the center of the target blip is made to coincide with the center of the range sighting ring.

Measurement of target bearings is accomplished by means of the bearing cursor.

Target bearings and the ship's course are determined by the external (fixed) scale, and target relative bearing angles are determined by the internal (movable) bearing scale.

The accuracy of measuring directions in the near zone (up to 0.3 miles) can be increased by offsetting the image center on the 0.4P scale. This is achieved by decreasing the angular dimensions of the point target marker by moving the marker away from the center of the screen and thereby increasing the accuracy of dividing the target marker in half when its position is fixed by the range cursor.

In all instances, accuracy of bearing determination is increased if the target marker is located farther away from the center of the screen. This is achieved by increasing the image scale (by switching in a larger range).

To prevent gross errors due to parallax in measuring bearing, it is vital to coincide the upper and lower cursors with sighting target markers visually. For greater accuracy, alignment of the target marker cursor should be performed with one eye closed, and illuminating the screen in the process with the discriminator control knob.

When using the set it is important that the center of the radial-circular sweep coincide precisely with the center of the adjustable range sighting ring. This is a most important condition for the avoidance of gross errors in bearing measurement.

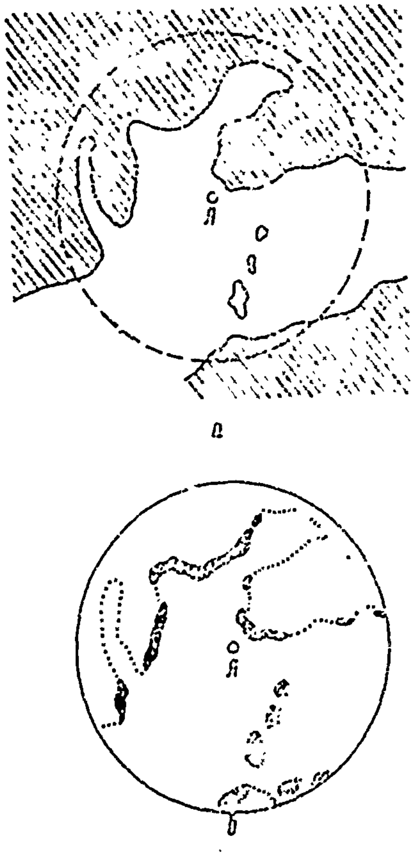


Fig. VI-1. Radar shadowing phenomenon: a. Plan of shore line section; b. image of shoreline section on screen. Portions of the bay, designated by dotted lines, are not visible because they are shaded by the cape. A. location of radar equipment.

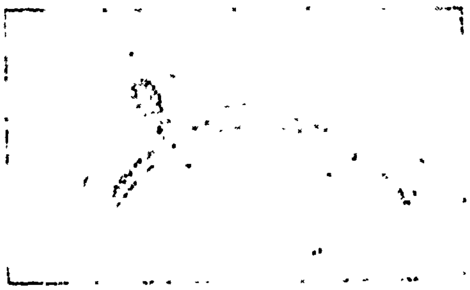


Fig. VI-2. Coinciding the adjustable range sighting ring with target markers in measurement of range. 1. Adjustable range sighting ring; 2. signal markers from elongated target; 3. signal marker from point target; 4. leading edges of targets.

CHAPTER VII

TROUBLESHOOTING AND CORRECTING MALFUNCTIONS /101

Malfunctions in radar units are located with built-in automatic control systems. A malfunctiong replacable unit or assembly is supplanted by a working element taken from the kit of spare parts. Control sockets for testing the supply line voltage and basic parameters are provided on the front panels of units, and in the instruments as a supplement to the control system. Voltage curves at the control sockets are provided in the operating instruction book. These are an aid to the base specialists, when they are called upon to perform adjustments on radar equipment on the ship and during preventive repair sessions, to accurately measure the parameters of equipments, and to seek out and correct malfunctions in inter-unit connections (plug connections, wires, cables, etc).

VII-1. CONTROL OF EQUIPMENT OPERATING EFFICIENCY

The built-in control system is used for troubleshooting only when indications of radar operating malfunctions are noted on the screen of instrument II when it is in operation or when the power characteristics of the set are checked. Search for the malfunction is performed on the control panel in instrument П. Checking sequences indicated on the panel should be strictly observed in the process. Unless this procedure is followed it may lead to erroneous conclusions. Before and after the check all swtiches on the control panel should be set in the extreme left position.

Checks on the operating efficiency of the various mechanisms are accomplished in the following order (the sequence is indicated on the control panels).

1. The working order (proper) of the safety devices at the input to the feed sources is verified if the signal lights above the safety devices on the first section of the control panel remain unlit. If the signal bulb lights up the device should be replaced (spare fuses are carried on the cover of instrument П, as well as in the kit of spares. If the signal lights continues to be illuminated following this, some power source is defective and should be replaced by a spare part. The designation of the defective unit is indicated under the signal light.

2. Check the power source voltage on the control panel in sector 2, including: the on-board line circuit, ~ 220 volts, 400 cycles, and the voltage put out by the rectifiers (units П-5 - П-9, И-4). Before checking, the tumbler switch located to the left of the indicator on the control panel is set toward section 2. The "Power Source Control" switch is turned in a /102 clockwise direction. The indicator knob should not extend beyond the limits of the appropriate color sector in all switch positions (when checking the ± 110 volt current the antenna rotor should be switched on). In this case, the color of the sector is indicated by the initial letter toward which the switch knob is directed. When the "Onboard line circuit" switch is

not in sector, it is necessary to check for the presence of line voltage in instrument C by the indication of the "Onboard Line Circuit" bulb located on the control panel of instrument C. Next, check the working order of the safety device in instrument C because of the absence of a light in the "Safety device Inoperative" bulb which is also located there. If the indicator goes beyond the limits of the sector when the switch is in the "Onboard power Line" setting, check the voltage in instrument C in sockets Г 1, Г 2 with instrument Ц-57 carried in the kit of spares, tools, and accessories. If the instrument does not indicate "In Sector" with the switch in the "220 Volt Stabilizer II" position, check the operating condition of unit C-1 in instrument C. This is accomplished by depressing the button on the control panel of instrument C.

If the signal light "C-1 Operating" still does not light up, the unit is defective and should be replaced by one in good operating condition from the kit of spares. If the instrument indicator extends beyond the limits of the sector when the switch is in the "220 Volt Stabilizer II" position, check the voltage in sockets Г 4 and Г 6 with special voltmeter Д567. If the indications deviate from standard and if the circuit shows no defects, the necessary voltage is established by resistor R16 contained in instrument C.

Check the rectified voltages of current sources in other positions of the switch. The absence of voltage suggests a defect in some rectifier unit. The defective unit is determined by the inscriptions on the control panel near each switch position.

3. The operating efficiency of functional units is tested with the "Search" switch located in section 3 of the control panel. The switch is turned in a clockwise direction and the units are checked according as the "Operative" or "Defective" signal lamps are illuminated. Defective units are replaced by good ones carried in the kit of spare parts. Automatic control (check of unit П-10 and the circuits of unit П-11) is accomplished with the switch set in the CK (autonomous control) position.

4. The operating efficiency of unit П-4 is checked by the "Unit П-4 Control" switch and by the indicator contained in section 4 of the control panel.

When switching the arrow indicator into the "Control-I) and "Control-II" positions, make certain that the indicator arrow of the instrument does not go beyond the limits of the pertinent sectors (the right hand sector for /103
the position "Control-I"). When the instrument arrow extends beyond the sector limits it indicates that unit П-4 is defective.

In those cases where replacement of unit П-4 is difficult while at sea, provision has been made through the installation in the set of an "Emergency Frequency Tuning" system, whereby the klystron frequency can be tuned manually by the operator from instrument И (without involving unit П-4 in the operation). For this purpose, the "Frequency Tuning Operations" switch located on the klystron tuning panel in instrument П should be set in the "Emergency Frequency Tuning" position.

5. Check the operating efficiency of the replaceable units (magnetron, klystron, discharger, and the automatic frequency control and intermediate frequency amplifier control crystals. The arrow indicator tumbler switch on the control panel should be set in position 2. If the assemblies are in good working condition, the instrument indicator will be found within the limits of the color sectors of the arrow indicator in all positions of the "Unit Control" switch. If the arrow of the instrument extends beyond the sector bounds the unit is defective and should be replaced by a good one from the kit of spares. However, the magnetron current may be tuned to the necessary magnitude by the potentiometer; access to its shaft is possible through an opening in the cover of instrument II. If the tuning does not give the desired results the magnetron itself is replaced.

Control sockets are provided in the units and instruments of the radar set for measuring the feed voltage and the basic parameters. This allows of positive information about equipment parameters and reduces the total time consumed in searching out defects, especially in the inter-unit and inter-instrument couplings. Table VII-1 gives a list of the necessary metering instruments. Tables VII-2 -- VII-16 give the data, tolerances, and voltage curves at the control sockets; they also indicate which metering instruments are to be used in making the necessary measurements.

Table VII-1

List of Recommended Metering Instruments
for Plugging into Equipment

Instrument	Type	Remarks
Combination	Ц-57	
Oscillograph	C1-8 or C1-20	
Voltmeter	M106	
Voltmeter	Д567	

Table VII-2

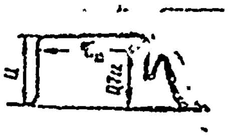
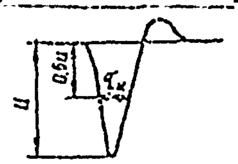
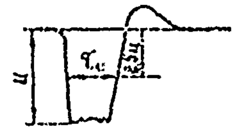
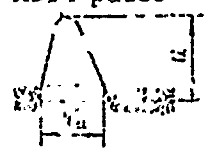
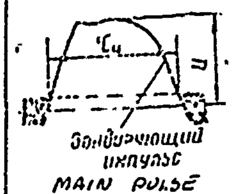
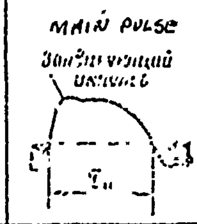
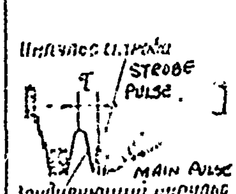
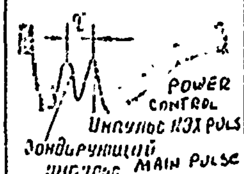
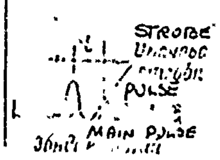
Voltages in the Control Sockets of Unit II-1				
Socket or plug marking	Purpose	Pulse Shape, Tyoe Voltage	Pulse Parameters and Voltage	Remarks
III2, III3	ATGC synch and starter pulse		U = 10./.12 v t_u = 4 ± 0.2 usecs	On 75 ohm load
III4	Unit II-1 control and ATGC strobe shaping pulse		U = 35./.50 v t_u=0.1./..25 usec $F_{11}=3000^{+250}_{-100}$ pps	0.4P-4-mile scale On 360 ohm load
			U=35./.50 v t =.25./..6 usec F_{11}=2000 ± 150 pps	8,16,24-mile scales On 360 ohm load
Γ 1	-40 volt unit feed	Direct Current	$40\ v^{+2.8\%}_{-0.3\%}$	Measure with M106 voltmeter
Γ 2	Unit feed -100/-150 v	Direct Current	$90v_{-4.5\%}$./.$115v^{+4.5\%}$	0.4P-4 mile — M106 Meter
			$136v_{-4.5\%}$./.$156v^{+4.5\%}$	8,16,24 mil — M106 Meter
Γ 3	Unit power supply +27 v	Direct Current	27 v ± 4.5%	Measure with M106 meter
Γ 4	Chassis			

Table VII-3

Voltages on Control Sockets of Unit П-3
Oscillograms given with set operating on equivalent antenna
Load of 75 ohms applied to plug III5 when obtaining oscillograms

Г 3	IFA output	Main pulse 	Г 3 U 0.5v t_u .55 usec III5 u 1.8v t_u .55 usec	0.4P-4 mile scales Int. Supp. & sig. differentiation switch in disconnect position Delay cable disconnected
III5	Unit П-3 output		I 3 U .5v t_u 1.2 usec III5 U 1.8v t_u 1.2 usec	8,16,24 mile scales Int. Supp. & Signal Diff. Switch in disconnect position. Delay cable disconnected
Г 3	IFA ouput		t_u .35 usecs	0.4P - 4 mile scales "Search" in position П-3. Int. Supp. & Sig. Diff. switch in disconnect pos'n. Delay cable disconnected
III5	Unit П-3 output		t_u .9 usec	8-24 mile scales. "Search" -- in position П-3. Int. Supp. & Sig. Diff. switch in disconnect position. Delay cable disconnected.
Г 3	IFA output		t=.22./..33 usecs	0.4P - 4 mile scales. Search - in position П-3. Int. Supp. & Sig Diff. switch in "On" position. Delay cable disconnected
			t=.22./.33 usecs	0.4P - 4 mile scales. "Search" - in position П-3. Int. Supp. & Sig. Diff. switch in "On" position. Delay cable connected
III5	Unit П-3 output		t=.22./..33 usecs	0.4F-4 mile scales. "Search" in position П-3. Int. Supp.& Sig Diff. switch "On" Delay cable disconnected

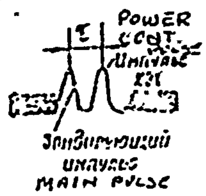
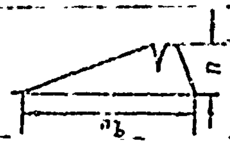
III5	Unit II-3 output		t - .22./. 0.33 usec	0.4P - 4 mile scalee. "Search" in II-3 pos'n. Int. Sup.&Sig. Diff" in "On" pos'n. Delay cable connected.
Γ4	ATGC pulse		U 2.5 v t_u= 5 ± 1 usecs	
Γ5	-12.5 volt unit power supply	D.C.	12.6 v ± 4.5%	Measure with M106 voltmeter
Γ6	Chassis			
Γ7	+27 volt unit power supply	D.C.	27v ± 4.5%	Measure with M106 voltmeter
Γ8	+50 volt power supply	D.C.	50 v ± 4.5%	Measure with M106 voltmeter

Table VII-4

Voltages at Control Sockets of Unit II-4

(Column Headings Same as Table VII-2				
Γ4	Chassis			
Γ5	-420 ./. -500v unit power supply	D.C.	420v - 4.5% ./. 500v + 4.5%	Measure with M106 voltmeter
Γ6	-40v unit power supply	D.C.	40v $^{+2.8\%}_{-0.3\%}$	"
Γ7	-12.6 v unit power supply	D.C.	12.6v ± 4.5%	"

Table VII-5

Voltages at Control Sockets of П-5

(Column Headings Same as Table VII-2)

Г 1 Г 2	+110 and -110v current developed by unit	D.C.	110v ± 4.5%	Antenna rotor on. Measure with M106 voltmeter
Г 3	+27 v current developed by unit	D.C.	27 v ± 4.5%	Measure with M106 voltmeter
Г 4	Chassis			
Г 5 Г 6	220v Stab. I power supply	A.C., 400 cyc.		Measure with Д567 voltmeter

Table VII-6

Voltages at Control Sockets of П-6

(Column Headings Same as Table VII-2)

Г 1	+27v unit power supply	D.C.	27v + 4.5%	Measure with M106 voltmeter
Г 2	-420 ./. -500v developed by unit	D.C.	420v-4.5% ./. 500v + 4.5%	Measure with Ц57 instrument
Г 3	-300v developed by unit	D.C.	300v ± 4.5%	Measure with M106 voltmeter
Г 4- Г 5	220v Stabilizer I unit power supply	A.C. 400 cycles	220 ± 1.5v	Measure with Д567 voltmeter
Г 6	Chassis			

Table VII-7

Voltages at Control Sockets of Unit П-7

	(Column Headings Same as Table VII-2)			
Г 1	+400 volts developed by unit	D.C.	400 v ± 4.5%	Measure with П-57 instrument
Г 2 - Г 3	220v stabilizer I unit power supply	A.C. 400 cycles	220 ± 1.5volts	Measure with Д567 voltmeter
Г 4	+50v developed by unit	D.C.	50v ± 4.5%	Measure with M106 voltmeter
Г 5	Chassis			

Table VII-8

Voltages on Control Sockets of Unit П-8

	(Column Headings Same as Table VII-2)			
Г 1	-12.6v developed by unit	D.C.	12.6v ± 4.5%	Measure with M106 voltmeter
Г 2	-40 volts developed by unit	D.C.	$40v^{+2.8\%}_{-0.3\%}$	Measure with M106 voltmeter
Г 3 - Г 4	220 volts Stabilizer I Unit power supply	A.C.- 400 cycles	220volts ± 1.5v	Measure with Д567 voltmeter
Г 5	Chassis			

Table VII-9

Voltages at Control Sockets of П-9

(Column Headings Same as Table VII-2)				
Г1 - Г2	220 volts, Stabilier II power supply unit	A.C. - 400 cycles	220 ± 1.5 volts	Measure with Д567 voltmeter
Г3	-100/-150v developed by unit	D.C.	90v-4.5% ./.115v + 4.5% 136v-4.5% ./. 156v + 4.5%	0.4P-4 miles 8,16,24 miles M-106 unit
Г4	-40 volts by transit into unit П-1	D.C.	40v $^{+2.8\%}_{-0.3\%}$	Measure with M106 voltmeter
Г5	+27 volts unit power supply	D.C.	27v ± 4.5%	Measure with M106 voltmeter
Г6	Chassis			

Table VII-10

Voltages at Control Sockets of П-10

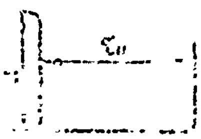
Г1	Chassis			
Г2	Control voltage of units П-10, П-1, И-1, И-2, И-10		U=1.1 ± 0.1v t_u=3 usecs ± 10%	Only in the CK position of the "Search" switch
Г7	Control voltage of units П-3, И-3, П-10	D.C.	Not less than 0.5v	Only in the CK, П-3, and И-3 positions of the "Search" switch. Instrument Ц-57
Г12	-12.6 volt unit power supply	D.C.	12.6 ± 4.5%	In all positions of the "Search" switch, except "Radar Operation"
Г13	+27 volt unit power supply	D.C.	27v ± 4.5%	Measure with M106 voltmeter

Table VII-11

Voltages at Control Sockets of ИЛ-1

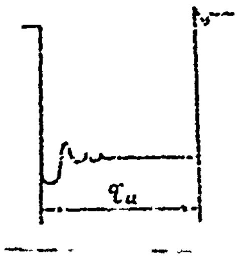
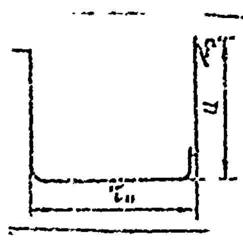
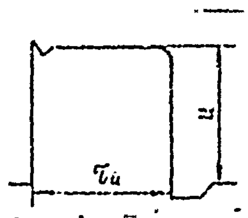
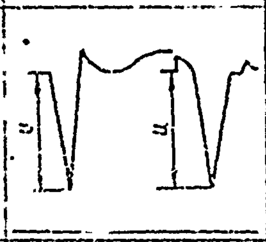
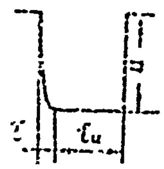
(Column Headings Same as Table VII-2)				
Г 3	Multivibrator pulse		t_u, usecs	Scales, miles
Г 6	II-2 starter pulse		U 9v t_u usecs	Scales, miles
Г 7	Illumination pulse		U=20± 3v, t_u usec	Scales, miles
Г 8	Control pulse		U 1.5 volts	On all scales
Г 4	-12.6 volt unit power supply	D.C.	12.6 ± 4.5%	Measure with M106 voltmeter
Г 5	-40 volt unit power supply	D.C.	40v $^{+2.8\%}_{-0.3\%}$	Measure with M106 voltmeter
Г 2	+27 volt unit power supply	D.C.	27v ± 4.5%	Measure with M106 voltmeter

Table VII-12

Voltages at Control Sockets of И-2

(Column Headings Same as Table VII-2)

Г 1 — Starter pulse

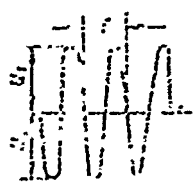


U 10 в

τф, мксек	τи, мксек
0,8	≥ 12
0,8	≥ 12
0,8	≥ 12
1,0	≥ 22
1,1	≥ 51
1,1	≥ 100
1,2	≥ 200
1,2	≥ 300

Scales, miles

Г 2 — Shock excited oscillator output

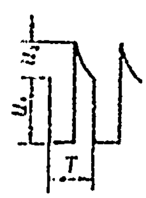


U_2 2в

T, мксек	U_1, в	Число импульсов в пачке
2,47	2,2	≥5
2,47	2,2	
2,47	2,2	
4,91	2,3	
12,35	3,6	
21,7	2,6	
49,4	2,9	
49,1	4	≥7

Scales, miles

Г 3 — Trigger pulses

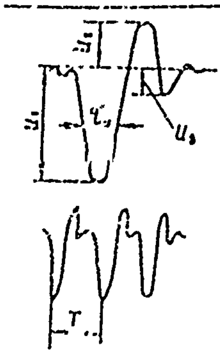


U_1 = 12 в
U_2 = 2 в

T, мксек (μsec)	Число импульсов в пачке (pulses/packet)
2,47	≥ 5
2,47	
2,47	
4,91	
12,35	
24,7	
49,4	
19,1	≥ 7

Scales, miles

Г 4 — Range marker pulses



U_1 ≈ 2в
U_2 30% от U_1
τи 0,03 - 0,05 мксек

T, мксек	Число импульсов в пачке
2,47	≥ 5
2,47	
2,47	
4,91	
12,35	
21,7	
49,4	
19,1	≥ 7

U ≤ 0,2 в

Taken with PK-75-3-11 cable with 150 ohm load. Cable disconnected from III?

Г 5 — -12.6v unit power.

D.C.

12.6 v ± 4.5%

Measure with M106 voltmeter

Table VII-13

Voltages at Control Sockets of Ⅱ-3

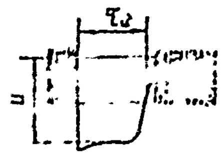
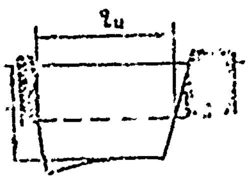
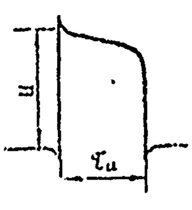
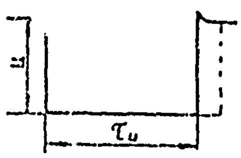
(Column Headings Same as Table VII-2)				
Г 3	Video mixer output		U = 6 ./. 25v t_u not over 0.5 usecs	Taken via divider applied to oscillograph. 0.4P-0.4 miles. Discriminator in extreme right. "Int. Sup.& Sig. Dif." switch in "Off" pos'n. Delay cable disconnected.
Г 3	Video mixer output		U = 6 ./. 25v not over 1.2 usec	Taken via divider applied to oscillograph. 8 - 24 mile scales. Discriminator in extreme right. "Int. Sup.&Sig. Dif." switch off. Delay cable disconnected
Г 4	+50 volts, unit power supply	D.C.	50v ± 4.5%	Measure with M106 voltmeter
Г 5	-50 volts, unit power supply	D.C.	$40v^{+2.8\%}_{-0.3\%}$	Measure with Ⅱ-6 voltmeter

Table VII-14

Voltages at Control Sockets of Ⅱ-6

Г 1	Starter pulse		U = 10 ./. 12v t_u = 4 ± 0.2 usec	
Г 3	Trigger pulse		U = 9.5 ± 0.5v t_u=2 ./. 300 usecs	

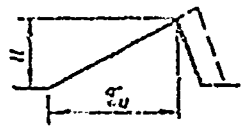
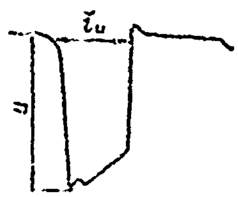
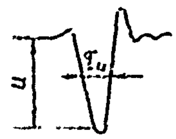
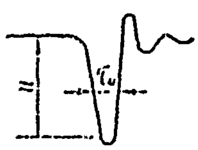
Г 5	Sawtoothed oscillator pulse		U = 0.15 ./. 17v t_u= 2 ./. 300 usecs	
Г 7	Comparator pulse		U ± 5.5 ± 0.5v t_u=2 ± 0.2 usecs	
Г 8	Range Sight Ring Pulse		U 2v $t_{u0.5}$=.03./. .06 usecs	Taken with PK-75-3-11 cable with 150 ohm load. Cable from Ш2 disconnected.
Ш3	Control pulse		U 1.5v $t_{u0.5}$=.03./..06 usecs	Taken with PK-75-3-11 cable with 75 ohm load

Table VII-15

Voltages at Control Sockets of Unit И

Г1 - Г2	220v Stabilizer I power supply	A.C., 400 cycles	220 ± 1.5v	Measure with Д567 voltmeter
Г1 - Г3	220v Stabilizer II power supply	A.C., 400 cycles	220 ± 1.5 volts	"
Г4	+400 volt instrument power supply	D.C.	400 volts ± 4.5%	Measure with Ц-57 instrument
Г5	-300 volt instrument power supply	D.C.	300 volts ± 4.5%	Measure with M106 voltmeter

Table VII-16

Voltages at Control Sockets of Unit C

(Column Headings Same as Table VII-2)

Г 1 Г 2	- Ship's electrical system + Ship's electrical system	D.C. or A.C. -- 400 cycles	24v ± 10% 110v " 220v " ~220v, 400 cycle	For C/=24v For C/=110v For C/=220v For C/~220v, 400 cycles
Г 3	+27 volt instrument power supply	D.C.	27v ± 4.5%	Measure with M106 voltmeter
Г 4 - Г 6	~220v Stabilizer I current developed by instrument	A.C. -- 400 cycles	220v ± 1.5v	Measure with Д567 voltmeter
Г 4 - Г 6	~220v Stabilizer I current developed by instrument	A.C. -- 400 cycles	220v ± 1.5v	Measure with Д567 voltmeter

VII-2. POSSIBLE DEFECTS AND METHODS OF ELIMINATING THEM

The built-in control system gives a great volume of information about the operating efficiency of individual units and assemblies. However, in exceptional cases malfunctions are encountered which cannot be pinpointed by this system. Typical of such defects and the recommendations for correcting them are those listed in Table VII-17. This table should be used as an aid only when search of the malfunction by the built-in control system has proven fruitless. /125

In addition to instrument Ц-57, which is available in the ship's kit of spare parts, tools, and instruments, base specialists engaged in troubleshooting work are advised to use the instruments and devices listed in Tables VII-1 and VII-17.

Table VII-17

Radar Equipment Malfunctions and Recommendations for Correcting Them

External symptoms of malfunction	Possible reason for malfunction	Methods used to correct defect
Image orientation on screen of instrument И (Kivadh-2) radar does not respond to switching.	No +27 volt current in electromagnet ЭМ1 in instrument A.	Check for plate voltage on Ш2/1 of instrument A and on electromagnet (C,BC)*
	+27v commutation current circuit through tumbler B2 of instrument Г affected.	Check circuits: Ш3/3 of instrument A, Ш 1/3 of instrument Г, B2 of instrument Г, and chassis (C,BC).
	Image orientation switching mechanism in instrument A defective.	Visually check operation of switching mechanism (C, BC).
Changes in length (shorter or longer) of sweep on screen of instrument И on 24-mile scale (evaluated by the number of markers)	Change in division factor of multivibrator in unit И-1 due to departure of synch pulses of unit И-1 beyond tolerance.	Replace unit П-1, and if no improvement, replace unit И-1, as well (C,BC).
No scan on screen of instrument И on all range scales.	Synch pulse shaping circuit in unit И-1 defective.	Replace unit П-1 (C, BC)
	Synch pulse relay circuit from П-1 to unit И-1 affected.	Check following circuits with instrument Ц-57: Ш2 of equipment П, Ш23 of device П, Ш14 of device И, Ш 1/17 of И-1 (C,BC).

(*Note: C indicates malfunction that can be corrected by navigator; BC corrected by base specialist on the ship)

Table VII-17 continued

	Required power supply voltages or illumination pulses from unit И-1 lacking at CRT	Check CRT power supply voltage on tube panel. Check for illumination pulses on socket 17 of unit И-1 and on tab 5 of CRT panel with oscillograph (BC)
	CRT inoperative	Replace CRT (C,BC)
Sweep on screen of instrument И moves only in horizontal or vertical directions on all range scales	No circuit between one of the stator windings of rotating transformer (5BT-И) in instrument A) and CRT circuit.	Check following circuits with instrument Ц-57: Ш 13/5, 16,6,17 of instrument И, П1/3,4,5,6 of instrument A in pairs (C, BC)
Sweep brightness increases sharply	Blocking voltage supply circuit to CRT modulator in instrument И affected	Check with instrument Ц-57 the -300 v power supply in circuit Ш12/45 of instrument И,R5, and R2 (brightness), Д10, tab 5 of CRT socket) (BC)
Course marker width - increased, brightness - decreased. "Course marker" regulator does not increase brightness.	Normal electrical contact in contacting device of instrument A course marker device affected	Wipe contacts with gauze soaked in alcohol or benzine (C, BC)
	No -12.6 volt current in course marker circuit	Check voltage resistor R16 in course marker circuit (C, BC)
Number of range blips on screen of instrument И has changed markedly	Shock exciter frequency of range scale being tested in unit И-2 out of tolerance.	Replace unit И-2 (C, BC)
	Range marker control channel contact impaired	Check circuits with instrument Ц-57 as follows: Ш3, Ш16 of instrument И, Ш25 of П, resistor R4 of unit П-11, chassis (C, BC)
Range marker rings or adjustable range sighting rings on screen of instrument И greatly curved.	Bridges (Д2 ./. Д9) in CRT circuit malfunctioning.	With instrument Ц-57 test forward and back resistance of diodes Д2 - Д9 in CRT circuit (BC).
Many unstable range sighting rings showed up on instrument И screen	Excitation of comparator in unit И-6	Replace unit И-6 (C, BC) /127

	Defective contact in range sighting ring control circuit.	With instrument П-57 check following circuits: Ш11, Ш17 of instrument И; Ш27 of instrument П; R5 of unit П-11, Chassis (C. BC).
When tuning klystron, indicator arrow does not deflect to section 4 of control panel in instrument П	Coupling of tuning mechanism to klystron shaft weakened	Tighten coupling mechanism (C, BC)
	Klystron defective	Replace klystron (C, BC)
When tuning klystron, ifa and afc crystal currents changing or lacking	Variable resistor R2 "Maximum current setting on 5" on klystron tuning panel or power supply voltage not getting to it	Check variable resistor, check for presence of voltage on same (C, BC)
When set switched on, no circular rotation of sweep beam	Antenna does not turn	Check for 110 volts with П-57 instrument on electric motor M1 of instrument A (C, BC).
	No coupling between reducer and shaft of rotating transformer (5BT-И in instrument A)	Check coupling visually (C, BC)
	Electric motor M1 in instrument A defective	Replace electric motor (C, BC)
No image discrimination control on screen of instrument И	No discriminator control voltage in unit И-3.	With instrument П-57, check for -40v current on R22 of instrument И and the probability of it having changed in contact Ш4 (Ш3 of instrument П) (B, BC)
	Defective variable resistor R22 "Discrimination" in instrument И	Check resistor R22, replace (C. BC)
	Antilogarithmic video amplifier in unit И-3 defective.	Replace unit И-3 (C, BC)
One or several parasitic circles appeared on the CRT screen (with range sight ring and range marker disconnected)	Parasitic negative overshoots appearing on magnetron cathode	Replace unit-П-1 (C, BC) /128

Intermediate frequency applifier crystals repeatedly breaking down (current beyond limits of lower edge of sector of indicator)	Discharger in unit II-2 defective	Replace discharger. Replace ifa crystal (C, BC)
Target detection range or indicator screen greatly reduced. No signal marker on screen when power characteristic control button depressed, but control system in instrument II does not give information on condition of units and assemblies.	Increased losses in antenna-waveguide system.	Drain water from catchment section of antenna-waveguide system (C, BC)
	Voltage standing wave ratio of waveguide system deteriorated	Check condition of interior surface of waveguide and replace damaged portions, after insuring electrical impermeability on flange couplings. (Repair at base shop)
	Klystron not tuned	Tune klystron in accordance with instructions (C, BC)
No reference marker on screen of instrument II in checking power curve; control system in instrument II does not record defect in the unit or one of the assemblies. Target detection range on screen is normal	Unit II-1 does not produce ATGC shaping pulse which should go to connector III4 of unit II-3 or the ATGC starter pulse to connector III3 of unit II-3	With an oscillograph check for pulses in connectors III 11 and III12 of instrument II (BC)
	ATGC circuit or differentiator in unit II-3 not operating	Replace unit II-3 (C, BC)
	Baffle in unit II-2 not operating (characteristic noise not heard in instrument when power characteristic control button depressed or when "Search" switch is set in position II-3)	Check +27 volt commutation to baffle in unit II-2 (C, BC). Check mechanical condition of baffle (after removing ifa mixing compartment) and adjust (Base repair job)
	Electrical circuit between units A-3 and II 2 (along delay cable) defective	Check delay cable circuit visually, by touch, and with instrument II-57 (C, BC) /129
	Above tolerance increase in length of modulating pulses along base, or negative bursts (static) of pulse moving directly after modulating pulse	

Uneven changes or pulling of sweep trace and range markers noted on screen of instrument И on all range scales.	High voltage of CRT breaks through to chassis. High voltage CRT lead not in center of screen slot or unit И-4 defective.	Check position of CRT high voltage or replace unit И-4 (C, BC).
Illumination of CRT excessively bright and cannot be controlled	Negative cutoff voltage not fed to CRT control electrode.	Determine point of break in circuit with instrument Ц-57 (BC)
No range sight ring marker. Interferences observed along entire length of sweep trace on CRT screen at extreme left position of "Discrimination" regulator.	No reference voltage from linear potentiometer to unit И-6	Determine point of break in circuit with instrument Ц-57 (BC)
No image on CRT screen. Control system shows that voltage in the +14 kw sector, unit П-1 is O.K; and defective in units И-1, И-2, and И-6.	No indicator synch pulse from instrement П.	Check synch pulse with instrument Ц-57 starting with connector Ш2 of instrument П (C, BC).
Concentric rings observed on CRT screen evenly distributed in distance whose brightness is regulated by "Discrimination" control.	Discharger in unit П-2 defective	Replace malfunctioning discharger (C, CB).
At certain ranges the range sight ring marker moves unevenly, flickers.	Potentiometer ППМЛ-М in instrument И defective.	Replace potentiometer (C, BC)
After replacing unit П-5 or П-9 safety device on control panel in instrument П continues to break down.	Short circuit in rectifier output circuit of one of the units.	Check output circuits with instrument Ц-57. Locate short circuit ((C, BC) /130
No magnetron current. When cover of magnetron section is open, corona discharge observed on secondary winding of transformer filament.	Break in magnetron filament wire	Replace magnetron (C, BC)

CHAPTER VIII

TUNING INDIVIDUAL SYSTEMS

VIII-1 SETTING AND PRE-AGING MAGNETRON CURRENT

The operating condition of a magnetron and its power output are controlled by regulating the magnetron current. The required magnetron current is set during the initial tuning of the radar set, after replacing the magnetron, and, when the set is in operation, whenever its power and current decrease in the process of magnetron wear.

After the equipment has been on for 5-10 minutes the magnetron current is set as follows.

1. Set tumbler switch on the control panel adjacent to the arrow indicator in position 5 (arrow indicator is connected to "Assembly Control" switch).
2. "Assembly Control" (currents) switch on the control panel in instrument II is set in the "Magnetron" position.
3. Switch in the 4-mile scale on the control panel of instrument II.
4. After cutting in the high voltage (this is signalized by the "Transmitter" light on the control panel), set the magnetron current by arrow indicator located on the control panel. Set current in left half blue sector of arrow indicator by rotating potentiometer "Magnetron Current" shaft of unit II-1.
5. Switch in 8-mile scale on the control panel.
6. Check value of magnetron current in this scale. The arrow of indicator instrument should also be in left half of the blue sector. If this is not observed, regulate the current with this same potentiometer and /131 then check the value on the 4-mile scale.
7. After adjusting the thermal condition of the radar set (30 or 40 minutes later), check to determine whether the magnetron current is within blue sector limits of the arrow indicator. If, for some reason, a radar set had not been switch on for a period of six months or more, or a magnetron had been installed which had been inoperative for a long time, it should be aged by means of "Control, Unit II-4" switch located on the control panel in instrument II. The high voltage to the magnetron is disconnected when this switch is set in the "Control-1" position. When it is set in the "Operation II-4" position, the high voltage is fed to the magnetron.

The aging process is accomplished by repeatedly switching the high voltage off and on until the magnetron ceases to spark. Evidence of the disappearance of sparking in the magnetron is the cessation of indicator arrow flicker on the control panel in the "Magnetron" position of the "Assembly Control" switch. If sparking in the magnetron does not cease after 30 minutes of aging it should be replaced with another unit.

VIII-2. TUNING THE KLYSTRON

The klystron is tuned to a frequency higher than the magnetron frequency by the amount of the intermediate frequency, which is 60 Mc in the Kivach. The klystron is tune for maximum power.

The klystron should be tuned during the initial adjustment of the set, after replacing the magnetron or klystron, and during preventive maintenance work by base specialists.

It should be tuned after the set has been on for a half hour with the high voltage switched in. The tuning is done in the following order.

1. Switch in one of the scales of the 0.4 - 4-mile range on the control panel.
2. Set the "Frequency Tuning" switch located on the klystron tuning panel of instrument II in the "Automatic Frequency Control Tuning" position.
3. Set the tumbler switch on the control panel in position 5 and turn the "Assembly Control" switch to the position "Automatic Frequency Control Crystal" (the Unit II-4 Control" switch should be in the "II-4 Operation" position.
4. Move the mechanical tuning regulator of the klystron "Frequency for 4" on the klystron tuning panel to the extreme right position. /132
5. Uniformly rotate the mechanical tuning regulator of the klystron in a counterclockwise direction until the afc crystal current appears; this is determined by the arrow indicator on the control panel. Then, using the "Setting Maximum Crystal Current for 5" regulator on the control panel, keep the current of the afc current at a maximum value.
6. Continue rotating the "Frequency" regulator until the indicator arrow in section 4 of the control panel deflects to the right of zero and then to the left of it. Set the indicator arrow in the zero position, which corresponds to a change in polarity.
7. Set the "Frequency Tuning" switch in the position "Control of Klystron Tuning on 4" (arrow to the left) and check to determine whether the klystron is tuned to main and not image frequency. If the arrow was deflected to the left in the process, the tuning was improperly done. If the arrow deflects to the right the tuning should be repeated more carefully.
8. The "Frequency Tuning" switch is set on "Automatic Frequency Control Operation". The current of the crystals should remain unchanged.

VIII - 3. CENTERING THE SWEEP

Centering the sweep consists in precisely coinciding the center of the radially-circular sweep on the screen with the center of the meachical bearing cursor. The error in measuring bearing is governed in a very large measure by the accuracy of centering. The latter is performed in the original tuning of the set, following replacement of the CRT, and during preventive maintenance work by base specialists.

The sweep is centered with the front cover of the indicator open in the following manner.

1. Set interlock switch in instrument И and switch on the set.
2. Cut in 0.4P-mile range scale.
3. Loosen two lock nuts of CRT centering system.
4. Rotate the centering system around the neck of the tube and the centering magnet about its own axis, striving accurately to coincide the origin of the sweep with the center of the bearing cursor. For greater accuracy in centering the screen should be observed with one eye closed.
5. Carefully tighten lock nuts and again check centering accuracy. The center of the radially-circular sweep should not deviate from the bearing sight by more than 0.3 mm.

VII-4. REGULATING SWEEP FOCUS AND BRIGHTNESS /133

Optimum adjustment of brightness and sweep focus offers the best image presentation on the PPI. The focus and sweep brightness are regulated in the original tuning of the radar equipment, on replacing the CRT, and during preventive maintenance work by base specialists.

Before focussing with the brightness potentiometer located on the tuning panel inside instrument И set the threshold sweep brightness. The adjustment is made with the front cover of instrument И open, using the interlock switch.

By threshold brightness is meant a sweep brightness magnitude at which the sweep is hardly visible on the screen of the CRT when the discriminator located on the indicator control panel is set in the extreme left position. Uniformity of sweep brightness, when switching in scales, is insured during the initial adjustment of the radar equipment at the manufacturing plant by selecting the values of resistors R25, R23, R21, R19, R18, and R17 located in unit И-1. The focusing of range markers is then accomplished as follows.

Switch in the range marker and set the 24-mile scale; using the "Focus" adjustment contained inside instrument И try to get the best focus on the range markers. Focused range markers should be sharp and show no "Tails" (elongated shapes). If optimal focussing cannot be achieved with the "Focus" potentiometer, a preliminary focussing is performed, using the magnetic focussing system in the following sequency.

1. Loosen screw which draws the magnetic focussing collar tight.
2. Moving the magnetic focussing system longitudinally and rotating it around the tube axis, determine the position at which focussing of the the range markers on the CRT secreen is best. When using a CRT with shortened neck the magnetic focussing system can be turned 180°.
3. Tighten magnetic focussing collar screw without disturbing the focus.
4. Loosen lock nut and, rotating the magnet around its own axis, try to improve the quality of the focus.
5. Again center the sweep (cf Chap VIII-3) and focus with potentiometer according to the methods described above, striving for minimal width of range markers along the entire circle. With a good focus, the width of range markers on the 13 ЛМ5B CRT should not exceed 0.35 mm. /134

VIII-5. REGULATING SWEEP LENGTH AND LINEARITY

The sweep line is regulated when the equipment is tuned initially and following replacement of the CRT by base specialists.

The length of the sweep on the CRT indicator should be 71 ± 5 mm from the origin of sweep center to the last range marker. The length of the sweep is set on the 0.4, 0.8, 4, 16, and 24-mile range scales.

The length of the sweep is measured with a piece of millimeter graph paper applied against the CRT screen with the antenna switched on. The sweep length is regulated by changing the values of the type РЭВР resistors: R53, R51, R49, R47, and R46 variable resistors in equipment И on the 0.4, 0.8, 1.6, 4, 8, 16, and 24-mile scales respectively.

Sweep linearity is controlled only at the manufacturing plant at the time of the initial tuning and regulating of the set equipment or when it is repaired by the base specialists. The departure from perfect sweep linearity on all range scales, except the 24-mile scale, should not exceed 3%. A 4% tolerance is permitted for the latter.

Non-linearity of sweep H is determined in percent from the following formula:

$$H = \frac{Д_{макс (мин)} - Д_{ср}}{Д} \cdot 100\%.$$

where $Д$ is the distance between zero and the last range marker in mm; $Д_{макс (мин)}$ is the maximum or minimum distance between markers, mm; $Д_{ср}$ is the mean distance between markers, mm (where K is the number of intervals between markers).

Linearity on the 0.8 scale is measured on the section between the first and fourth range markers.

The magnitude of departure from sweep linearity is controlled in unit И-1 as follows:

On the 0.4-mile scale -- by the ЛЗ-1 delay line (by re-soldering wire No. 139 to the appropriate delay line lead);

On the 0.8 mile and 1.6 mile scales -- by the ЛЗ-1 delay line (re-soldering wire No. 134 to appropriate lead of delay line);

On the 4-mile scale -- by the ЛЗ-1 delay line (re-soldering wire No. 140 to the appropriate lead of delay line);

On the 8-mile scale -- by matching resistor R40 and re-soldering leads of choke Др5; /135

On the 16-mile scale -- by matching resistor R38 and re-soldering leads of chokes Др3 and Др4;

On the 24-mile scale -- by matching resistor R37 and re-soldering leads of chokes Др1 and Др2.

On completing the adjustments, the diameter of the circle described by the main pulse should not exceed 4 mm on the 0.4 - 4-mile scale and 3 mm on the other scales.

VIII-6. SETTING THE VIDEOSIGNAL LIMITING LEVEL

Before adjusting the limiting level, check the brightness of the sweep line. It should be at threshold (weak) level when the discriminator regulator is set in the extreme left position. Then cut in the 4-mile scale on the control panel of equipment И. Set the discriminator regulator in the extreme right position and the interference suppression and signal differentiation tumbler switch in the disconnect position. Strive for a precise marker with maximum brightness of main pulse on the CRT screen without creating an excessively intense halo, using limiting regulator located in unit И-3 inside of instrument И.

VII- . REGULATING BRIGHTNESS OF COURSE MARKER, RANGE MARKERS, AND RANGE SIGHTING RING

Before the brightness of the course marker, range markers, and range sighting ring is set, a check is made of the threshold brightness of the CRT sweep trace; the discrimination control is used to set the noise level corresponding to the operating illumination.

The course marker brightness is set on the 0.4 mile range scale by the course marker regulator in instrument II. A reasonable intensity of brightness is used (the course marker should be visible as afterglow for a complete sweep revolution, but should not interfere with observation of the screen). The course marker should not be over 0.5° in width. The width of the course marker is evaluated by comparing it with the graduations on the movable azimuth scale of the indicator.

The brightness of the range markers and range sighting ring is set on the 0.8 mile range scale by the "Range Marker Pulse Amplitude" regulator in unit И-2 and the "Amplitude" adjustment in unit И-6. A medium intensity brightness is used (the range rings should be observed on the screen as afterglow for a full revolution of the sweep trace. The brightness of the range rings on all scales is then checked and regulated if necessary.

VIII-8. REGULATING AUTOMATIC TIME GAIN CONTROL STROBE DELAY AND DEPTH /136

Automatic time gain control strobe delay is regulated during the initial tuning of the radar set at the manufacturing plant, and after installing the radar equipment on the ship in those cases where the length of the waveguide feeder line is longer than the standard length (5 meters).

The depth of the atgc strobe is regulated at the time of the initial tuning of the equipment at the factory and after installation on the ship, in those instances where the atgc strobe delay was re-adjusted, or when the power performance control signal marker is camouflaged on the PPI by the interference ring. In addition, the depth of the atgc strobe is regulated on the ship when the power performance signal is absent, provided other systems are functioning normally, according to the built-in indicators.

Adjustments are made in accordance with the following sequence.

1. Disconnect delay cable of the power performance control devices from the plug of instrument П (Ш34).

2. Extract unit П-3 from the instrument (the operation is accomplished with radar set disconnected).

3. Re-solder connector in unit П-3 on the atgc plate which connects the cathode of diode Д5 to the delay line Л3-1 from the fourth lead of the line to the fifth lead.

4. Place unit П-3 into instrument П and switch set on.

5. If noise is observed on the screen in the area where a power performance control signal marker should be, set the strobe depth with the atgc regulator of unit П-3 on the threshold at which a hardly noticeable increase in noise brightness is noted at the point of the strobe (the position of the strobe coincides approximately with the position of the power performance signal marker).

For convenience in working with the set, instead of pressing the "Power Performance Control" button, continuous power performance operation can be provided by cutting in the "Interference Suppression and Signal Differentiation" switch (when working with the 0.4P-mile scale), and setting the "Search" switch on the control panel in the П-3 position.

6. Connect the delay cable of the power performance characteristic to the plug Ш34 of instrument П and make certain the power performance signal is readily visible on the CRT screen. If it is poorly visible, the adjustment should be repeated, re-soldering the connector to the lead of the sixth delay line Л3-1.

At the time of the initial tuning after the equipment has been installed on the ship, the delay and strobe depth of the П-3 unit of the kit of spares and accessories are adjusted in a manner similar to the tuning of the basic П-3 unit.

CHAPTER IX 137

PREVENTIVE MEASURES

IX-1. ROUTINE WORK

Service work should insure constant readiness of the equipment for operation and the timely disclosure and correction of factors inducing premature wear and damage to parts and assemblies. Toward this end, it is necessary to observe the instructions for the use of the equipment, make timely inspections, and perform preventive maintenance work.

Daily inspection. Ice or dirt on the surface of antenna horns (units A-1, A-3) should be carefully hosed off with warm water (not over two atmospheres of pressure) without damage to covering. Dust should be removed from the external parts of the instruments. The radar set is switched on and its functioning is tested as previously indicated (cf Chap VI-1).

Weekly inspection. Carry out the work included under daily inspection, followed by an inspection of the conditions of the waveguide channel, the state of the flange connections, and carry out the necessary repairs. If the silica gel is moist (gray or rose-colored) replace the cartridge with a spare. Wipe the light filter of the indicator and moveable part of the cursor with a tampon lightly soaked in gasoline, after which wipe dry with cotton cloth or chamois. Switch the set on and check operating efficiency as set forth in Chapters VI-1 and VII-1.

Monthly inspection, inspections before ship sailings, and inspections on completion of a voyage. Perform work listed under weekly inspection. Next inspect mechanisms without dismantling assemblies and lubricate where required.

Check integrity of covers on external surfaces of instruments and antenna-waveguide equipment. If the paint is peeling the affected areas should be touched up, bearing in mind not to cover the radiating portions of the antenna (unit A-1 and A-3) with any paint other than ЭM-XB-124, series III T-4 type. The paint should be applied in a thin even layer.

Check for the absence of external mechanical damage.

Check on the working condition of all switches; see that they are set in the required positions; and see that there is no sticking or excessive clearances when the tuning elements are turned.

Carefully clean access places in instruments (without taking them apart) of dust and dirt with a brush or dry clean cloth. Switch on set and check its operation as set forth in Chapters V-2, VI-1, and VII-1.

Periodic technical servicing. This type of servicing is performed one a year and includes the following. /138

All work included in the monthly inspection.

Remove units and carefully clean all assemblies inside units of dust and dirt with vacuum cleaner. Correct any damages noted. Lubricate mechanism in accordance with the description in Chapter IX-3.

Check operating condition of plug type connectors, cleanliness of contacting surfaces of plugs, and correct any defects.

Resupply kits of spares, accessories and tools as required.

Check basic characteristics of set as stipulated in pertinent section of equipment logbook.

IX-2. INSPECTION OF ELEMENTS AND ASSEMBLY

The kind of preventive measures used depends on the kind of units and parts involved.

In cleaning radio parts with printed circuits of dust and dirt it is important to avoid damage to leads and not short circuit them against the chassis or the leads of other elements.

When inspecting high voltage condensers it is essential to prevent their being electrically discharged and thereby injuring the operator; they should be discharged before making the inspection. All such condensers should have a normal temperature or be only slightly warm.

When inspecting resistors bear in mind that decolorization, swelling, and melting of resistor surface coverings are indicative of damage due to overloading. Resistors of this kind should be replaced and the cause of the defect established.

When radio elements are replaced or resoldered it is essential that they be not less than 1-2mm apart in order to avoid short-circuiting due to vibration.

When inspecting safety devices and terminal plates make certain that there is no soot or corrosive fouling. When safety fuses burn out it is important to determine the cause of overheating; after determining the cause it should be corrected and a new fuse installed.

When checking switches and relays make certain they are properly secured, that coupling connections and wires are properly insulated, and that there is no dust or dirt on the plates.

When inspecting selsyns carefully note whether the contacts and assembly connections are secure. Selsyns should be properly secured to insure complete immobility of the stator, otherwise errors in transmission of data will occur. Terminals and points of electrical contact should /139
be carefully cleaned of dirt and corrosion with a brush or tampon soaked in alcohol.

When inspecting transformers and choke coils attention should be directed to the cleanliness and reliability of connections and soldered joints. Dust, dirt, and moisture between high voltage transformer terminals and chokes may lead to breakdowns. Overheating of transformers and chokes with their insulation usually results in damage to the insulation (cracks and influxes appear on the external surface of the transformer), hence the necessity of taking proper measures to eliminate the causes of overheating.

When making internal inspections of instruments see that there are no cracks, cuts, and bare places in the high frequency cables. Eliminate sharp bends or unwarranted tensions on the cables.

Check on the cleanliness and integrity of the grounded shielding braids of cables, as well as the security of the cable clamping brackets. When inspecting high frequency cables observe extreme care not to bend or twist the cables to excess.

When inspecting plug connectors and high frequency connectors, check on their fastening to the cables and to instrument grounds, the integrity of the contacts, and look for short circuits. All contacts should be clean and should have good electrical contacts.

When inspecting the fuse cartridges see that there is no mechanical damage, cracks, or other defects which might lead to short circuits.

IX-3. LUBRICATION OF MECHANISMS AND PARTS

For normal operation of the set it is essential periodically to lubricate the gears of mechanisms, bearings, contacting wheels, rollers, and parts which have no anticorrosive covering. Before lubrication, the parts should be wiped with gauze, lightly soaked in gasoline (aviation gasoline), and after the element is dry it should be lubricated properly. The type of lubricant and the periodicity of application are indicated in Table IX-1.

<u>Lubricating antenna rotation drive (Kivach-1 antenna)</u>. The antenna rotor drive 2 (fig. IX-1) can be lubricated through open covers and bearing access points without dismantling assemblies and removal of subunits and parts. To change bearings 1 and 4 of the main shaft 12, and to repair subunits 10 and 18 and other parts the following is necessary.

Disconnect set on control panel of instrument II (see fig. IV-5) /143
and electric motor СЛ-369, using switch 32 contained on the antenna drive mechanism 2.

Loosen four nuts securing antenna 19 to bracket 8 and four screws securing antenna waveguide to rotating shf adapter 10 and remove antenna 19.

Loosen four secrews, remove cover plate 23, drop rubber ring 25 on tube of waveguide channel 24.

Loosen eight drop-proof screws, and open side plates 20 and 30.

Loosen four bolts 17 and remove reducer 18 from pins.

Disconnect wires from electric motor СЛ-369, 31. Loosen four plate screws 29, and remove electric motor.

Unsolder wires from rotating transformer 36, loosen four screws 34, remove cover plate 33 and rotating transformer.

LUBRICATION CHART

	Наименование и обозначение прибора, номер позиций на рисунке 3	1. Смазочные материалы и ГОСТ (ТУ)			Число смазываемых мест 7	Способ нанесения смазочных материалов 8	Периодичность смазки 9	
		2 при эксплуатации						
		зимой при температуре до −50°C 4	летом при температуре до +50°C 5	при длительном хранении 6				
10	Привод антенны (блок А-2) РЛС «Кивач-1», рис. IX—1, *1, 4, 7, 14, 16* и *21*	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	6	Набивка шпателем, смазка кистью 19	1 раз в 2 года	17
11	Привод антенны (блок А-2) РЛС «Кивач-2», рис. IV—2, *19, 21, 29, 30, 31* и *51*	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	6	Набивка шпателем, смазка кистью 19	1 раз в 2 года	17
12	Редуктор (субблок А-2-1), рис IV—3	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	—	Набивка шпателем 20	1 раз в год	18
13	Вращающийся СВЧ-переход (субблок А-2-2), рис. IX—2, *3*	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	ОКБ-122-7Т МРТУ 38-1-230-66	1	Набивка шпателем 20	1 раз в 2 года	17
14	Устройство дистанционной передачи направлений (субблок А-2/3) рис IV—2	ОКБ-122-7Т МРТУ-38-1-230-66	ОКБ-122-7Т МРТУ-38-1-230-66	ОКБ-122-7Т МРТУ-38-1-230-66	44	Набивка шпателем, смазка кистью 19	1 раз в 2 года	17
15	Механизм шкал (блок П-5), рис VI—6, *1, 12, 20, 22, 23, 24* и *34*	ОКБ-122-7Т МРТУ-38-1-230-66	ОКБ-122-7Т МРТУ-38-1-230-66	ОКБ-122-7Т МРТУ-38-1-230-66	20	Набивка шпателем, смазка кистью 19	1 раз в 2 года	17
16	Устройство сопряжения с тахометром (прибор Г), рис. IV—7, *4, 7, 9, 11, 13* и *15*	ОКБ-122-7Т МРТУ-38-1-230-66	ОКБ-122-7Т МРТУ-38-1-230-66	ОКБ-122-7Т МРТУ-38-1-230-66	9	Смазка кистью 21	1 раз в 2 года	17

See following page for explanation of key

Key to Table IX-1. (preceding page)

1. Lubricants and All-Union State Standard (GOST)(Technical specifications); 2. period of operation; 3. designation and marking of device; position number on diagram; 4. wintertime at temperatures down to -40°C; 5. summertime at temperature to +50°C; 6. for prolonged storage; 7. number of lubrication points; 8. how lubricant applied; 9. periodicity; 10. antenna drive (unit A-2) Kivach-1 radar, fig. IX-1, 1,4,7,14,16, and 21; 11. Antenna drive unit (unit A-2), Kivach-2 radar, fig. IV-2, 19,21,29, 30 and 54; 12. reducer (subunit A-2/1), fig. IV-3; 13. rotating shf adapter (subunit A-2/2, fig. IX-2, 3; 14. remote bearing transmission device (subunit A-2/3), fig. IV-2; 15. scale mechanism (unit VI-5), fig. VI-6, 1, 12, 20, 22, 23, 24, and 34; 16. device for coupling with gyrocompass (instrument Г), fig. IV-7, 4, 7, 11, 13, and 15; 17. once every two years; 18. once a year; 19. packed with putty knife, lubricate with brush; 20. pack with putty knife; 21. lubricate with brush.

Loosen seal nut located alongside switch 32, disconnect wires from terminal plate 35, and remove cable through the seal.

Loosen four screws 27, remove flanges 22 and 28 and rubber ring 26.

Loosen four screws 11, remove rotating shf adapter 10.

Loosen five bolts 9, remove bracket 8.

Loosen screw 15 of gear 16, and remove spline 13.

Loosen binding screw of worm sector 21.

Remove shaft 12, place rubber ring 7 on shaft.

Loosen six screws 5 and remove ring 6.

Press out two bearings 1 and 4, wash in gasoline, and lubricate with grease as indicated in Table IX-1.

Wash gears 14 and 16 in gasoline, cable seal packing, flange 28, wheel 6, and housing at points adjacent to them, following which lubricate in accordance with Table IX-1.

Assemble in the Following order.

Press in bearings 1 and 4.

Place ring 6 in non drying compound and secure with screws 5.

Insert shaft 12 successively placing on it gears 14 and 16 and worm section 21.

Insert spline 13 and secure with screw 15.

Place rubber ring in groove after first lubricating it as indicated in Table IX-1.

Secure worm section 21 with screws.

Set bracket 8 and secure with bolts 9.

Place rotating shf adapter 10 in non-drying compound and secure with screws 11.

Place flanges 22 and 28 in non-**hardening** compound, insert rubber ring 26, and secure with screws 27.

Draw cable through stuffing box, spread out on terminal plate 35. Fill stuffing box with packing material 421A, tighten seal nut. /144

Place housing with rotating transformer 36 on pins, secure with screws 34, resolder wires to rotating transformer.

Place reducer 18 on pins and draw down bolts 17.

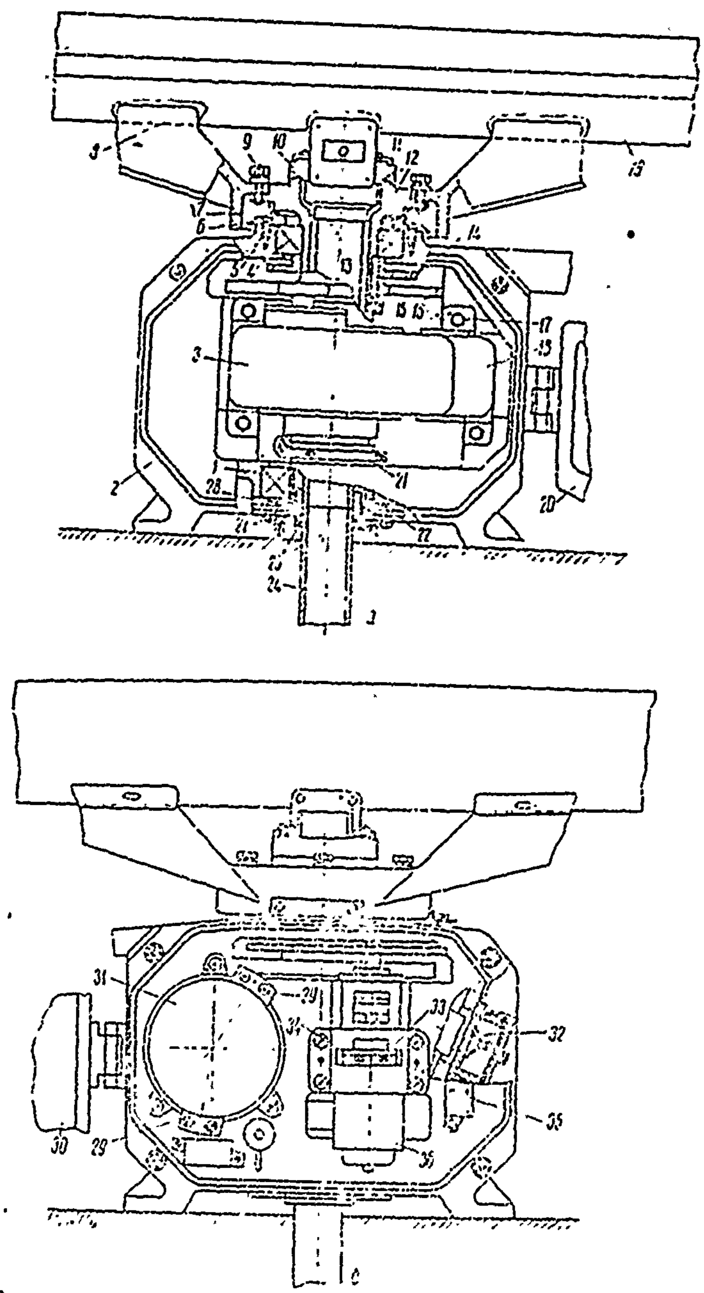


Fig. IX-1. General view of device A in Kivach-1 radar set with covers off: a. view from reducer side; b. View from side of electric motor and rotating transformer.

Place electric motor 31 in housing, engage, secure electric motor with two straps 29, and connect wires to it.

Cover side plates 20 and 30 with drop-proof screws.

Place antenna 19 on bracket 8, secure with nuts, and connect antenna waveguide to rotating adapter with screws.

Cut in switch 32.

Switch set in on control panel of instrument И (cf IV-5).

After assembling, the backlashes and moments should conform to the kinematic diagram of unit A-2 of the Kivach-2 radar set (cf fig. IV-4).

<u>Lubricating the Kivach-2 radar antenna rotor unit.</u> The antenna rotor drive 3 (cf fig. IV-2) can be lubricated through open ports and bearing access areas without dismantling the assemblies and removing the subunits and parts. To replace bearings 29 and 54, the main shaft 36, and to repair subunits 15, 23, and 35 in the units and assemblies, it is necessary to proceed as follows.

Disconnect the set on the control panel 16 of instrument И (cf fig. IV-5) and electric motor СЛ-369 with switch 6 located on the side wall of the antenna rotor drive mechanism 3 (cf fig. IV-2).

Loosen four screws securing antenna 12 to the bracket 40, and the four screws securing the antenna waveguide to the rotating shf adapter 35, and remove antenna.

Loosen four screws, remove straps 57, and lower rubber ring 58 on the waveguide channel tube 56.

Loosen the eight drop-proof screws and open side covers 17 and 25.

Loosen the four bolts 13, and lift reducer 15 off the pins.

Disconnect the wires from electric motors СЛ-369, 26. Loosen the four screws of straps 27 and remove electric motor.

Unsolder the wires from rotating transformer 41, disconnect the wires from selsyn 51, loosen the four screws 53, and remove subunit A-2/3 23 from the pins.

Unsolder the wires, loosen three screws and remove electromagnet 18.

Loosen the nuts of seals 5, disconnect wires from terminal plates 4, 20, and 50 and push cables through seal 5. /145

Loosen four screws 59, remove flanges 60, 61, and rubber ring 55.

Loosen four screws 34, remove rotating shf adapter 35.

Loosen five bolts 32 and remove bracket 40.

Loosen three screws 39 of gear 30, screw 28, and remove spline 33.

Loosen four screws 16 securing wheel 19.

Loosen screws binding sector to worm 21 and course marker contact wheel screw 1.

Remove shaft 36 and place rubber ring 31 on shaft.

Loosen six screws 37 and remove wheel 38.

Pressout two bearings 29 and 54, wash with gasoline, lubricate as indicated in Table IX-1.

Wash with gasoline gears 30 and 19, seal stuffing material, flange 61, wheel 38, and housing at points of attachment, following which lubricate as indicated in Table IX-1.

Assemble in accordance with the following sequence.

Press in bearings 29 and 54.

Place ring 38 in non-hardening compound, secure with screws 37.

Insert shaft 36 successively placing on it gear 30, spline 33, gear 19, contact wheel of course marker 1, and sector with worm 21.

Secure spline 33 with screws 28, wheel 30 with screw 39, and wheel 19 with screw 16.
Screw down section with worm 21.
Rope rubber ring 31 into groove after first lubricating it with grease as indicated in Table IX-1.
Set up bracket 40 and secure with bolts 32.
Place rotating shf adapter 35 on non-hardening compound and secure with screws 34.
Set up flanges 60 and 61 in cement compound, apply rubber ring 55, and tighten with screws 59.
Pull cables through stuffing boxes 5 and spread out on terminal plates 4, 20, and 50; fill stuffing boxes with packing material 421A, and tighten stuffing box nuts.
Install electromagnet 18, secure with screws, and resolder wires.
Place subunit A-2/3 23 on pins and tighten with screws 53.
Solder wires to rotating transformer 41 and connect wires to selsyn 51.
Set reducer 15 on pins, secure with bolts 13.
Place electric motor C ЛI-369 into housing, engage the guide, and secure electric motor CЛI-369 with two straps and connect wires to it.
After assembly, the backlash and moments should correspond to the kinematic diagram of unit A-2 of the Kivach-2 radar set (cf fig. IV-4.). /146
Cover side plates 17 and 25 with drop-proof screws.
Connect waveguide channel 56 to rotating shf adapter 35 with straps 57, rubber ring 58 and screws.
Set antenna 12 on bracket 40, secure with nuts, connect antenna waveguide to rotating shf junction 35 with screws.
Cut-in swtich 6.
Switch on set on control panel 16 of instrument VI (cf fig. VI-5).

Lubrication of device for remote transmission of azimuth, Kivach-2 radar antenna rotor drive. Lubrication can be performed, without taking the assemblies and units apart, through the open tops and access points of bearings. The following procedure is followed in replacing bearings and repairing devices for remote transmission of azimuth (subunit A-2/3).
Disconnect set at control panel of instrument VI and electric motor CЛI-369 with swtich 6 located on antenna rotating drive unit 2 (cf fig. IV--2).
Loosen eight drop-proof screws, open side plates 17 and 25.
Unsolder wires from rotating transformer 41 and disconnect wires from selsyn 51.
Unscrew plate 43 and remove rotating transformer 41.
Loosen four screws of bracket 52 and remove selsyn 51.
Loosen four screws 53 and remove subunit A-2/3 23.
Wash bearings, gears, and shafts in gasoline and lubricate as indicated in IX-1.
Install subunit A-2/3 23 and secure with screws 53.
Engage dog 49, place selsyn in socket, and secure bracket 52 with four screws.
Set rotating transformer 41 and secure with strap 43.
Connect wires to selsyn.
Solder wires to rotating transformer.
Following assembly, the backlash and moment should correspond to those given in the kinematic diagram of unit A-2 of the Kivach-2 set (cf fig. IV-4).

When measuring backlash and moment between M2 and M3 it is necessary to transfer the electromagnetic sleeve to position M, press in pins 16 and 15, and lock wheel 9.

When measuring backlash betwen wheel 9 and M3 it is necessary to shift the electromagnetic sleeve into position K and press down pins 12 and 14.

The measurements are made with subunit A-2/3 removed from the housing of unit A-2.

Secure side covers 17 and 25 with eight drop-proof screws. /147

Close the switch.

Connect the set on the control panel of instrument И (cf fig. IV-5, 16).

<u>Lubrication of the reducer (subunit A-2/1) of Kivach-1 radar antenna rotating drive mechanism.</u> The following procedure is following in changing the lubricant in the antenna drive mechanism reducer.

Cut in the set on the control panel of instrument И (cf fig. IV-5, 16) and electric motor СЛ-369 with switch 32 (cf. fig. IX-1).

Loosen the four drop-proof screws, and open cover 20.

Loosen six screws to remove the cover of reducer 3.

Remove old lubricant from reducer 18, wash with gasoline and fill with new lubricant as indicated in table IX-1.

Cover reducer mechanism with plate and secure with six screws.

To replace damaged ball bearings in reducer carry out the following procedures.

Remove old lubricant from reducer.

Loosen four screws 13 and remove assembly A (cf Fig. IV-3).

Extract pin 15, remove dog 16, bushings 18, 19, and 17, and protective washer 20.

Press out two ball bearings from bushing 12.

Wash parts in gasoline, lubricate the new ball bearings with the grease indicated in table IX-1, and assemble parts in reverse order of disassembly of unit A.

Loosen three screws and remove cover plate 26.

Extract pin 25, remove pinion together with spline 3, bushing 6, and protective washer 5.

Loosen three screws and remove bushing 4.

Press out two ball bearings from housing 2.

Loosen six screws and remove bushing 9 and 23.

Press out two ball bearings.

Loosen six screws and remove covers 10 and 22.

Press out two ball bearings from housing 2.

Wash parts in gasoline and assemble reducer.

Charge reducer with new lubricant as indicated in table IX-1.

<u>Lubricating reducer (subunit A-2/1) of Kivach-2 radar antenna rotation drive mechanism.</u> The following procedure is used to change the lubricant in the reducer of antenna turning mechanism.

Switch on the set on the control panel of instrument И (cf fig. IV-5, 16) and electric motor СЛ-369 with switch 6 (cf fig. IV-2).

Loosen four screws and open cover plate 17.

Loosen six screws and remove reducer cover plate 14.

Remove old lubricant from reducer 15, wash with gasoline and charge with fresh lubricant as indicated in table IX-1.

Cover reducer with plate containing six screws. /148

Replace worn ball bearings in reducer as described for the reducer of the Kivach-1.

Lubricating the rotating shf adapter (subunit A-2/2) of Kivach-1 radar antenna rotor unit. The lubricant of the rotating shf adapter is replaced in the following manner.

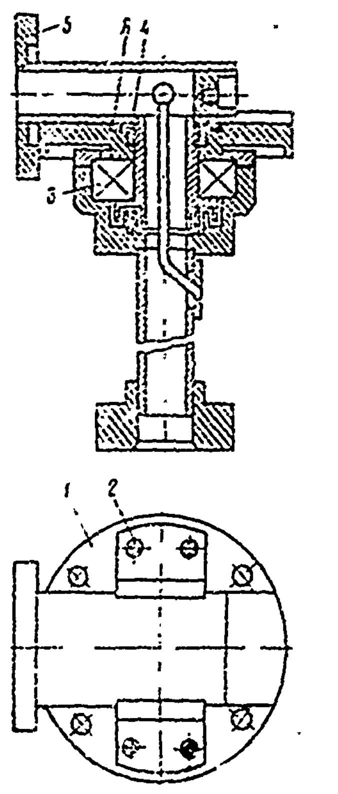


Fig. IX-2. General view of subunit A-2/2.

Disconnect set on control panel of instrument И and electic motor СЛ-369 with switch 32 (cf fig. IX-1).

Loosen four nuts holding antenna 19 to bracket 8.

Loosen four screws securing antenna waveguide to rotating shf adapter 10 and remove antenna 19.

Loosen four screws, remove plate 23, and lower rubber ring 25 on waveguide channel tube 24.

Loosen four screws 11, and remove rotating shf adapter 10.

Loosen four screws 2 (fig IX-2) and remove waveguide section 5.

Loosen nut 4 and remove disk 1.

Wash bearing 3 in gasoline and smear with lubricant indicated in table IX-1.

Assembly in the following order.

Set up disk 1 and secure with nut 4. Arrest the nut with paint on base AK-20.

Fill groove A with compound 421A.

Apply waveguide section 5 and secure with screws 2.

Set rotating shf adapter 10 (cf fig IX-1) in non-hardening compound and secure with screws 11 to shaft 12.

Couple waveguide line 24 to rotating shf adapter by means of plates 23 and rubber ring 25.

Fasten antenna 19 to bracket 8 with nuts.

Connect antenna waveguide to rotating shf adapter by means of screws.

Lubrication of rotating shf adapter (subunit A-2/2) of Kivach-2 antenna rotator. The following procedures are observed when replacing the lubricant of the rotating shf adapter. /149

Switch off set from control panel of instrument И and electric motor C I-369 with switch 6 (cf fig. IV-2).

Loosen four nuts that fasten antenna 12 to the bracket 40.

Loosen the four screws securing the waveguide of antenna 12 to the rotating shf adapter 35 and remove antenna.

Loosen four screws, cover plates 57, and lower rubber ring 58 on tube of waveguide line 56.

Loosen four screws 34 and remove rotating shf adapter 35.

Loosen four screws 2 (cf fig IX-2) and remove waveguide section 5.

Loosen nut 4 and remove disk 1.

Wash bearing 3 in gasoline and cover with lubricant indicated in table IX-1.

Assemble in the following sequence.

Set up disk 1, secure with nut 4. Lock nut with pain to base AK-20.

Fill groove A with compound 421A.

Put on waveguide section 5 and tighten with screws.

Set rotating shf adapter 35 (cf fig. IV-2) in non-hardening compound and secure with screws 34 to shaft 36.

Couple waveguide line 56 to rotating adapter by means of cover plates 57, rubber ring 58, and screws.

Secure antenna 12 to bracket 40 with screws.

Connect antenna waveguide to rotating shf adapter with screws.

Lubricating scale mechanism (unit И-5). The element can be lubricated without removal of the scales, reducer, range sighting ring potentiometer, and other parts from the open port of instrument И (cf fig. IV-6).
The following procedure is employed when replacing parts and making repairs in unit И-5.

Loosen nut 28 and remove knob 29.

Loosen screws 26 and remove bracket 27.

Pull out pins and remove conical gears 24, adjusting ring 25, and cylindrical wheel 23.

Loosen screw of sleeve 8 and slide off shaft 10.

Loosen screw 6 and remove counter 22 from pins.

Loosen stop screw 14 and remove wheel 13.

Unsolder three wires 11 from potentiometer and two wires 18 from microswitch 19.

Remove three screws 15 and take out reducer of counter 12. /150

Loosen nut 33 and remove gear 34.

Loosen nut 32 and remove washer 30 with screws 31 from potentiometer 9.

Loosen rollers with eccentrics 17 and remove gear with scale 20.

Loosen shaft screw 16 and remove roller with eccentrics 17.

Pinions, gears, wheels, rollers, shafts, and raceways of end wheels should be wiped with a piece of cloth moistened with gasoline and the elements smeared with the lubricant indicated in table IX-1. Without removing counter 22 and counter reducer 12, wash in gasoline, dry, and lubricate with grease indicated in table IX-1.

Assembly is performed in the following order.

Assemble rollers with eccentrics 17 and tighten shaft screw 16.

Install gear with scale 20 on rollers with eccentrics.

Set counter on pins and drawn down base 7 with screws 6.

Set washer 30 with screws 31 on potentiometer after securing with nut 32. Place gear 34 on potentiometer shaft and tighten with nut 33.

Install counter reducer and secure with three screws 15.

Install sleeve 8, secure without rotating flexible shaft 10.

Apply the three wires 11 to the potentiometer and the two wires 18 to the microswitch 19.

Install handwheel 13 after securing it with locking screw 14.

Install cylindrical wheel 23, conical wheel 24, and adjustment wheel 25 on the shaft 1 of bracket 27 and insert pins.

Install bracket 27 and tighten with screws 26.

Install wheel 29 and tighten with nut 28.

CHAPTER X

REPLACEMENT OF UNITS AND ASSEMBLIES IN SET

X-1. GENERAL RULES CONCERNING REPLACEMENT OF UNITS AND ASSEMBLIES

To replace units and assemblies carried in the kit of spare parts, accessories, and instruments, it is necessary to follow the procedures set forth in tables X-1 to X-5, observing the sequence of operations indicated in the tables and noting the markings indicated under each item of replacement. /151

Before replacing the various units and elements it is necessary to de-energize the radar equipment completely. To do so, make the following disconnects: switch off the radar set on the control panel of instrument И; switch off the onboard poer line circuit to the element replaced; the power supply light on instrument C should go out in the process. Switch off the power supply to the gyrocompass (Kivach-2 only) -- the ~110 volt light on instrument Г should go out.

After replacement of the unit it is necessary to check the parameters of the set which are governed directly by the replace unit and make adjustments as required.

The following will be observed in replacement of units.

II-1--make adjustments (cf Chap VIII-4 and VIII-5);
И-2-- adjust range marker brightness (cf Ch VIII-7);
И-3 -- make adjustments as in Chap VIII-6;

И-4 -- make adjustments as indicated in Chap. VIII-5;

И-6 -- make adjustment of zero range and range sight ring brightness (cf. Chap. V-6 and VIII-7);

П-1 -- regulate magnetron current and set zero range scale (cf. Chap. VIII-1, V-6, and V-7), as well as depth of automatic time gain control strobe (cf. Chap. VIII-8);

П-6 and П-7 -- make adjustment as described in Chap. VIII-4;

П-4 or klystron -- make adjustment (cf. Chap. VIII-2);

П-3 -- tune depth of automatic time gain control strobe (cf. Chap. VIII-8).

When replacing the magnetron, make adjustments according to Chapters VIII-1 and VIII-2;

When replacing intermediate frequency amplifier crystals, tune attenuator Y12 (cf Chap. VIII-2);

When replacing automatic frequency control crystals, tune attenuator Y4 of unit II-2 (cf. Chap. VIII-2);

When replacing CRT make adjustments as set forth in VIII-4, VIII-3, VIII-5, and VIII-7;

When replacing deflecting coil make adjustments according to VII-4, VII-3, VIII-5, V-3, V-4, and V-5;

When replacing the linear potentiometer of the range sighting ring make adjustment according to Chap. V-6;

When replacing rotatory transformer make adjustments as indicated in Chapters VIII-5, V-3, V-4, and V-5;

In replacing selsyns make adjustments according to Chapter V-5;

When replacing the electric motor drive of the antenna, set the rate of antenna rotation at 17 ± 2 rpm with the aid of resistor R1 in unit A-2.

X-2. SEQUENCE OF OPERATIONS IN REPLACING UNITS AND ASSEMBLIES IN INSTRUMENTS П AND C

The sequence of operations in the replacement of units of instruments П and C is given in Table X-1, and replacement of assemblies is given in Table X-2.

The arrangement and system of securing units in instrument П are shown in fig. X-1; for assemblies of instrument П and the magnetron they are shown in fig. X-2; for the klystron -- in fig. X-3; for the discharger -- in fig. X-4; and for the diodes-crystals -- in fig. X-5.

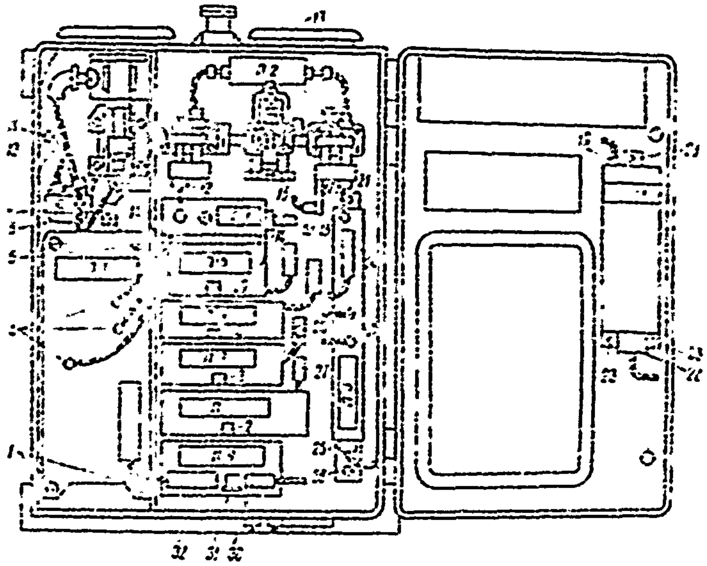


Fig. X-1. Arrangement and fastening of units and assemblies inside instrument II.

For arrangement and fastening of assemblies of unit C-1 of instrument C see fig. IV-8.

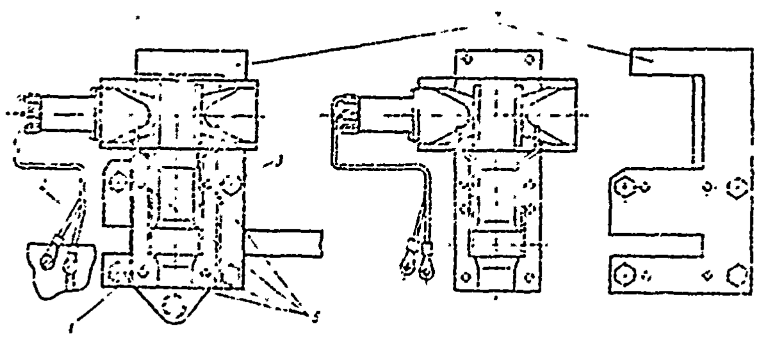


Fig. X-2. Magnetron fastening in instrument II.

Table X-1

Sequence of Operations in Replacing Units of Instruments П and C

Operation	Element Replaced									
	П-1	П-3	П-4	П-5	П-6	П-7	П-8	П-9	П-10	C-1
Switch off radar set on control panel of instrument П (cf figs. IV-5, 16) . .	+	+	+	+	+	+	+	+	+	+
Turn two catches, open common cover of instrument П	+	+	+	+	+	+	+	+	+	-
Turn two catches, open common cover of instrument C	-	-	-	-	-	-	-	-	-	+
Remove connector PП10 in units П-1 (32), П-3 (24), П-4 (15), П-5 (16), П-6 (18), П-7 (26), П-8 (27), П-9 (30,22), П-10 (22), C-1 (8).	+	+	+	+	+	+	+	2	+	+
Disconnect high frequency connectors of unit П-1 (5), П-3 (17 and 25), П-4 (12), П-10 (19)	3	4	2	-	-	-	-	-	1	-
Loosen drop-proof screw 11 of magnetron compartment and open cover 10	+	-	-	-	-	-	-	-	-	-
Loosen ground wire screw 7 and nut 9 which secures high voltage lead of transformer 8 in magnetron compartment	+	-	-	-	-	-	-	-	-	-
Depress arresting device of units П-5 (29), П-6 (4), П-7 (3), П-8 (2), П-9 (31) and remove unit to be replaced from instrument	-	-	-	+	+	+	+	+	-	-
Loosen drop-proof screws from units П-1 (1,6), П-3 (21,28), П-4 (14), П-10 (20,23), C-1 (9) and remove unit to be replaced from instrument . . .	4	2	2	-	-	-	-	-	3	5
Install unit in instrument	+	+	+	+	+	+	+	+	+	+
Secure with drop-proof screws units П-1 (1,6), П-3 (21,28), П-4 (14), П-10 (20,23), C-1 (9)	4	2	2	-	-	-	-	-	3	5
Secure with arresting device units П-5 (29), П-6 (4), П-7 (3), П-8 (2), П-9 (31)	-	-	-	+	+	+	+	+	-	-

Table X-1, continued

Operation	Element Replaced									
	Π-1	Π-3	Π-4	Π-5	Π-6	Π-7	Π-8	Π-9	Π-10	C-1
Place connector PΠ10 on unit Π-1 (32), Π-3 (24), Π-4 (15), Π-5 (16), Π-6 (18), Π-7 (26), Π-8 (27), Π-9 (30, 32), Π-10 (22), C-1 (8)	+	+	+	+	+	+	+	2	+	+
Connect high frequency connectors of units Π-1 (5), Π-3 (17,25), Π-4 (12), Π-10 (19).	3	4	2	-	-	-	-	-	1	-
Secure ground wire 7 to magnetron bracket, and high voltage lead 9 to transformer 8	+	-	-	-	-	-	-	-	-	-
Close cover 10 of magnetron compartment and tighten screw 11	+	-	-	-	-	-	-	-	-	-
Close common cover of instruments Π and C with arresting devices	+	+	+	+	+	+	+	+	+	+
Switch in radar set on the control panel of instrument И (cf fig. IV-5, 16)	+	+	+	+	+	+	+	+	+	+

Note: In this and in tables that follow the "+" sign means that the work is to be done on a particular unit or assembly, and the "-" sign indicates work is not to be performed. The Arabic digit refers to the number of connecting or securing elements (screws, connector plugs, and the like) to be removed.

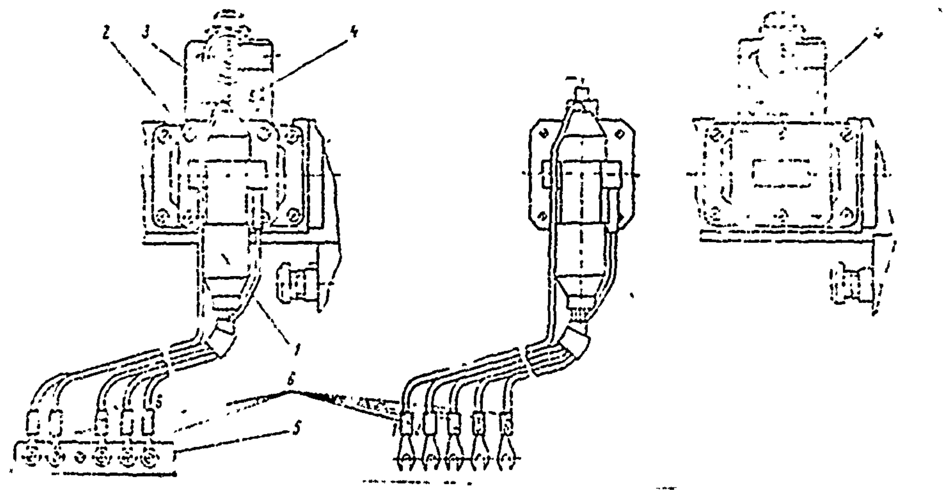


Fig. X-3. Securing klystron in unit Π-2

Sequence of Operations for Replacing Assemblies of Instruments П and C

Operation	Item to be Replaced			
	Magnetron fig. X-2	Klystron fig. X-3	Discharger fig. X-4	Diodes (crystals) fig. X-5
Disconnect radar unit on control panel 16 of unit И (cf fig. IV-5)	+	+	+	+
Turn two arresting devices, open common cover of instrument П	+	+	-	+
Loosen secrew, open upper cover 13 of instrument П (cf fig. X-1)	-	-	+	-
Loosen screw 11 of magnetron compartment, open cover 10, unscrew two nuts 9, disconnect two wires 2 of transformer filament	+	-	-	-
Loosen screws 5 of terminal plate, disconnect five wires 6	-	+	-	-
Release spring 5, remove anode tipe 4 .	-	-	+	-
Slacken lock nut 3	-	-	+	-
Slacken nut 1 until assembly emerges readily	-	-	+	-
Loosen four secrews 2 of klystron, loosen collar screw 4	-	+	-	-
Loosen four drop-proof screws 3 . . .	+	-	-	-
Remove magnetron 1 from pins 5 together with cap 4 and screws 3	+	-	-	-
Remove mounting assembly of diode Д405Б 4	-	-	-	+
Remove mouncing assembly of diode Д-405Б П4	-	-	-	+

Table X-2 continued

Operation	Item to be replaced: Magnetron fig. X-2	Klystron fig. X-3	Discharger fig. X-4	Diodes (crystals) fig. X-5
Remove assembly	+	-	+	+
Lower klystron 1, remove from mounting	-	+	-	-
Install assembly 2	-	-	+	+
Set up klystron 1. Before installing, screw in shaft 3 of klystron as far as possible and secure collar in extreme upper position	-	+	-	-
Secure holders 3 together with diodes Д-405БП in housing 5	-	-	-	+
Install mounting assembly 4 of diode Д405Б and Д-405БП	-	-	-	+
Secure magnetron 1 with screws 3 in magnetron compartment	+	-	-	-
Secure klystron 1 with secrews 2 and tighten screw of collar 4	-	+	-	-
Secure nut 1	-	-	+	+
Secure lock nut 3	-	-	+	-
Press out spring 5 and set anode tip 4	-	-	+	-
Install 5 wires 6 with tips and secure with screws 5	-	+	-	-
Secure two wires to transformer filament 8, tighten with two nuts 9. Secure cover 10 of magnetron compartment and secure screw 11	+	-	-	-
Close upper cover plate 13 and screw down	-	-	+	-
Close cover of П and secure with arresting device	+	+	-	+
Switch radar in on control panel . .	+	+	+	+

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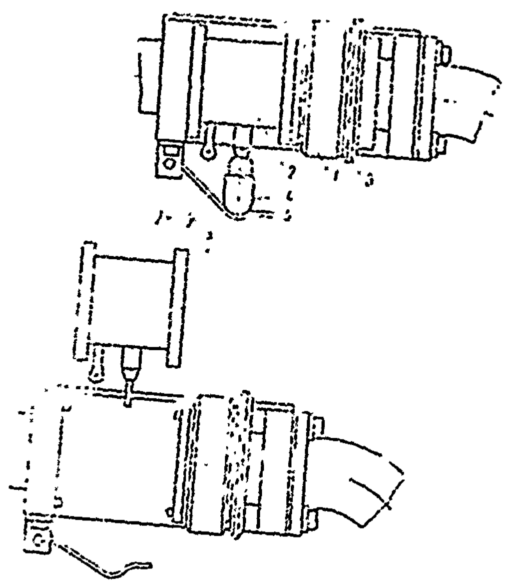

Fig. X-4. Attachment of discharger in П-2

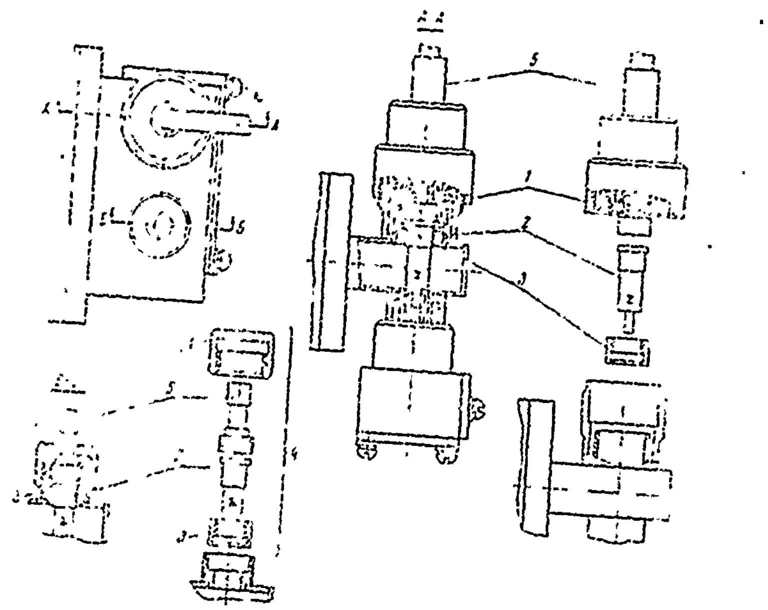

Fig. X-5. Attachment of diodes (crystals) in П-2

X-3. Procedures Following in Replacing Units and Assemblies in Instrument И /158

The sequence of operations involved in replacing units of instrument И is given in Table X-3; installation of assemblies is given in table X-4.

The location and method of attachment of units in instrument И is given in fig. X-6, and the location and attachment of assemblies for instrument И -- the CRT, deflecting coil, centering and focussing magnets -- is given in fig. X-7, and the location of the counter potentiometer of the range sighting ring is given in fig. IV-6.

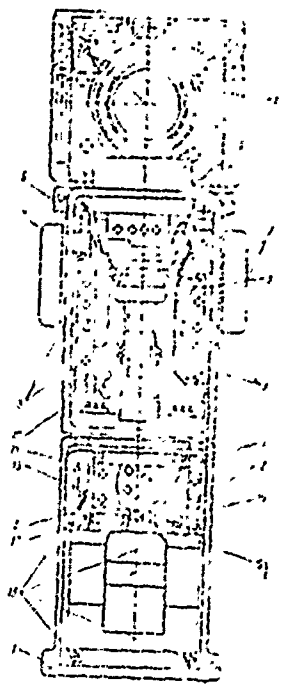

Fig. X-6. Arrangement of units and assemblies inside instrument И.

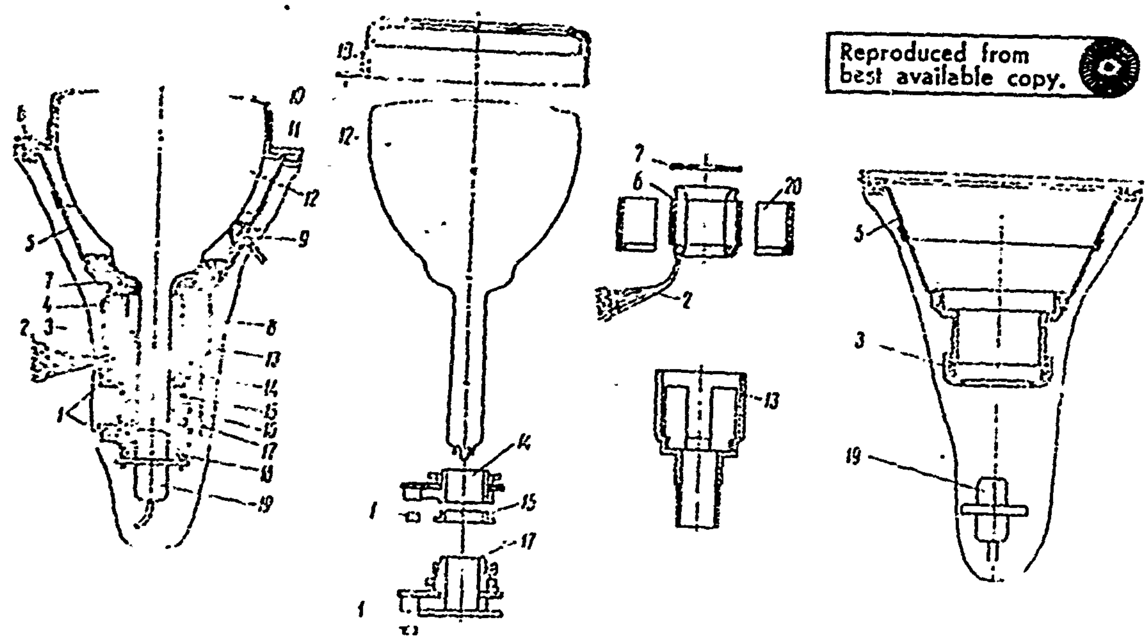

Fig. X-7. Attachment of CRT in instrument И

Table X-3

Sequence of Operations in Replacing Units in Instrument И

Operation	Item to be Replaced				
	И-1	И-2	И-3	И-4	И-6
Switch off radar on control panel of instrument И (cf fig. IV-5, 16)	+	+	+	+	+
Loosen two screws 1, open cover of instrument И (cf fig X-6)	+	+	+	+	+
Before removing unit И-2 it is necessary to remove unit И-6	-	+	-	-	-
Remove connector РП10 in units И-1 (14,17), И-2 (14), И-3 (6), И-6 (15	+	+	+	-	+
Disconnect high voltage plug connectors in units И-2 (11), И-3 ( ), И-6 (13)	-	2	4	-	2
Loosen four screws, remove housing 8	-	-	-	+	-
Disconnect four tips 9	-	-	-	+	-
Remove anode capt from CRT	-	-	-	+	-
Loosen attaching screws in units И-1 (18), И-2 (2, 12), И-3 (4), И-4 (7), И-6 (16) .	4	3	1	2	1
Loosen butterfly nut 10 of unit И-3	-	-	+	-	-
Set switch guide in horizontal position with scale switching lever	+	-	-	-	-
Remove unit from instrument	+	+	+	+	+
Place unit in instrument	+	+	+	+	+
Secure units И-1 (18), И-2 (2,12), И-3 (4) И-4 (7), И-6 (16)	4	3	1	2	1
Secure unit И-3 with butterfly nut 10 . . .	-	-	+	-	-
Secure anode cap to CRT (after first turning it inside out)	-	-	-	+	-
Place tips 9 on unit И-4 and cover with case 8	-	-	-	+	-

Table X-3, cont'd

Sequence of Operations in Replacing Units in Instrument И

Operation	Item to be Replaced				
	И-1	И-2	И-3	И-4	И-6
Set connector РП10 of units И-1 (14,17), И-2 (14), И-3 (6), И-6 (15)	+	+	+	-	+
Connect high voltage plug connectors of units И-2 (11), И-3 (3), И-6 (13)	-	2	4	-	2
Close cover of instrument II with screws 1 .	+	+	+	+	+
Switch off radar on control panel of instrument II	+	+	+	+	+

Table X-4

Sequence of Operations When Replacing Assemblies in Instrument И

Operation	Item to be Replaced			
	CRT fig. X-7	Deflection Coil fig. X-7	Centering and Focussing Magnets fig. X-7.	Range Sighting Ring Potentiometer Counter fig. IV-6
Switch off radar set on control panel of И instrument (cf fig. IV-5, 16)	+	+	+	+
Depress two arresting devices and remove И instrument hood	+	+	-	+
Loosen two screws 5 of instrument И and uncover unit И-5 (cf fig. X-6)	+	+	-	+
Loosen two screws 1, open cover of unit И	+	+	+	-
Disconnect two holders 18 and remove CRT feed panel 19	+	+	+	-

Table X-4, cont'd

Operation	CRT fig. X-7	Deflection coil fig. X-7	Centering and Focussing Magnets fig. X-7.	Range Sighting Ring Potentiometer Counter fig. IV-6.
	Item to be Replaced			
Remove anode cap 9 of CRT	+	+	-	-
Loosen two clamping nuts 3 and 4	+	+	-	-
Remove three secrews 6, remove framing 10 from base 11	+	+	-	-
Remove wires 2 of deflection coil 8	+	+	-	-
Take out CRT 12	+	+	-	-
Loosen collar screw 16 of lower magnet assembly (focussing) and remove unit 17	-	-	+	-
Remove nut 15 which secures upper magnet assembly (centering) and remove assembly 14	-	-	+	-
Remove housing 13 of deflection coil 8 after first turning loose lower nut 3	-	+	-	-
Remove deflecting coil 8 and remove insert 20 .	-	+	-	-
Remove magnets 1 of focusing 17 and centering units 14	-	-	+	-
Carefully note rating plate on potentiometer ППМЛ-М 9	-	-	-	+
Set "zero miles" on counter 22	-	-	-	+
Loosen stop screw 14 and remove wheel 13 . .	-	-	-	+
Unsolder and disconnect three wires 11 from the potentiometer and two wires from microswitch 19	-	-	-	+

Table X-4, cont'd

Operation	Item to be Replaced				
	CRT fig. X-7	Deflection coil fig. X-7	Centering and Focussing Magnets fig. X-7	Range Sighting Ring Potentiometer Counter fig. IV-6.	
Loosen screw of sleeve 8 and slide same off roller 10	-	-	-	+	
Remove three screws 15 and remove remove reducer of counter 12 together with potentiometer 9 and microswitch 19	-	-	-	+	
Remove nut 33 and remove gear 34	-	-	-	+	/162
Loosen nut 32 and remove washer 30 with screws 13 from potentiometer	-	-	-	+	
Switch in ohmmeter of instrument И-57 to leads 1 and 2 or 2 and 3 of potentiometer F3 "zero range" and rotate shaft until a resistance of 180 ohms appears	-	-	-	+	
Set nuts 35 and 36 of assembly 12 in extreme left position	-	-	-	+	
Read instruction on the operation of potentiometerППМЛ (see rating plate). Set zero of the new potentiometer. Rotating the shaft in a clockwise direction, set it between taps 1 and 3 when the ohmmeter shows a resistance of 180 ohms	-	-	-	+	
Set washer 30 with screws 31 on potentiometer 9 and secure with nut 32. Set gear 34 on potentiometer shaft and clamp with nut 33 without moving potentiometer shaft out of adjustment	-	-	-	+	
Install reducer of counter 12 in unit И-5 secure with three screws 15 without moving reducer shaft out of adjustment	-	-	-	+	

Table X-4, cont'd

Operation	CRT fig. X-7	Deflection coil fig. X-7	Centering and Focussing Magnets fig. X-7	Range Sighting Ring potentiometer Counter fig. IV-6.	
	Item to be Replaced				
Install sleeve 8, and secure without turning flexible shaft 10. In doing so, counter 22 should be set on zero	-	-	-	+	
Install three wires 11 to potentiometer and two wires 18 to microswitch	-	-	-	+	
Install wheel 13 and secure with step screw 14	-	-	-	+	
Set zero of range sight ring on zero range (cf V-6)	-	-	-	+	
Install magnet 1. For tight seating of magnet wrap with cable paper and bond together with БФ-4 glue	-	-	+	-	
Install upper magnet assembly (centering) 14 and secure with nut 15	-	-	+	-	/163
Install lower magnet assembly (focussing) and secure with screw 16	-	-	+	-	
Install inserts 20 of deflection coil 8 after first wrapping the coil in cable paper in an amount sufficient to insure tight seating of coil assembly 8 in housing 13	-	+	-	-	
Install deflection coil assembly 8, 13, and 20 and tighten nut 3	-	+	-	-	
Secure the eight wires 2 of the deflection coil	-	+	-	-	
Install CRT 12 after applying rubber ring 7	-	+	-	-	
Set up CRT framing and secure with three screws	+	+	-	-	
Secure CRT with two nuts 3 and 4	+	+	-	-	

Table X-4. cont'd

Operation	Item to be Replaced			
	CRT fig. X-7.	Deflection coil fig. X-7	Centering and Focussing Magnets fig. X-7	Range Sighting Ring Potentiometer Counter fig. IV-6
Apply anode cap 9 to CRT. Before installation the rubber clasp should be turned back as shown by dotted line in drawing	+	+	-	-
Set power supply panel 19 on CRT and secure with two holders 18	+	+	+	-
Close cover of instrument И and turn down the two screws 1	+	+	+	-
Cover unit И-5 of instrument И with screws 5	+	+	-	+
Set hood on instrument and secure with 2 **holds**	+	+	-	+
Switch on radar set on control panel of instrument И	+	+	+	+

X-4. PROCEDURES FOLLOWED IN REPLACING ELECTRIC MOTORS IN INSTRUMENTS A AND Г

The sequence of operations involed in replacing electrical machinery is indicated in table X-5.

The arrangement and method of securing the electric motor and the rotating transformer of the Kivach-1 radar sets is shown in fig. IX-1; the 164 arrangement and method of securing the electric motor, **rotating** transformer, and selsyn of instrument A are shown in fig. IV-2; and the location of the selsyn in instrument Г is shown in fig. IV-7.

Table X-5

Sequence of Operations Followed in Replacement of Electrical Equipment

Operation	Item to be Replaced					
	Electric motor of Kivach-1	Electric motor of Kivach-2	Rotating transformer of Kivach-1	Rotating transformer of Kivach-2	Instrument A selsyn of Kivach-2	Instrument Г selsyn
Switch off radar on control panel of instrument И (cf fig VI-5, 16)	+	+	+	+	+	+
Switch off electric motors; in Kivach-1 with switch 32 and in Kivach-2 with switch 6	+	+	+	+	+	-
Loosen eight screws and open side covers 20 & 30	+	-	+	-	-	-
Remove eight screws and open sides 17 and 25 .	-	+	-	+	+	-
Open cover 19, remove four screws, and remove panel 16	-	-	-	-	-	+
Disconnect wires from malfunctioning assembly (electrical machinery)	+	+	+	+	+	+
Remove cap 29 and remove electrical motor 31 .	+	-	-	-	-	-
Remove cap 27 and remove electric motor 26 . .	-	+	-	-	-	-
Loosen hold down screws and remove assembly 36	-	-	+	-	-	-
Loosen hold down screws and remove assembly 41	-	-	-	+	-	-
Loosen hold down screws and remove assembly 51	-	-	-	-	+	-
Loosen scress 3 and remove bracket with selsyn. Loosen selsyn hold down screws, move cap away from center and remove selsyn from bracket.	-	-	-	-	-	+

Table X-5 cont'd

Sequence of Operations Followed in Replacement of Electrical Equipment

Operation	Item to be Replaced: Electric motor of Kivach-1	Electric motor of Kivach-2	Rotating transformer of Kivach-1	Rotating transformer of Kivach-2	Instrument A selsyn of Kivach-2	Instrument Γ selsyn
Remove dog from electric motor and Woodruff key .	+	+	-	-	-	-
Remove dog from rotating transformer shaft . . .	-	-	+	+	-	-
Remove sleeve 49 from selsyn 51	-	-	-	-	+	-
Remove gear 15 from selsyn shaft 18	-	-	-	-	-	+
Install Woodruff key and dog on new electric motor	+	+	-	-	-	- /165
Install dog on new rotating transformer	-	-	+	+	-	-
Install sleeve 49 on new selsyn 51	-	-	-	-	+	-
Install gear 15 on shaft of new selsyn 18	-	-	-	-	-	+
Place electrical equipment in unit and engage dog catch	+	+	+	+	-	-
Install new selsyn 51 and engage sleeve	-	-	-	-	+	-
Install bracket with new selsyn 18. Engage gear. Secure bracket with screws 3 and insert pins. .	-	-	-	-	-	+
Secure selsyn 51 on bracket with clamp 52 and four screws.	-	-	-	-	+	-
Secure electrical unit with straps, bracket and screws	+	+	+	+	-	-

Table X-5 cont'd

Sequence of Operations Followed in Replacement of Electrical Equipment

Operation	Item to be Replaced: Electric motor of Kivach-1	Electric motor of Kivach-2	Rotating transformer of Kivach-1	Rotating transformer of Kivach-2	Instrument A selsyn of Kivach-2	Selsyn of instrument Γ
Connect wires to replacement electrical equipment	+	+	+	+	+	+
Secure side plates 17 and 25 with screws	+	-	+	-	-	-
Secure panel 16 and close cover plate 19	-	-	-	-	-	+
Set instrument Γ on bracket	-	-	-	-	-	+
Switch on electric motor in Kivach-1 with switch 32 and motor of Kivach-2 with switch 6.	+	+	+	+	+	-
Switch on radar from control panel of instrument И	+	+	+	+	+	+

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APPENDIXES

Appendix 1. Block diagram of Kivach-2 radar set.

With an on board ~ 220 volt, 400 cycle power supply the instrument C circuit lacks a C-1 unit and inverter circuit on thyristors. If a 220 v, 400 cycle current is used, stabilizer I is the first sequence of switching, and stabilizer II is the second sequence of switching.

Appendix 2. Functional radar diagram.

If a ~220 volt, 400 cycle power supply is used, the instrument C circuit lacks a C-1 unit and inverter circuit on thyristors. With a ~220v 400 cycle current stabilizer I is the first sequence of switching, ~ 220v 400 cycles stabilizer II, second sequence of switching. If a 220/380v, 50 cycle current is used the radar set is provided with a C, 220v, 400 cycle instrument and can then be powered by AДA-1.5M/O equipment.

Key to numbered elements in schematic diagram:

1. Course marker contact; 2. from course marker circuit of instrument И; 3. M1 electric motor; 4. from unit И-5; 5. course marker contact; 6. from course marker circuit of instrument И; 7. electric motor; 8. differential selsyn; 9. coupling with gyrocompass switch; 10. image orientation switch; 11. to electric motor of instrument A; 12. to course marker contact of instrument A; 13. linear potentiometer with reducer; 14. power characteristic control; 15. to instrument П and И; 16. to tuning panel of instrument П; 17. logarithmic ifa stages; 18. video signal integration line; 19. two-stage video amplifier; 20. emitter-repeater; 21. differentiator; 22. emitter-repeater; 23. ifa band signal switch; 24. ifa band relay switch; 25. differentiator time constant relay switch; 26. differentiator switch relay; 27. control stage; 28. discriminator; 29. emitter-repeater; 30. preliminary video amplifier; 31. channel II amplifier; 32. channel I amplifier; 33. channel I peak detector; 34. channel II peak detector; 35. emitter-repeater; 36. atgc shaping stage; 37. mixer; 38. atgc strobe shaping cascade; 39. power supply tolerance control element; 40. operating condition of separate hf assemblies, tolerance control; 41. defective protective element indicator; 42. device for searching out defective functional unit; 43. unit operating condition indicator; 44. unit П-4 control device; 45. converter and 1st stage compression; 46. synch pulse shaping circuit; 47. magnetron current control; 48. master oscillator; 49. pulse recurrence frequency switching relay; 50. modulating pulse shaping circuit; 51. power amplifier; 52. sawtooth current generator on 0.4 mile scale; 53. sawtooth current generator on 0.8 ./.24 mile scales; 54. output stage commutation relay; 55. sweep center shift magnet; 56. antilogarithmic video amplifier; 57. amplifier-limiter; 58. output stage; 59. course and range marker switch; 60. range marker scale switching system; 61. discrimination regulator; 62. interference suppression switch; 63. unit C-1 control circuit; 64. output stage; 65. amplifier-limiter; 66. coincidence circuit I; 67. output stage; 68. amplifier-limiter; 69. coincidence circuit II; 70. multivibrator; 71. shaping stage; 72. industrial interference filter; 73. automatic radar switching circuit; 74. inverter on thyristors; 75. alternating current stabilizer; 76. on board circuit: 24v, 220v, ~ 220v, 400 cycles, 220;380v, 50 cycles through AДA-1.5M equipment.

Appendix 3. Basic electrical circuit of instrument П.

1. Klystron cathode voltage -300v; 2. klystron reflector voltage; 3. unit control operation -12.6v; 4. afc reference voltage; 5. modulating GC afc pulse; 6. converter output; 7. constant voltage control; 8. malfunction indicator; 9. unit П-4 +27v tuning and control; 10. pulse control; 11. control И-2; 12. +27v tuning and control of unit П-4; 13. +27v control operation of unit П-3 and И-3; 14. control И-3; 15. -12.6v unit control; 16. control П-3; 17. П-1 and atgc shaping unit control; 18. GC afc control П operation; 19. GC afc modulating pulse; 20. ИП-2 blocking; 21. transmitter disconnect; 22. afc reference voltage; 23. klystron reflector voltage; 24. on board power supply control; 25. magnetron current; 26. ignition voltage of discharger; 27. klystron cathode voltage (-300v); 28. afc crystal current; 29. ifa crystal current; 30. unit П-4 tuning and control + 27v; 31. klystron reflector voltage; 32. afc reference voltage; 33. ИП-2 blocking; 34. power characteristic control switching; 35. transmitter switch-in signal; 36. synchronization pulse; 37. video signal; 38. control И-2; 39. control И-6; 40. synchronization pulse;

Appendix 4. Basic electrical circuit of instrument И.

1. Sweep; 2. synch pulse; 3. 8, 16, and 24-mile switching; 4. brightness selector; 5. luminance pulse; 6. control И-1, 27v; 7. 0.4P-mile switch; 8. common filament; 9. 0.4P-mile on signal; 10. 0.4-mile on signal; 11. 0.8-mile on signal; 12. 1.6-mile on signal; 13. 4-mile on signal; 14. 8-mile on signal; 15. 16-mile on signal; 16. 24-mile on signal; 17. range marker change switching; 18. feedback; 19. range markers every 0.2 miles; 20. feedback (range marker every 0.2 miles); 21. range marker every 0.4 miles; 22. feedback (range marker every 0.4 miles); 23. range marker every mile; 24. feedback (range marker every mile); 25. range marker every 2 miles; 26. feedback (range marker every 2 miles); 27. range marker every 4 miles; 28. feedback (range marker every 4 miles;

Appendix 5. Basic electrical circuit of instrument A, Kivach-2 radar equipment. Selsyn receiver CC-150 is installed in unit A-2 when coupling in the Amur type gyrocompass; the БС-404АН sensyn receiver is used when coupling to the Kurs-4 gyrocompass. Key: 1. contact; 2. circuit; 3. chassis; 4. cos scan; 5 sin scan; 6. course marker; 7. -110v motor feed; 8. chassis; 9. orientation switching; 10. own course from gyrocompass; 11. instrument Г.

Appendix 6. Basic electrical circuit of instrument Г.
A СДСМ-1А type selsyn is installed in this instrument when the Kivach-2 radar is coupled to the Amur gyrocompass, and a НЭД-101ТВ selsyn is used when the radar set is connected to the Kurs-4 gyrocompass.

Appendix 7. Basic electrical circuit of instrument C/-220v. Key: 1. depress; 2. unit C-1 O.K.; 3. on board line circuit; 4. on board power circuit; 5. +220v power circuit; 6. safety devices defective; 7. contact; 8. control unit C-1; 9. feed (-); 10. circuit; 11. cathode of PTL; 12. (+) power supply; 13. chassis; 14. instrument II; 15. on board power supply control; 16. radar switch.

Appendix 8. Basic electric power and protective circuit for alternating current systems. In the C-24v instrument relay P5 has the positional designation P6, and in the C220v,400 cycle instrument it has the positional notation P4.

Key: 1. Instrument C; 2. CRT and course marker circuit; 3. instrument И; 4. instrument П; 5. unit П-11; 6. unit П-3; 7. unit П-2.

Appendix 9. Basic electrical power supply and protection systems for rectified voltage circuits.

Instrument A receives no +27 volts in the Kivach-1 . Resistor R10 in instrument C/220v has a positional designation R18, and in instrument C/24v resistor R10 has a positional designation R7 and relay P6 has the designation P7. In instrument C/∼ 220v, 400 cycles, resistor R10 has the positional designation R18, and relay P6 has the positional designation P3. Key: 1. Electric power supply and protection diagram of the +110v and +27v circuits; 2. electric power supply and protection diagram for the -300v, -420v, -500v, and -600v circuits (discharger ignition voltage) +14 kv; 3. electric power supply and protection diagram for the 100v/-15v circuit; 4. electric power supply and protection diagram for the -40v and -12.6v circuits; 5. electric power supply and protection diagram for the +400v and +50 circuits.

Appendix 10. Electric power supply and protection diagram for onboard network circuits.

Key: 1. Instrument C=220v; 2. safety devices defective; 3. unit C-1; 4. to instrument П; 5. safety devices defective; 6. instrument C∼220v, 400 cycles; 7. onboard network; 8. instrument C=24v; 9. instrument C=110v; 10. safety device defective; 11. onboard network; 12. to instrument П; 13. to instrument П; 14. to instrument C; 15. instrument П; 16. power supply source control; 17. radar "Off-On" switch; 18. instrument И.

Appendix 11. Block diagram of Kivach-2 radar control system. The following elements are lacking when onboard power supply network 220v, 400 cycles is used in instrument C: P, Д, and inverter circuit on thyristors; radar switching circuits are designated with broken lines.

Key: 1. synchronization pulse shaping circuit; 2. pulse duration 0.3 usecs choke switch; 3. pulse recurrence frequency relay; 4. converter and first compression stage; magnetron current regulator; 5. master oscillator; 5a. differentiator cut-in relay; 6. differential time constant relay switch; 7. ifa band relay switch; 8. atgc cut-in relay; 9. atgc strobe shaping circuit; 10. inverter on thyristors; 11. alternating current stabilizer; 12. 0.4P mile switching relay; 13. 0.4 mile switching relay; 14. multivibrator; 15. power amplifier; 16. delay line; 17. delay line; 18. sawtooth voltage generator on 0.4 mile scale; 19. output cascade commutation relay; 20. sawtooth voltage generator on 0.8 ./. 24 mile scales; 21. shock excited oscillator; 22. range sight ring potentiometer calibration; 23. sawtooth voltage generator.

Appendix 12. Block diagram of control system.
Numbering of elements in instrument C is for an onboard power line of 220 volts. If a ∼ 220 volt, 400 cycle current is used in instrument C, the following elements are lacking: KH1, Л13, Л14, R1, an inverter circuit on thyristors, unit C-1; and if the 24 volt circuit is used, the normalizer, relay 2, and the rectifier (Д7, Д8) are missing.

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