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2. In some cases, the articles were translated in their entirety; in other cases, they were summarized.

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Herald of Antiaircraft Defense

No 10, October 1963

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Vestnik Protivovozdushnoy Oborony, No 10, October 1963

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Their Deeds Match Their Words (Page 2)

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Abstract:

Honors Komsomol members of PVO Strany Troops in recognition of the 45th anniversary of the Komsomol and notes that the Military Council of PVO Strany Troops has approved their initiative exemplified by Komsomol members of the Baku PVO District, where 45 percent of the Komsomol personnel are outstanding in combat and political training. The commander in chief of PVO Strany Troops has awarded many valuable gifts and honor certificates to a large group of Komsomol workers.

(A captioned photograph by R. IVANOV shows Pvt V. STEPANOV, radar operator 1st class and secretary of a Komsomol bureau, checking the work of Pvts V. BLINOV and A. SIDOROV. All members of the radar crew headed by STEPANOV are rated specialists.)

Onward With the Komsomol (Pages 3-6)

Abstract:

Editorial written in honor of the 45th anniversary of the Komsomol, discusses military Komsomol activities and accomplishments and states that the Order of the Red Banner, the Order of the Labor Red Banner, and three Orders of Lenin have been awarded to the Komsomol for services to the motherland.

PARTY-POLITICAL WORK AND MILITARY EDUCATION

Raise the Level of the Ideological Work by Lt Gen Avn N. V. PETUKHOV (Pages 7-12)

Abstract:

Discusses achievements of party-political work in the Moscow PVO District as a result of the June Plenum of the Central Committee of the CPSU, noting that servicemen were inspired by the decisions of the Plenum causing an upsurge in meetings of party organizations, Komsomol organizations and personnel conferences. Areas for improvement of the quality of ideological, educational, and political work are discussed.

A Chronicle of Komsomol Life (Page 9)

Abstract:

Enumerates accomplishments of Komsomol organizations of various military units.

(A captioned photograph by A. KLIMOV on page 11 shows Sr Lt Ye. FILIMONYCHEV talking with students of a political study group which FILIMONYCHEV heads.)

Initiators of Worthy Projects -- by Capt V. F. SEMENYUK (Pages 13-15)

50X1

Abstract:

Discusses various competitions, contests, pledges, etc. undertaken by Komsomol members in preparation for the 45th anniversary of the Komsomol.

(A captioned photograph by V. INYUTIN of Pfc Irek MUKHAMETSHIN appears on page 13 and a captioned photograph by I. Rybin of Pvt Timrish SAPAROV appears on page 15.)

The District is Proud of Them -- by correspondents of the Moscow PVO District newspaper, Na Boyevom Postu (Pages 16-22)

Text:

In the Moscow PVO District, as in all units of our troops, the training year is coming to an end. In comparison with previous years, this year was more fruitful. Led by the historic decisions of the 22nd Party Congress and the June Plenum of the Central Committee of the CPSU; aviators, rocketeers, radar operators, signalmen, and servicemen of other specialties raised their combat skills to new levels while putting them into practice this year. Several of these servicemen are discussed in the materials published below.

Things Are Going Well (Pages 16-17)

Abstract:

States that the squadron of rocket carrying interceptors commanded by Maj TIKHONOV is capable of intercepting air targets in all weather conditions, day or night, and at low altitudes and in the stratosphere.

The Commander's Concern (Pages 17-18)

Abstract:

Praises Capt TELEPNEV, commander of an air defense rocket unit who succeeded in making all of his subordinates rated specialists. The district commander in chief twice awarded TELEPNEV valuable gifts and on 22 February 1963, Capt TELEPNEV was awarded the medal "For Combat Services" by decree of the Presidium of the Supreme Soviet of the USSR.

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A Lesson for a Higher Rating (Page 18)

Abstract:

Praises the professional skill of Tech-Sr Lt POLETKIN, commander of a radar crew, and his subordinates for their ability to detect targets at great distances. All members of the crew are rated specialists.

In an Outstanding Platoon (Page 19)

Abstract:

Praises the outstanding communications platoon commanded by Lt KIRICHENKO of which all members are rated specialists. Pvts ZHITKOV and MOLOTKOV were cited for voluntarily crosstraining on the ST-35 teletypewriter.

Aviation Equipment Expert (Page 20)

Abstract:

Extols the professional skill of Tech-Sr Lt Arkadiy Yegorovich SHCHEGLOV, an aviation specialist who always maintains aircraft in excellent condition.

Full Interchangeability (Page 21)

Abstract:

States that the air defense rocket podrazdeleniye commanded by Sr Lt STEPANOV has achieved full interchangeability of specialists and notes that during an examination they succeeded in destroying air targets in the stratosphere with the first rockets and with high precision.

A Leader of Youth (Page 22)

Abstract:

Comments on the political work of Lt Aleksey KOVTUNENKO, a leader of a primary Komsomol organization.

COMBAT TRAINING

A Model Material Basis for Training -- by Col Gen Avn N. D. ANTONOV (Pages 23-27)

Abstract:

Discusses the importance of special stands, models, diagrams, placards, and trainers to aid in training personnel to operate and repair equipment, especially since modern equipment is so complex that training supervisors can no longer always give visual demonstrations with actual equipment. Examples are given of how various arms of PVO Strany Troops use specialized training material.

(A captioned photograph by K. FEDULOV on page 27 shows Capt V. CHUMAK, flight commander, and pilots V. PEREVOZCHIKOV, G. GLADKIY, and V. FETISOV learning how to land aircraft at unfamiliar airfields by using what appears to be a flight course simulating crab on a table.)

When a Situation Is Complicated -- by Capt Med Serv V. A. PONOMARENKO (Pages 28-30)

Abstract:

States that emergency situations in flight are most often caused by pilot inefficiency, perhaps due to emotional unbalance, inadequate memory, poorly developed skills in instrument flying, or poor coordination of movements, and attempts to answer psychological questions which can aid a pilot when in dangerous situations. Technical know-how and flying skill are discussed as the most important qualities providing a safe outcome of difficult situations.

Methodological Training for Squadron Commanders -- by Lt Col M. M. BOL'SHAKOV (Pages 31-34)

Abstract:

Discusses aspects of methods training for squadron commanders, including commanders' check flights, methods classes, methods councils, and the organization of flights and critiques. The article maintains that the higher a squadron commander's methodological training, the better are the results of his work with pilots.

(A captioned photograph by I. RYBIN on page 32 shows Maj N. GALKIN, Pilot 1st Class. The caption states that the squadron which GALKIN commands is the most outstanding in its unit.)

(Capt I. YERMOSHIN, pilot first class, is identified as an outstanding interceptor-pilot in a captioned photograph by I. RYBIN on page 33.)

This Was a Special Case -- by Maj S. I. KLIMENKO (Page 34)

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Abstract:

Describes an incident in which the generator failed on an aircraft piloted by Capt KUTS, pilot first class, during a night intercept mission. By operating his radio only every two minutes, KUTS succeeded in prolonging the battery power until he had landed safely.

The Effect of Meteorological Conditions on Radar Operation -- by Engr-Capt Yu. A. FADEYEV (Pages 35-37)

Text:

Weather conditions in the lower layers of the atmosphere have a significant influence on the propagation of radio waves emitted by a radar. This influence is seen in the form of atmospheric refraction, attenuation of propagated energy, and in the scattering and reflection of electromagnetic waves by atmospheric inhomogeneities. The latter cause substantial changes in the images formed on radar screens and complicate the observation of useful echoes from aerial objects.

For a better understanding of the processes occuring in the propagation of radio waves in atmospheric inhomogeneities it should be useful to become more familiar with these phenomena.

It is known that atmospheric refraction is caused by the passage of radio waves through media with different densities. The latter are characterized by refractive indices which determine the dielectric constants of the layers. The refractive index is the ratio of the speed of propagation of radio waves in a vacuum to their speed of propagation in the atmosphere. The atmosphere, especially in the lower layers, is not homogeneous. Therefore, the speed of propagation of radio waves changes in different layers which causes a change in the refractive index and a distortion of the trajectory of the radio waves, that is, atmospheric refraction.

The nature of attenuation of radio waves in droplet formations of the atmosphere (clouds, fog, rain) is caused by absorption and scattering of the energy of an electromagnetic field. The action of the electric field of an electromagnetic wave causes a "Mixing" of electrical charges in the droplet formations. The oscillating charges are the centers for the creation of secondary radiation. Thus, part of the energy of the radio waves is converted to scattered radiation. This results in dielectric losses, that is, a partial absorption of electromagnetic energy takes place. With small drop sizes (fog and some types of clouds) and long radio waves from 0.5 to 10 cm, attenuation caused by absorption of electromagnetic energy is rather great. With large drop sizes (cumulonimbus clouds) and radio waves 10 cm and longer, attenuation is determined mainly by scattering of electromagnetic energy.

Of greatest interest in the case of radar is the phenomenon occuring at the moment the radio waves reach the boundaries of droplet formations. Here the radio waves undergo scattering and reflection. Part of the reflected electromagnetic energy passes to the antennas and receiver of the radar and partially illuminates the screen of the indicator. Through practice and theoretical calculations it has been established that the magnitude of the scattered energy depends on the duration of the pulse emitted by the radar. This is explained by the fact that the echoes (signals) from the droplet formations are formed not at some sharply defined boundary such as, for example, an aircraft, but in the space limited by the directivity pattern of the antenna and at a distance approximately corresponding to the value of the product of the speed of radio wave propagation times the duration of the radiated pulse.

With high radiation power a reflected signal of sufficient intensity is received from an accumulation of water drops or snowflakes falling in the form of precipitation. Cloud and fog droplets, due to their small size, provide no reflections until immediately before precipitation when the size of the droplets increases. Thus, clouds which are not producing rain and fog are usually not detected by radar. Shower clouds, cumulonimbus clouds, and nimbostratus clouds are more effectively detected.

The droplets in cumulonimbus clouds are large. Therefore, reflections from the cloud will be strong and its outline will be sharply defined. The duration of the pulses reflected from this type of cloud exceed the duration of the pulses emitted by the station. This increase in the duration of reflected pulses occurs as a result of time and phase shifts when the preceding pulses reflected from the rear boundary of the cloud "overtake" the subsequent pulses reflected from the front boundary of the cloud. Clouds having sharply defined boundaries on the screen of a radar indicator denote a storm and are dangerous for aircraft flights.

Due to the small droplet size in nimbostratus clouds, the water content per unit of volume is considerably less than in cumulonimbus clouds. Therefore, reflections from such a cloud will be less powerful and will be weakened around the periphery so that the boundaries of the cloud will be indistinct and blurred.

Reflections from rain and rain clouds occupy a large area on radar screens and hinder the normal work of the operators. Therefore, in order to solve the problem of detection and tracking of targets, it is necessary to know how echoes are produced in a reflecting background and what measures must be taken in order to observe a target against a background of meteorological interference.

Good radar observation of a target will be achieved at short ranges with a sufficiently effective scattering cross-section of the target and with small cloud intensity. With heavy precipitation, at great distances, and with a small effective cross-section of scattering, loss of the target may occur.

While the target and the drop formations are located at distances exceeding the resolution of the radar, they are seen separately on the radar screens as two objects. As these distances decrease, the target will be observed against a background of meteorologicial noise.

In order to evaluate the radar observability of a target against a background of meteorological noise, it is convenient to use the "contrast transmission characteristic" which relates the contrast at the input of the radar receiver to the contrast of these signals at the output of the receiver.

For plan position indicators it is advantageous to use optical contrast of signal brightness. According to the laws of optics, two brightnesses, of which one is greater than the other, are visually distinguishable if the ratio of their brightnesses to the greater exceeds a certain value "K" which is called the visual brightness difference threshold. If this ratio is less than "K," the brightnesses appear equal and it is impossible to separate the target from the background of noise.

Thus, the conditions for observing a target against a background of meteorological noise depends on the amount of contrast of the signals or on the threshold of visual brightness difference.

The methods of operation of radar operators are different depending upon the type of radar used. However, certain general rules exist which provide the greatest effectiveness in the use of radar technique for observing targets against a background of meteorological noise.

The radar operator in his work can improve the target image against a noisy background by decreasing the power of the radar, decreasing the gain of the receivers, adjusting the sweep brightness on a plan position indicator, and by switching in special noiseproof circuits.

By decreasing the radiated power on a plan position indicator screen, the reflections from clouds will disappear and only high-intensity reflections will remain, but it should be remembered that reflections from the target will also worsen. Therefore, when the range to the target is great and the scattering cross-section of the target is small, this mode of operation cannot be used.

The best mode of operation for the detection and tracking of targets under conditions of meteorological noise is a reduction in the gain of the receiver. This may be accomplished manually as well as by switching in special circuits which improve the contrast at the output of the radar receiver by reducing receiver gain only during the reception of pulses reflected from droplet formations. However, even in this case, the target may be lost if the scattering cross-section of the target is small.

Practice has shown that brightness adjustment must be used carefully, keeping in mind that with increased brightness the sweep trace itself will create noise which when added to meteorological interference will increase the visual brightness difference threshold even when proper contrast is present at the receiver input.

Increasing the duration of pulses reflected from droplet formations makes it possible to use special circuits which select useful signals on the basis of their duration. In this case, the screen of the plan position indicator will receive only part of the energy reflected from the clouds in the period of time equal to the duration of the radiated pulse. However, even in this case, there is attenuation of the useful signal.

A knowledge of the basic processes occuring in the propagation of radio waves in atmospheric inhomogeneities will assist the operator in determining the nature of cloud images on the screen of radar indicators, in correctly evaluating meteorological conditions, and in determining the presence of storm clouds. The skillful utilization of all methods of reducing the effects of meteorological interference will facilitate the detection and continuous tracking of targets under the most intense meteorological conditions.

(A photograph of a small, simple teaching machine developed by Sr Lt POLTAVETS and Pvts ARISENKO and ZLENKO appears on page 37. A brief article accompanying the photograph discusses achievements in teaching machine development.)

Radar Detection of Low Flying Targets -- by Engr-Lt Col A. S. MIKHAYLOV (Pages 38-41)

Text:

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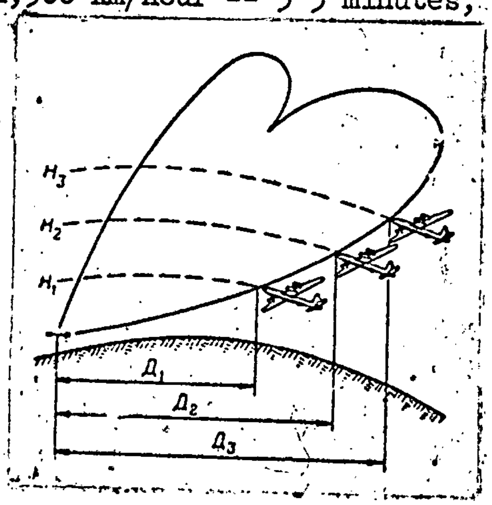
Practice has shown that radar detection of targets flying at average altitudes presents no special difficulties. Sufficiently great radar operation range a significant degree of overlapping of scanning zones by adjacent radar units provides for timely detection and continuous tracking of airborne targets at these altitudes. Radar detection of low-flying targets is considerably more complex and is conditional upon a number of peculiarities. A description of these peculiarities and how they are taken into consideration by radar units in radar detection is the subject of this article.

One of the factors influencing the results of combat action against low-flying targets is the small detection range of radars. This range depends both on the altitude of the aircraft as well as on the very shape of the zone of detection. As may be seen from figure 1, the lower the altitude of the target the smaller the range of its detection. Since radars have a small range of detection for low-flying targets, the time alloted for finding a target in the zone of detection of one station will be brief. In addition, this time will depend on the speed of the target (the time will be very small at high speeds). If, for example, the range of detection of a radar is 60 km and the speed of the target is 900 km/hour, the maximum time which the target will spend in the zone of detection of one radar is approximately 8 minutes (when the direction of flight is through the point at which the radar is located). With target speeds greater than 900 km/hour, the time alloted for detection of the target in the zone of the station will be less, comprising, at detection ranges of 60 km, the following: at speeds of 1,200 km/hour -- 6 minutes; at speeds of 1,500 km/hour -- 5 5 minutes, etc.



D1
D2
D3

Figure 1. Radar Zone of Detection in the Vertical Plane

Obviously a time of 6 to 8 minutes is very small. With a radar antenna scan rate of 6 rpm, a maximum of 36 displays will be made in 6 minutes if each rotation of the antenna successfully provides a display. With a smaller scanning rate the number of displays of each target with one radar will be even less. Therefore, in determining the operation of the radar, it is necessary to use those methods which will provide for the timely detection of low-flying targets and their continuous tracking. It is fully obvious that the constant maintenance of equipment in excellent condition and a high level of technical training of the combat radar crews are of utmost importance. In preparing meteriel for combat as well as in the conduct of routine work on equipment, more attention should be devoted to checking the basic parameters of the radar which influence the range of detection of aerial targets such as the pulse power of the transmitter, the sensitivity of the receiver, etc.

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The use of radar plotting data is recommended for early detection of low-flying targets. In this way the operator, by observing a certain sector of his screen, can detect the target at a considerably earlier moment.

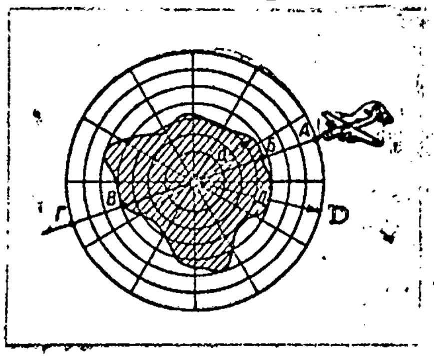

Figure 2. Zone of Reflections From Ground Objects on a Radar Screen

D -- range of detection of the radar
d -- mean radius of reflections from ground objects

Ground-clutter return also has a great effect on the detection of low-flying targets. Figure 2 shows that ground clutter occupies a significant part of the radar detection zone at low altitudes. Consequently, part of the course of a low-flying target passes through this clutter zone. For example, if a target is detected at a range of 60 km, the direction of its flight passes through the position of the radar station, and the screen of the station contains ground clutter within a radius of 25 km, the target will be observed without interference only over small sections of the flight course A-Б and B-Г which are each 35 km in length. Therefore, a target moving at a speed of 900 km/hour will be observed outside of the clutter zone on the radar screen for a period of less than 5 minutes (two sections at 2.35 minutes per section with a break of 3.3 minutes). At a target speed of 1,200 km/hour the time will be even less, or three minutes (two sections at 1.75 minutes per section with a break of 2.5 minutes).

As was seen from this example, the amount of useful information from the radar station concerning low-flying targets is reduced due to the effect of ground-clutter return which, in turn, considerably complicates radar detection of low-flying targets.

Ground-clutter return in hilly terrain has an especially great influence on the operation of radar. The zone of reflections may be equal to and even greater than the zone of detection at low altitudes. Therefore, the detection of low-flying targets and their tracking may be carried out in a background clutter over the entire flight course.

It is known that superrefraction phenomena are possible in coastal regions. In this case the detection range of low-flying targets is sharply increased. This is beneficial, but it must not be forgotten that the clutter zone also increases sharply in this situation and complicates the operation of the station.

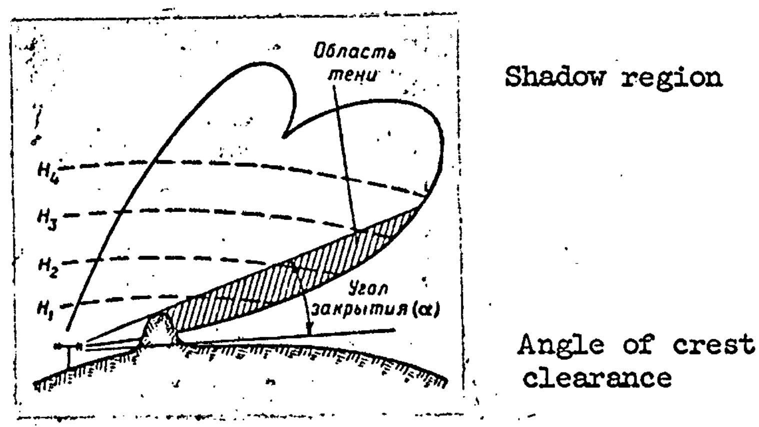

Figure 3. Zone of Detection of a Radar in the Vertical Plane With Consideration for Crest Clearance

Angles of crest clearance of ground objects also have a great effect on the range of detecting low-flying targets (figure 3). Ground objects which form positive angles of crest clearance are a screen for the propagation of electromagnetic energy. Consequently, as behind every screen, there is created behind the ground obstacle a shadow region in which targets are not detected by radar. Some mathematical calculations are given below to show the effect of angles of crest clearance on the range of detecting targets flying at different altitudes.

The angle of creast clearance (α) is a function of the range of detection and the flight altitude

$$\alpha = \arcsin\left(\frac{H}{D} - \frac{D}{2R_e}\right) \quad (1)$$

where α -- the angle of crest clearance in degrees;

H -- the flight altitude of the target in kilometers;

R_e -- the radius of the earth, equal to 6,370 kilometers;

D -- radar detection range in kilometers for the given angle.

$$D^2 + D2R_e\sin\alpha - 2R_eH = 0,$$

or

$$D = -\frac{2R_e\sin\alpha}{2} + \sqrt{\frac{(2R_e\sin\alpha)^2}{2} + 2R_eH} =$$

$$= -R_e\sin\alpha + \sqrt{(R_e\sin\ )^2 + 2R_eH}$$

By substituting different angles of crest clearance and flight altitudes we can obtain the detection ranges corresponding to them. Results of the calculations are given in the table

Table 1

Angle of crest clearance (α)	Flight altitude (m) 100	300	500	1,000	2,000	3,000	5,000	10,000
15'	18	40	57	89	135	170	227	330
30'	11	28	42	71	114	149	204	308
1°	6	16	26	48	85	116	167	264
29	2.5	8	14	28	54	74	118	202

The maximum range of target detection at low altitudes is determined by the visual range which is determined for the formula:

$$D_v = 3.57(\sqrt{h_a} + \sqrt{H}), \qquad (2)$$

where D_v -- the maximum visual range;

h_a -- the height of the radar antenna;

H -- the flight altitude of the aircraft;

3.57 -- a constant,

without considering the effect of fraction (for normal refraction the constant would equal 4.12).

The visual range for different flight altitudes and a radar antenna height h_a = 5 meters may be computed and the information entered in a table as follows:

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Table 2

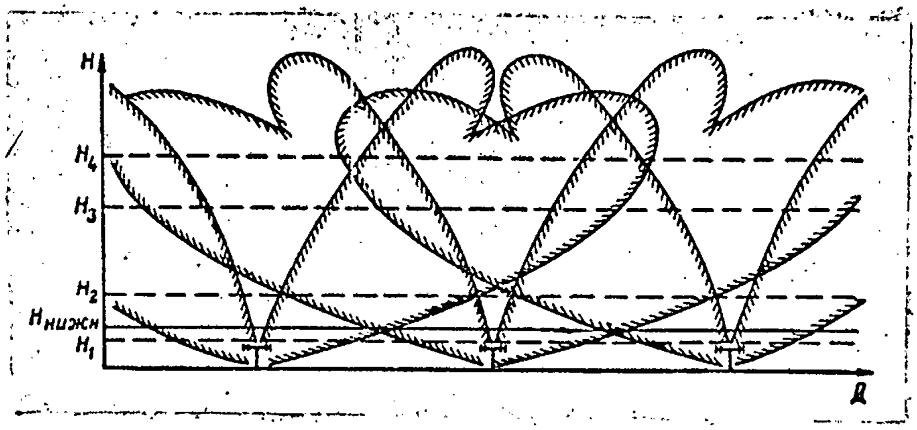
Flight altitude / D_v	100	300	500	1,000	2,000	3,000	5,000	10,000
Without considering refraction (km)	44	70	86	126	169	200	262	368
Considering normal refraction (km)	50	81	101	139	193	237	300	421

By comparing the data in tables 1 and 2 and figure 3, one notices how great is the effect of angles of crest clearance on target detection range. Further, even small angles of crest clearance lead to a sharp reduction in detection range. Their effect is particularly great on the range of detecting low-flying targets, is less for flights at average altitudes, and is negligible for flights at high altitudes.

In view of the fact that radio waves are subject to the phenomenon of diffraction (bending around objects), the range of detecting low-flying targets in this case would be somewhat greater than given in table 1. The influence of angles of crest clearance in hilly terrain may sometimes be of great importance. For example, a rise of 200 meters located at a distance of 12 km from the radar station will create an angle of crest clearance of 1°.

From the above it can be seen that ground clutter and angles of crest clearance exhibit a real influence on radar detection of low-flying targets. Careful selection of a position while taking into account the effect of ground obstacles on combat radar operation, a substantial knowledge of the layout and the nature of possible reflections, the correct formation of detection zones, and competent operation of the radar equipment will greatly facilitate the successful detection and continuous tracking of targets at low altitudes.

Another factor which should be considered in radar detection of low-flying targets is that the zones of detection for adjacent radar units at low altitudes do not always overlap along the entire flight course. Therefore, the radar at one of the units is sometimes the only source of radar display information. The situation may also arise when the overlapping of detection zones by several radar units is very important. In this case, the information from one unit is supplemented and verified by the others and the gaps which may exist in tracking a target are filled. Overlapping will be greater at average altitudes (H_3, H_4 -- figure 4) and less at lower altitudes (H_2).



H_{lower} D

Figure 4. Structure of the Vertical Plane Radar Field of Several Adjacent Units

Consideration of the unscanned sectors in a radar field is important in radar scanning for low-altitude targets. The possibility of continuous target tracking by adjacent radar units is determined by the presence of a solid radar field at a given altitude. The minimum altitude above which exists a solid radar field for a given grouping of radar units is called the lower limit of the radar field (H_{lower} - figure 4). For flight course altitudes less than H_{lower} there may exist unscanned sectors (H_1) in which the target will not be detected by the radar units. The target will be observed at this altitude in short sectors of its course by the radar station of only one unit. For this reason, the responsibility of each unit in tracking low-flying targets also increases.

The radar guidance of fighter aircraft operating at low altitudes involves many difficulties and has certain characteristics. There are cases when it is impossible to privide simultaneous observation of a target and guidance of fighter aircraft toward it on one radar screen due to the small detection ranges of the stations at these altitudes.

The demands for producing data with increased accuracy and less discreteness originate from the peculiarities of the operation of fighter aircraft at these altitudes and is characterized by, first, a decrease in range and duration of the flight of fighter interceptors and, second, by the small range of radio communications between the fighter interceptors and, second, by the small range of radio communications between the fighter aviation command post (or observation post) and the aircraft sent to intercept the targets. The radio communication range is limited to the visual range which is determined from formula (2). Taking normal refraction into account, the formula becomes:

$$D_v = 4.12(\sqrt{h_a} + \sqrt{H_f}),$$

where H_f is the flight altitude of the fighter aircraft (interceptor).

Without considering the height of the antenna at the radio station ($h_a = 0$), the visual ranges are given in table 3.

Table 3

H_f (m) / D_v	100	200	300	400	500	1,000
Without considering refraction	35.7	50	62	71	79	112
Considering normal refraction	41	58	71	82	91	130

As seen from the formula, in order to increase the visual range, it is necessary to place the receiving and transmitting antennas of the radio station at the highest possible points and to use tall masts. It should also be remembered that in hilly or broken terrain the visual range is significantly reduced as a result of the effect of angles of crest clearance caused by ground objects.

In conclusion, we should note that flight at low altitudes requires a great deal of concentration by the pilot since his proximity to the ground significantly hampers any maneuver with the aircraft in both the vertical and horizontal planes. Piloting the aircraft at low altitudes over a terrain with a varying profile is especially complicated.

The actions of the fighter pilot at low altitudes are also hampered by the fact that it is considerably more difficult to search for an aerial target against a background of ground obstacles and, if the target is detected, it is difficult to continuously observe (track) it.

These are some of the peculiarities of radar detection of low-flying targets and the guidance of fighter aircraft.

Measuring Angles of Crest Clearance of Radars -- by Engr-Lt Col Yu. P. GALKIN (Pages 42-44)

Text:

Radar stations of PVO Strany Troops have high tactical and technical performance capabilities and are able to quickly detect and reliably track aerial targets. However, these units can perform these tasks only with the strict fulfillment of certain requirements. One of these is the proper selection and equippping of a position with particular care paid to providing the necessary angles of creast clearance for the sta- 50X1 tion.

As is known, the angle of crest clearance influences the accuracy of forming the directivity pattern and, consequently, the accuracy of determining coordinates. At the same time, the angles of crest clearance of a radar also have a significant influence on the range of detecting targets, particularly those targets moving at low altitudes. It follows from figure 1 that if refraction is not taken into consideration, an aircraft flying at 3,000 meters may be detected at a range of 85.7 kilometers with an angle of crest clearance equal to two degrees. Increasing the angle of crest clearance by one degree reduces the detection slant range to 57.7 kilometers and an angle of four degrees will reduce the detection range to 42.8 kilometers.

Angles of crest clearance are determined at the present time by measuring with an ordinary artillery aiming circle. The aiming circle must be placed in immediate proximity to the receiver-transmitter cabin of the unit at a height of 130-150 cm from the surface on which the cabin rests.

However, practice has shown that the recommended method is not suitable in the majority of cases. The reason for this is that the receiver-transmitter cabin is usually located at a position within an earth wall whose height may reach several meters. Hence, with the eyepiece of the aiming circle placed at an elevation of two degrees, the line of sight hits the earth wall and measurement of the true angle of crest clearance of the radar is impossible.

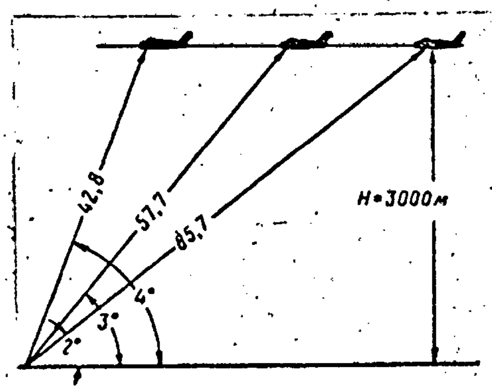


Figure 1

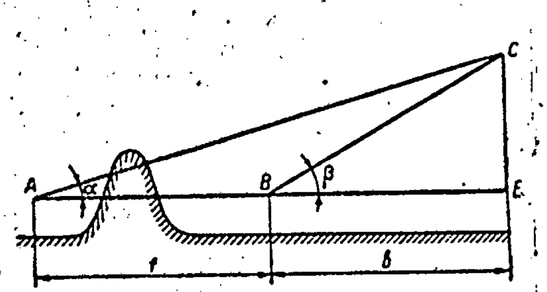


Figure 2

How should the angle of crest clearance be measured in this situation? Here, we may use a method of bringing the aiming circle out from behind the earth wall to a certain point B (figure 2). But, as we see from the figure, the angle of crest clearance measured from this point will never equal the true angle, that is, from point B we will measure some other angle which we will call the reduced angle of crest clearance. In order to establish its relationship to the true angle, let us examine the two right triangles ACE and BCE. For convenience we will denote the distance between points A and B (the base of the aiming circle) as f and the distance to the objects determining the angle of crest clearance of the station as b. We will call the angles formed by the triangles at points A and B as α and β respectively.

Then, from triangle ACE:

$$tg\alpha = \frac{CE}{b+f}, \qquad CE = tg\alpha\,(b+f).$$

On the other hand, from triangle BCE:

$$tg\beta = \frac{CE}{b}, \qquad CE = b\,tg\beta.$$

Equating the right sides of these equations we have:

$$tg\beta = tg\alpha\,\frac{b+f}{b}$$

or

$$tg\beta = tg\alpha\left(1+\frac{f}{b}\right).$$

From this formula it follows that the reduced angle β depends on the base of the aiming circle and the distance to the objects which determine the angle of crest clearance. Both of these distances may be measured easily at the site. Therefore, it is easy to find the reduced angle which will give us the true angle of crest clearance. By substituting the values for b, f, and the required angle of crest clearance α in the above formula, we may determine an entire series of reduced angles. The results of such calculations are given in the table. For purposes of these calculations the angle was taken as two degrees.

Let us assume that the aiming circle has been brought out to a point 25 meters from the cabin and the distance to the object determining the angle of crest clearance is 125 meters. From the table we find that the reduced angle of crest clearance, that is, the angle measured from the chosen point, should not exceed 2°24' or 0-40 divisions on the scale. This gives us the true angle of crest clearance of the station.

Using the data in the table, we were able to build curves showing the relationship between the reduced angle of crest clearance and the values "b" and "f." Such a table is shown in figure 3. The table permits us to easily determine β not only for fixed values of "b", but

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for intermediate values as well. For this, it is necessary to draw a vertical line from the point corresponding to the measured distance "b" to the point of intersection with the curve of the required base "f" and then to read the value of the reduced angle of crest clearance from "β" axis. For example, for a distance to the disturbing object of 131 m and an aiming circle base of 30 m, the value of the measured angle should not exceed 2°28'.

Dist. to obj. in meters (value b)	Value of reduced angle of crest clearance							
	for f = 15 m		for f = 20 m		for f = 25 m		for f = 30 m	
	in deg.	in div. on scale	in deg.	in div. on scale	in deg.	in div. on scale	in deg.	in div. on scale
25	3° 12'	0-53,5	3° 36'	0-60,0	4° 00'	0-67	4° 23'	0-73,2
50	2° 36'	0-43,4	2° 48'	0-46,8	3° 00'	0-50	3° 12'	0-53,2
75	2° 24'	0-40,0	2° 32'	0-42,3	2° 40'	0-45	2° 48'	0-46,8
100	2° 18'	0-38,4	2° 24'	0-40,0	2° 30'	0-42	2° 36'	0-43,4
125	2° 15'	0-37,6	2° 16'	0-37,8	2° 24'	0-40	2° 29'	0-41,4
150	2° 12'	0-36,8	2° 15'	0-37,6	2° 21'	0-39	2° 24'	0-40,0
175	2° 09'	0-35,9	2° 12'	0-36,8	2° 15'	0-37,5	2° 18'	0-38,4
200	2° 09'	0-35,9	2° 12'	0-36,8	2° 15'	0-37,5	2° 18'	0-38,4
225	2° 08'	0-35,6	2° 11'	0-36,4	2° 13'	0-37	2° 16'	0-37,8
250	2° 07'	0-35,3	2° 10'	0-36,0	2° 12'	0-36,8	2° 15'	0-37,4
275	2° 06'	0-35,2	2° 09'	0-35,9	2° 11'	0-36,4	2° 13'	0-37,0
300	2° 06'	0-35,2	2° 08'	0-35,8	2° 10'	0-36	2° 12'	0-36,8

In a number of cases when a broad area must be taken into account in order to provide the necessary angle of crest clearance for the station, the cabin is elevated on a reinforced concrete, wood, or earth platform. In this case, it will be possible to use the existing method. With the aiming circle placed next to the cabin on the platform, one can easily measure the angles of crest clearance without interference from the surrounding earth wall which is now below the line of sight. However, if the platform has a height of 0.5 to 1.5 m, it will again be necessary to move the aiming circle beyond the earth wall. In this case, however, a correction which takes into account the height of the cabin must be inserted in the formula for determining the reduced angle of crest clearance.

In order to determine the value of this correction, let us examine figure 4. Now Point A, from which measurements should be taken according to existing rules, is not only removed from point B by the distance f, but is also raised by height h. Therefore from triangle ACE,

$$Tg\alpha = \frac{H - h}{b + f},$$

where H is the height of the objects measured from the level of the aiming circle eyepiece.

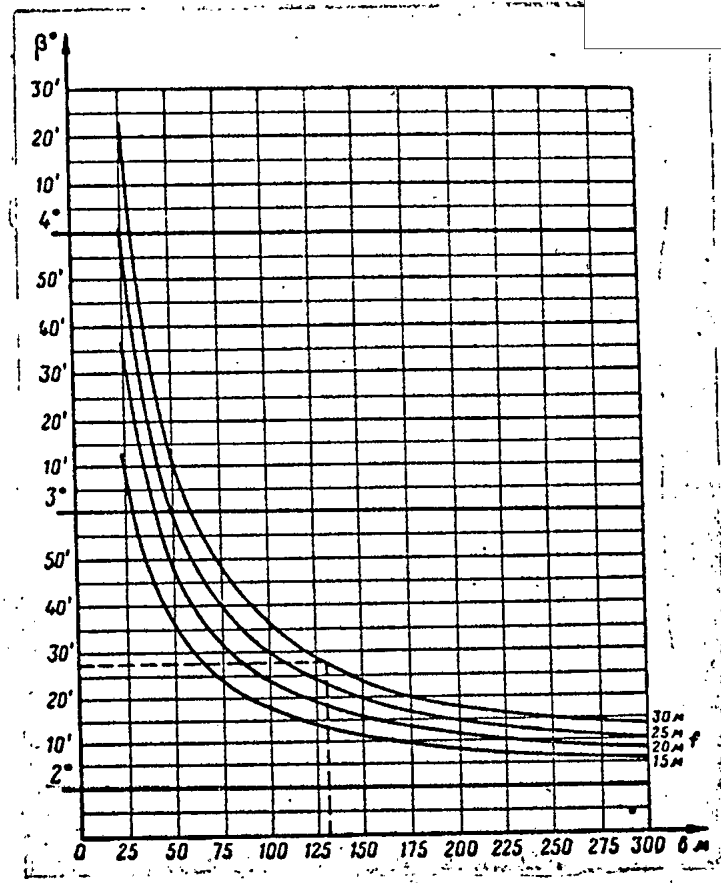

Figure 3

Solving this equation we find that $H = (b + f)tg\alpha + h.$ The value of H may be determined from triangle BCD:

$$tg\beta = \frac{H}{b} \quad \text{or} \quad H = b \cdot tg\beta.$$

Equating the right sides of the euations and converting the new equation, we have the required formula:

$$tg\beta = tg\alpha\left(1 + \frac{f}{b}\right) + \frac{h}{b} \,.$$

This formula differs from the previously derived formula only by the second addend which also determines the value of the correction for the difference between the levels of the cabin and the aiming circle. Consequently, the reduced angle of crest clearance for the case where the cabin is elevated may be successfully determined by using the data in the same table or graph and introducing the correction for the value h.

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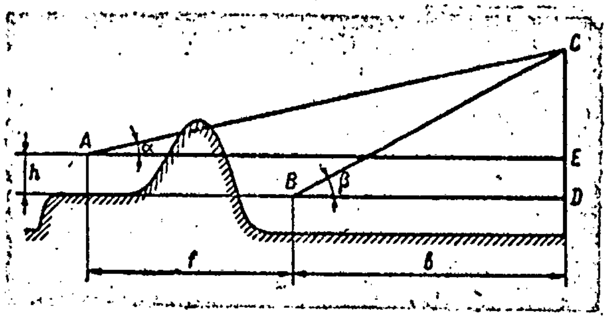

Figure 4

How should the measurement of reduced angles of crest clearance be made in practice at the radar unit position? For this purpose, three or four points should be chosen beforehand outside the earth wall where the aiming circle will be set up. For convenience in using the table or graph, it is desirable that all the points be the same distance from the cabin. Then, the aiming circle is set up at each point in turn. The highest obstacles in the chosen sector which will determine the angle of crest clearance for the station should be located by preliminary sighting. Then, the distance to the obstacles is measured. It should be noted that the farther away are the obstacles from the aiming circle, the less accuracy will be required in measuring the distance.

Knowing the values "b" and "f," it is easy to find the reduced angle of crest clearance from the table or graph and, after setting this value on the scale of the aiming circle, to again point the eyepiece at the obstacle. If the latter is below the horizontal crosshair of the aiming circle, the angle of crest clearance for the station will be less than 2°.

Measurements are taken at the other points in a similar manner. It is sufficient to select the points and determine the distances from them to the cabin and the obstacles only one time. After this, the previously derived data should be used in checking the angles of crest clearance.

It should be kept in mind that the tables and graphs given above are based on an angle of crest clearance for the radar station equal to 2°. If technical conditions demand that the angle be different, it will be necessary to make calculations according to one of the proposed formulas.

This method of measuring the angles of crest clearance of stations by moving the aiming circle outside the earth wall has been checked in practice. Experience has shown that, with good organization of work, personnel can perform all preliminary measurements in one hour and angles of crest clearance can be determined in 5-10 minutes.

Time Registering and Time Storage Equipment -- by A. A. LOGVINENKO and V. A. MERKUSHEV (Pages 45-48)

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Text:

It has been shown in practice that the accuracy of determining co-ordinates of different objects by visual tracking depends on the accuracy of the determination of the observation time. Since this problem is of particular practical interest, let us consider detailed methods of recording times accurately with the use of several chronometric devices.

Standard devices for the recording and storage of time include the 2P printing chronograph, the marine chronometer, the wide-band radio receiver that affords reliable reception of signals from time-service stations, the IP-M pulser, the stopwatch, etc.

Figure 1 shows the switching arrangement of time service equipment. The second signals are received by radio, amplified by the pulser, and printed on the chronograph tape. The chronograph motor is fed through a quartz oscillator. The signals of the recording chronometer can also be put on the chronograph tape. In order to prevent burning of the contacts ov the chronometer, it is hooked up to the chronograph input through relay RP-7. If the voltage of the loop fluctuates more than 10 percent, all the apparatus should be fed through a voltage stabilizer. At the same time, there should be no more than 4-5 amperes of current passing through the chronometer contacts.

A chronograph is a highly accurate instrument for recording time intervals. The moment of any printed impression can be determined in a universal system only if the chronograph indications are locked on to world time. This locking-on is accomplished by means of accurate time signals broadcast by radio stations on fixed schedules.

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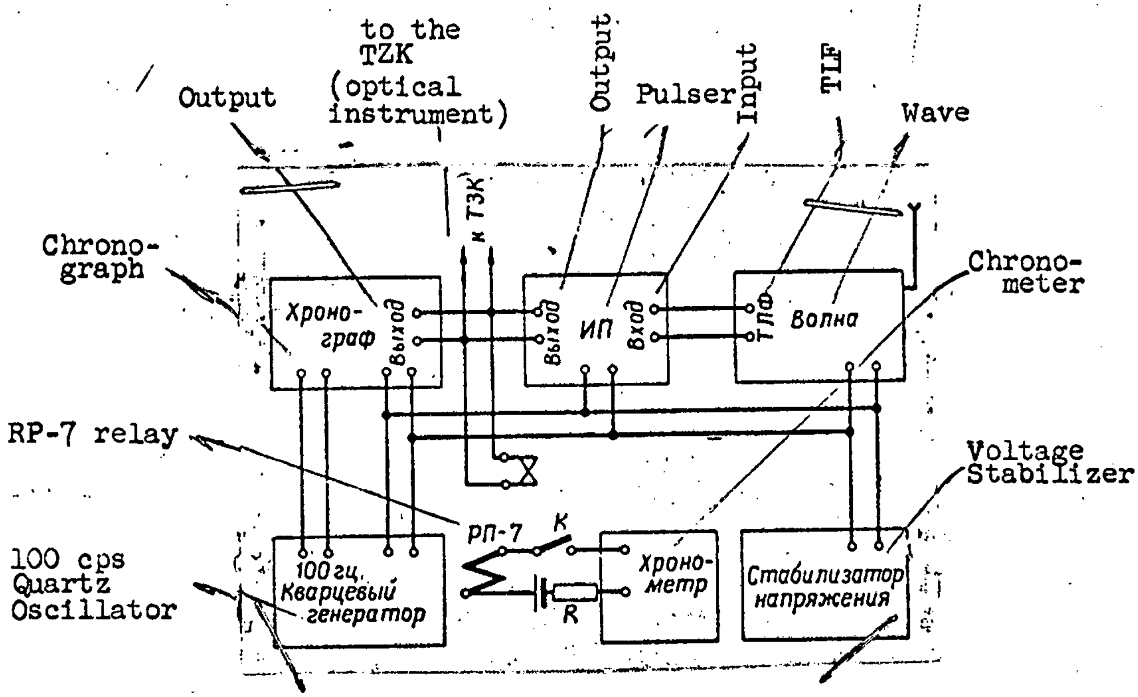

Figure 1. Switching Arrangement of Time-Serive Equipment

It is well known that all mechanical clocks have their particular movements, the accuracy of which is characterized by their constancy. The running of clocks, either slow or fast, is also a characteristic of the recording chronograph. The operation of a chronograph (for a given chrograph-oscillator unit) is satisfactorily stable, but with respect to absolute values it may be off as much as 0.05 seconds per hour. Variations occur primarily during the first hours of operation when the operating regime of the quartz oscillator has not yet become fully stabilized. This stabilization period differs for each quartz oscillator and can amount to as much as two hours even when the temperature variation in the compartment in which the instrument is located is not great. Therefore, before the chronograph is used for the storing of time, the stabilization period and the error must be determined. This work can be done most accurately by recording accurate time signals broadcast by radio stations on the chronograph with the use of the pulser.

The chronograph indications are locked on world time every 10 minutes for two or three hours. On the basis of the obtained data, a graph is plotted, with the abscissa indicating locked-on times in the sc 50X1 1 mm = 1 minute and the ordinate indicating the chronograph readings in the scale 1 mm = 0.001 seconds, the tenths and hundredths of a second being averaged out. The graph is used (Fig 2) to determine the time of unstable operation of the quartz oscillator, i.e., the time required for it to warm up, which is indicated by the projection of curve AB along the axis of the abscissa. On the illustrated graph this time is equal to one hour. An analogous determination is made of the chronograph error in the stable regime (projection of the straight line CD on the axis of the ordinate), which in our case is equal to 0.026 seconds per hour.

The chronograph error can be determined without making use of the continuous accurate time signals. All that is necessary is to determine the chronograph error three or four times according to the signals of one of the time-service stations. The time of unstable operation of the quartz oscillator can be determined by recording the second signals of highly accurate timepieces (for example, a marine chronometer) operated continuously and uninterruptedly for two to four hours.

The same method may be used to estimate the accuracy of the signals, "six dots," with reference to the accurate time signals. In this case the chronograph indications are locked on the accurate time signals and the "six dots" signals, and the results are plotted on a graph. If the accurate time signal curve and the "six dots" curve coincide, they have identical accuracy. The difference in the ordinates of these curves gives the value of the lag (or lead) of the "six dots" signals from broadcasting stations in relation to the signals of the accurate time service.

The accuracy with which moments of time can be fixed on a chronograph depends on the operation of a high-speed relay and impact-type electromagnet. The spread of the recordings on a chronograph should not exceed 0.005 seconds. Operating experience with printing chronographs has shown that their accuracy is most frequently impaired by a burning of the contacts of the high-speed relay or its maladjustment. For this reason, the accuracy of the printing mechanism must be tested periodically. To do this, print 10 second marks on the chronograph tape and check their accuracy. If the spread exceeds 0.005 seconds, the relay contacts are shielded and the spring tension is adjusted. Then repeat the printing of the 10 seconds marks and again test their accuracy. Repeat this procedure until the mean square error of 10 printings does not exceed plus or minus 0.002 seconds.

The chronometer is the chief time storer. The quality of an observation of a fast-moving object is determined by the accuracy of determination of the right ascention a, the declination δ, and time T (in a horizontal system, the accuracy of determination of the azimuth A, altitude h, and time T). The chronometer correction is determined according to the formula:

$$U = T_o - T_{khr},$$

where T_o is the average instant of arrival of the rythmic signals and

T_{khr} is the average value of the corrected instants.

The best method of determining observation times accurately for moving objects is to use a digital-recording chronograph, although at times it is necessary to determine observation times even without a recording chronograph. In such a case, the accuracy of the time fixing depends largely on the accuracy of determination of the chronometer error and correction. The most accurate method of determining the chronometer correction is that based on the use of the recording (printing) chronograph.

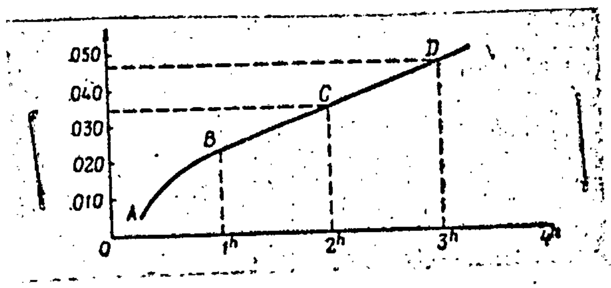

Fig 2. Graph for Studying the Chronograph Error

After the chronograph error has been determined by the reception of the accurate time signals, the output of the contact-chronometer is connected to the output of the printing chronograph (see Fig 1) and second pulses are printed on the chronograph tape as the chronometer contacts close each second. One of the teeth on the small gear wheel that closes the chronometer contacts is filed off. Thus at the moment of the passage of this gear wheel part, the mechanism does not operate and a two-second interval is left on the tape. The position of the filed-off tooth is arbitrary in relation to the second hand of the chronometer, but it will be constant over the entire operation of the chronometer.

Let us assume that the filed-off tooth of the chronometer will correspond to the 17th second. When a chronometer is hooked up to the chronograph for 15 seconds, the instants of contact 28.735, 29, 50X1 31.735, and 32.735 will be printed on the chronograph tape. The second interval shows that the first printing actually corresponded to 15 seconds and that the third printing corresponded to 18 seconds. Then the chronometer correction with respect to the chronograph entries amounts to 29.735 - 16.000 sec = 13.735 sec, i.e., the chronometer lags behind the chronograph by 13.735 seconds.

The detailed determination of the chronometer correction is done systematically.

The operation of the chronometer can also be ascertained on the basis of these observations.

Here we use the formula

$$\omega = \frac{U_2 - U_1}{\Delta T}$$

where U_1 and U_2 are chronometer corrections for the first and second locking-on of times and ΔT is the interval of time between these determinations.

The operation of the chronometer is very stable; for this reason it is, in practice, easy to determine the precise correction at any time of day or night.

It should be kept in mind that in those cases where the accurate time signals are heard very faintly and the pulser does not function, the chronograph correction can be obtained by means of the chronometer (reverse switching). If the chronograph or pulser is out of order, the chronometer correction can be determined by the reception of the rhythmic signals transmitted for 1-6 minutes almost every hour by the telegraph service. This is done as follows.

During 60 seconds of mean time, when the chronometer ticks 120 times, 61 dots are transmitted producing a particular venier whereby each minute one rhythmic signal precisely coincides in time with the tick of the chronometer as it tolls a full second. All that has to be done is to remember the number of this signal and record the chronometer indication so that the chronometer error can be computed. A reduction factor is taken from special tables and added algebraically to the chronometer indication. In the course of five series of signals, five coincidences will be detected. There will be just as many coincidences on the half-second ticks of the chronometer. Thus, for every transmission (reception) it is possible to compute the chronometer error ten times. An example of the determination is given below.

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No. of Series	No. of Signal	Chronometer Reading	Reduction Factor	Chronometer Indication at Mean Moment
I	5 /36/	$18^h\ 01^m\ 08^s.0$ 38.5	$2^m\ 25^s.08$ 1 54.59	$18^h 03^m 33^s.08$ 33.09
II	6 /37/	02 09.0 39.5	1 24.10 0 53.61	33.10 33.11
III	6 /37/	03 09.0 39.5	0 24.10 0 06.39	33.10 33.11
IV	5 /37/	04 08.0 39.5	0 34.92 1 06.39	33.08 33.11
				18 03 33.10

If the rhythmic time signals are to be received, it is recommended that a special record be set up as indicated.

When the rhythmic signals are received for the average chronometer, there is no need to use all five series. Only 4-6 coincidences or two-three series will suffice if the signal is loud and clear. It should be noted that an inexperienced observer will allow much greater deviation in the coincident seconds, but will in any case quite accurately determine tenths of a second, which are necessary for operating with the stopwatch-chronometer system.

Both the chronometer correction and the chronograph correction can be determined by means of the "six dots" signals that are transmitted by the broadcasting stations as a background to telephone transmission.

In this case, it is convenient to take advantage of the stopwatch, which should be started in time with the sixth dot and stopped on any tick of the chronometer and then read off. Let us consider an example. The stopwatch is started at $22^h00^m\,00^s0$ and stopped at 0^m30^s according to the chronometer. The stopwatch reads $0^m26.4^s$, which means that 26.4 seconds passed after the sixth dot. The chronometer is corrected on the basis of this value (chronometer reading was $22^h00^m30.0^s$; stopwatch read $0^m26.4^s$; the chronometer error was therefore -3.6^s and the chronometer correction accordingly is + 3.6 seconds).

The stopwatch can be used with an analogous method to determine the correction of the printing chronograph. However, a more reliable method has proved to be the printing of each of the six dots, as they are heard, by pressing down on the "print" button. In this case, the accuracy of the determination is within 0.5 second and the error of the intermediate member, of the stopwatch, is eliminated.

The recordings of time made by the digital printing chronograph are the simplest, most reliable, and most accurate means of determining the time for the passage of an object through a fixed point. The operation is extremely simple: a key or switch connected to the chronograph is closed at the time when the coordinates of an object are to be determined by one method or another. The decoded printing on the chronograph tape is adjusted in accordance with the chronograph correction and coded for telegraph.

A time determination by this method of observation is accompanied by inevitable errors, the most serious of which are the error due to the reaction of the observer (human error) and the lag of the recording device. The error of response of a high-speed relay and the error in the determination of the running of the chronograph in our case, i.e., in the case of an accuracy of time determination within plus-minus 0.1 second, do not exceed plus-minus .01 second and are therefore not taken into account, whereas the human error of the observer must be taken into account fully. A somewhat more accurate fixing of time is provided by the microswitch, the response of which is accompanied by a sharp click. However, the position of the object at the actual instant of the time fix will be determined with less reliability. When the time is fixed at the moment of the intersection of the grid crosshair by the object using the "ear-eye" method, it may be found that the object has not yet reached the crosshair or has already passed it.

The main shortcoming of an observation of a fast-moving object is the absence of a reliable check on the determination of the instant of observation. We still do not have a rule whereby we can compare two or more observations and separate the most reliable ones. For this reason, only a repeated time fix for a single passage of an object affords the possibility of comparing observations and estimating their accuracy. 50X1

The passage of an observed object through the cross hair of the grid of a telescope can also be fixed in time by means of a stopwatch, this method poses no particular difficulties. However, the accuracy of the final determination of the time of observation by this method requires close attention.

At the instant the object crosses the cross hair of the grid, the observer presses the stopwatch switch. Already, we can encounter two sources of error: that inherent in the reaction of the observer and that inherent in the operation of the stopwatch switch. After the entry of the necessary recording, the stopwatch is checked either with the chronometer or with the chronograph. First of all, it can be pointed out that the error in the locking-on of the time of observation to the indications of the chronometer will be greater than in the locking-on to the chronograph since it will be necessary to check the stopwatch against a particular second on the chronometer after counting off the required number of seconds. With the chronograph check, however, the comparison can be made at any time. Here, however, the error inherent in the response of the button that activates the relay must be added to the error inherent in the mechanism that stops the stopwatch. For this reason, the accuracy of the final determination of the time of observation with a stopwatch can be considered about the same, whether it is checked against the chronometer or against the chronograph.

If we consider each component of the error of time determination as equal to 0.1 second, the total error will be twice as great. The errors in the determination of the running of the stopwatch and its unreliability additionally distort the result by a value which is not accounted for and is therefore disregarded. Thus, the total value of the error of the time of observation amounts to not less than plus-minus 0.2 seconds.

It can be seen that the use of the stopwatch-chronometer system, like the single time fix with the chronograph, is not very accurate and especially does not afford the possibility of estimating the quality of observations, or, more precisely, does not afford the possibility of estimating the accuracy of the fixing of the time of observation. This is the reason why the repeated time fixes with the required digital-recording, or similar, chronograph and grid crosshairs are used, which afford the possibility of repeated time fixes.

It is well known that the use of the method of repeated time fixes is possible with the digital chronograph and special grid crosshairs and is applicable only in the case of a stationary optical device (TZK).

In practice, observations frequently are made simultaneously with the passage of two or more objects. Here, the main difficulty lies in the recognition of the chronograph printings that refer to the individual objects. There are several methods of getting around this difficulty. First, the observers can be assigned to different objects. At the moment his object passes, the observer calls out his number which is transmitted to an operator who records its time of occurrence in relation to the others. Subsequent processing of the chronograph tape is done in the usual order as with a group of observations of a single object. In the case of simultaneous observation of several objects by the same observers (second method), each object has its own number. Then, at the moment of passage, the observer announces his number and the number of the object which he is fixing at that particular moment. In this operation, the operator records all the reports forwarded to him and then divides the recordings according to object.

Another method is to check the printing of the chronograph by means of a stopwatch. In this method, one of the objects is fixed by all observers in the usual order and at the time of passage of a second object, the observer also starts his stopwatch and then checks it against the chronometer or the chronograph. Thus, two independent determinations of the moment of passage are obtained for one of the objects. Coincident moments of time will relate to one object and the remaining moments of time will refer to the other. The simultaneous fixing of the motion of an object with chronograph and stopwatch can also be used in the observation of a single object. This affords the possibility of an accurate determination of the sequence of intersection and excludes coarse errors without the participation of the operator.

<u>Questions of Interest to Officers</u> -- by Engr-Lt Col M. G. UTKIS (page 49)

Abstract:

States that modern commanders need to have wide knowledge in physics and mathematics and suggests that instructors be specially trained in these fields to provide better school training of officers.

<u>Necessary Training Aids</u> -- by Engr-Capt N. V. SMETANIN (page 49)

Abstract:

Suggests that a central organization for dissemination of technical literature be established in PVO Strany Troops.

EQUIPMENT AND ITS USE

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Reliable Radioelectronic Equipment Operation in Winter Conditions -- by Engr-Col V. A. SAKHAROV (pages 50-53)

Abstract:

Concerns difficulties encountered in operating and maintaining radar and cybernetics equipment in winter conditions and advises methods for better equipment operation.

(A captioned photograph by V. INYUTIN on page 53 shows M/Sgt A. ISKHANOV soldering electronic equipment).

Maintaining Airfields in Excellent Condition During Winter -- by Col G. V. ASTRAKHANTSEV and Engr-Col V. I. POLIVIN (pages 54-56)

Abstract:

Discusses the work performed by personnel of airfield maintenance services to maintain airfields in excellent operating condition during the winter months.

(A captioned photograph on page 55 by P. GORDIYENKO shows Tech-Sr Lt A. SAVITSKIY discussing equipment preflighting with aviators).

An Important Element in the Training of Military Engineers -- by Engr-Capt A. G. MIKHNUSHEV (pages 57-58)

Abstract:

Concerns work carried on in laboratories and by extracurricular technical groups in higher military training institutions.

(A captioned photograph on page 58 shows Engr-Capt A. BRYLEV working with electronic equipment).

Why Does Oil Consumption in an Engine Increase -- by Engr-Lt Col E. A. SHERSHER (pages 59-60)

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Text:

The following occurred in one of the aviation units. During the period of preparing an aircraft for flight when other operations were being conducted, a check was made on the oil fueling of the AM-5 engine. The oil level in the tank showed full. At the end of the flight, however, the tank showed no oil. Where could it have gone? During a postflight inspection, there was no evidence of an impairment of the tightness of the seal of the engine oil system and the filler neck of the tank was tightly closed. Such a condition put the aviation specialists on the alert since engine operation without oil can lead to a jamming of the transmission rotor and put the engine out of commission entirely.

An analysis of the occurrence showed that the oil began to eject from the breather tube into the atmosphere 16-20 seconds after the engine was brought up to full rpm. When the rpm were held constant, there was a spontaneous increase of pressure in all the cavities of the oil system. The pressure increased from 0.26 to 0.78 kilograms per square centimeter in the oil tank and from 0.8 to 1.0 kilograms per square centimeter in the cavity of the after bearing. In addition, the oil pressure increased 0.3 - 0.4 kilograms per square centimeter over the pressure value at take-off.

The processing of oscillographs on which the "pressurization" phenomenon was recorded showed that the initial pressure increased abruptly in the accessory housing and then, after 1-1 1/2 seconds, increased also in the oil tank and other cavities of the oil system. When the "pressurization" occurred, the level of the oil in the tank dropped approximately two liters. During this time, in the oil breather tube, there was an intense flow of foamy oil coming from the cavities of the middle and after bearings and up to the breather. As a result, the ejection of oil through the breather pipe was associated with a spontaneous increase of pressure in all main lines and cavities of the oil system.

Why did this spontaneous increase of oil pressure take place? The most probable reasons may be stated as follows: The ingestion of air from the compressor or of gases through the labyrinth seals inside the oil cavities; the unbalance of the input and output of oil in the cavity of the middle and after bearings; the increase of pressure in the oil system associated with the operation of the centrifugal breather.

A comparison of the parameters of the investigated engine for the time just before the ejection of oil began with the parameters of other engines in which no ejection of oil occurred showed that the values for various operating regimes were approximately the same. It should be pointed out that, in engines that had shown earlier ejections of oil, the adjustment of all the labyrinth seals to minimum clearances did not correct the defect.

In order to find out what influence on the oil system produced the increase of pressure in the cavity of the middle and after bearings, one normally operating engine was specially assembled without packing rings on the tubine shaft. Under take-off conditions there was an increase of pressure of 0.25 kilogram per square centimeter and the pressure reached a value of 1.0 kilograms per square centimeter. However, this did not lead to a sharp increase of pressure in the oil tank or in the accessory housing and did not cause an ejection of oil. At the same time, reducing the output of the air supplied to the labyrinth seal of the front bearing through the outside tube by throttling it completely with the throttle plates, did not remove the defect from the engine in which the oil was ejected through the breather. A check on the tightness of the seal in the oil cavity of the after compressor housing revealed no defects, such as cracks, which might lead to an abrupt "pressurization" of the oil cavities of the bearings.

Thus, the experiments conducted afforded the basis for the conclusion that the spontaneous increase of pressure in the oil system of the engine, the so-called "pressurization", accompanied by the ejection of oil into the atmosphere was not the result of an inrush or ingestion of compressed air or gases inside the oil system.

The determination of the relationship of input to output of oil in the cavity of the middle and after bearings of the rotor showed that the oil level in the bearing cavity did not change, but remained at the level of the top of the scavenge pipe when the engine was revved up to an overspeed of approximately 800 rpm.

From a comparison of the gap tolerances in the oil labyrinth seals and in parts of the oil pumps and breather, of the outputs of the oil-pressure pump and the oil-scavenger pump; of the seepage of the rotor-journal oil nozzles and the seepage through the front engine housing in the engine that ejected the oil with the same data for engines in which this faulty effect was not evident; no deviation from normal nor any pattern which would characterize the engine that used up the oil could be established. Consequently, the second reason for the defective operation was also invalid.

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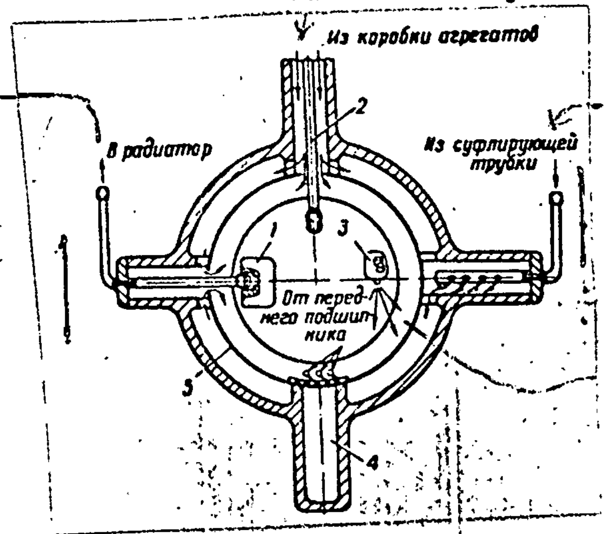
In order to determine the influence of the centrifugal breather on the operation of the oil system, it was put out of operation by removing its drive gear. Then, there was no "pressurization" of the oil tank, accessory/housing, and other parts of the oil system. On the basis of this, it was concluded that the changes in the operation of the oil system of the engine and

from accessory housing

to radiator

from the breather tube



from front bearing

Supply of Oil to the Front of the Compressor Housing

1. oil scavenger pumps
2. spring
3. centrifugal breather
4. forward sediment trap
5. liner

the associated consequences came from the centrifugal breather itself. This was also confirmed by the fact that when the output from the breather was briefly obstructed while the engine was operating normally the "pressurization" phenomenon resulted, whereby the pressure of the oil increased in all the cavities of the oil system.

Thus, plugging up the breather artifically produced a simulated phenonomen which was produced spontaneously in the engine ehich ejected the oil. It became evident that, for a number of reasons, the centrifugal breather was fed an amount of oil that it could not "digist", that is, it could not separate the air and discharge it through the pressure-relief opening. This means that there was a hydraulic occlusion in the breather which led to increased pressure in the oil system and the ejection of oil into the atmosphere through the air vent pipe.

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Inspections of glass liners inserted in the scavenger tubes and breather tube showed that a compressed oil emulsion moved at high speed along the pipes leading from the front, middle, and after bearings, and also along the breather pipe. It was evident that a rather large amount of oil flowed to the leading edge of the front housing via the breather pipe since after the engine was shut off this area was more than half full of oil. Even when the oil was being ejected strongly into the atmospheres, no oil collected in the forward sediment trap which remained almost empty the entire time. Oil can reach the sediment trap only after it has moved inside the liner since the greater part of the oil is sucked into the input openings of the breather and does not go immediately to the drain into the front sediment trap. This might explain the overfilling of the breather with oil and the small amount of oil in the front sediment trap as well. Such a condition is caused by the absence of openings in the lower extension of the inside cavity of the front housing of the compressor (see illustration).

It was thus established that the increased consumption of oil resulting from the ejection of oil through the breather was due to an insufficient passage capacity of the breather, causing a hydraulic occlusion of the breather when the amount of oil supplied to it was increased somewhat. At the same time, the excess supply of oil to the breather input can be explained by a number of causes, including the excess of oil supplied to the front housing from the cavity containing the middle and after bearings. Complete control of such a condition is extremely difficult to attain.

When engines are being tested on the ground or operated in flight, the times specified in the instructions for continuous operation at maximum rpm should not be exceeded. The number of checks on the consumption of oil should also be increased. Since the excessive consumption of oil is accompanied by an increase in oil pressure, the pressure should be checked immediately after the engine develops a particular speed and immediately after its period of operation at this speed, keeping in mind that the oil pressure increases 0.3-0.4 kilograms per square centimeter when hydraulic occlusion develops in the breather. In case of doubt, it is well to use the special stopper on the oil tank filler neck. This stopper has a screw-in type connector with attached manometer for measuring the oil pressure in the tank. At take-off rpm, a spontaneous pressure increase of 0.25-0.35 kilograms per square centimeter brings the pressure in the tank up to about 0.7 - 0.8 kilograms per square centimeter.

Prospective Developments in Short-Wave Radio Communications -- by Engr-Col V. P. YAGODIN (pages 61-65)

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Abstract:

Based on the foreign press, discusses the importance of short-wave radio communications, its history of development, and current research being carried on to improve it, primarily phase modulation. Foreign press sources cited include: Wireless World, April 1960; Journal of British Institute of Radio Engineers, No 12, 1960; Proceedings IRE, Australia, October 1960; Proceeding IRE, V. 107, 31, part B, 1960; Communication and Electronics, January 1958; Point to Point Telecommunications, No 3, 1960; and Missiles and Rockets, No 10, 1960.

Earth and Space Communications (page 65)

Abstract:

Based on an article in Space Aeronautics, No 6, 1962; discusses advantages and disadvantages of certain radio frequencies for earth space communications.

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INNOVATIONS AND INVENTIONS

Attachment to a Coil-Winding Bench -- by Engr-Maj V. T. ZAVIDEYEV, (pages 66-67)

Text:

The various attachments and instruments used to detect short-circuited windings in audio-frequency transformers and coils, as a rule, provide such a detection after the part has already been fully assembled, thus requiring the complete disassembly of the transformer or coil to eliminate the short and remove or repair the damaged conductor. This is a laborious operation.

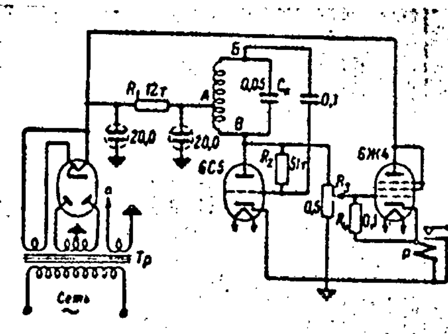

Рис. 1.

Figure 1

The coil-winding bench attachment described below affords the possibility of detecting a shorted winding directly during the conductor-winding operation. The electrical circuit shown in Figure 1 is installed under the base of the winding bench, and the main axle is altered as shown in Figure 2. A small special lamp signals the presence of the shorted winding.

The electrical circuit consists of the power supply circuit incorporating a 6Ts5S tube, an oscillator circuit with a 6S5 tube and an amplifier with a 6Zh4 tube. If the size and weight of the attachment have to be reduced, a rectifier circuit with DGTs-27 (or D7Zh) germanium diodes can be used. This alteration eliminates the necessity of using a power transformer.

All the parts of the circuit except for the tank coil L_k and the signal lamp L_s are mounted under the base of the bench. The tank coil (2) is coated and hermetically sealed to the main axle of the bench (1 in Fig 2). PEL (PEV) .25-mm wire is used to wind a coil consisting of two section, AV and AB. Section AB has approximately 500 turns, and section AV approximately 1,000 turns.

In order to provide a reliable contact between the rotating tank coil and the fixed electrodes of the 6S5 oscillator tube, a slip-ring (5) is attached to the axle between the tank coil (2) and the handwheel (7). The slip-ring (5) consists of two copper rings slipped tightly over the cylinder which is made of textolite, ebonite or organic glass. Each of the rings of the slip-ring is directly coupled to points A, B and V of the tank coil L_k by means of jumper wires. The brushes (6) which slide on the rings of the slip-ring, remove the voltage to the circuit.

The main (driving) axle of the winding bench has three parts. Section (1) is a separate unit made up of sheets of electrical steel 110-120 millimeters long. On the right end of this laminated section, the tank coil (2) is slipped on and hermetically sealed. Part (3) is made of nonmagnetic material and connects part (1) to the general steel axle, where on the center between the two bearings (4), the slip-ring (5) is slipped on and hermetically sealed. The dimensions of all the parts of this drive axle are quite arbitrary and depend only on the design of the winding bench.

The form of the coil to be wound is slipped on and temporarily attached to the unwound core of the tank coil (1). The appearance of a short-circuited winding as the coil is wound produces a change in the over-all inductance of the circuit.

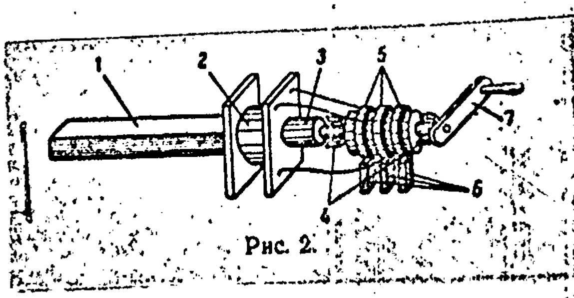

Рис. 2.

Fig 2

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As a result, the cathode current of the 6Zh4 tube increases and relay R responds to close the circuit of the signal lamp L_s.

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The sensitivity of the attachment can be regulated by changing the value of resistor R_3 which is accessible from outside for the sake of convenience.

The thus remodeled winding bench affords the possibility of detecting, during the winding process, a single shorted winding 0.1 millimeter in diameter when the average diameter of the loop is 100 millimeters. To get more sensitive response from the attachment when the coil has windings 0.1 millimeters in diameter and less, it is best to replace the signal lamp with a needle indicating instrument such as a voltmeter. If this is done, the relay R in the cathode circuit of the 6Zh4 tube is replaced by an 800-ohm resistor R with a 0.25 watt output, to which a voltmeter is connected in parallel. The use of the voltmeter assures a reliable signalling of not only a shorted out winding, but even of reduced insulation on a conductor.

<u>Quicker Thermometer Readings</u> -- by Lt Col Med Serv S. A. TAMAZYAN (page 67)

Abstract:

Describes the construction and operation of a device used to prewarm thermometers used to give preflight medical examinations to pilots.

Nuclear and Plasma-Jet Engines -- by Engr-Maj I. S. KRASIL'NIKOV and Engr-Sr Lt I. N. MAKARYCHEV (Pages 68-71)

Text:

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During the past decade rocket engineering has made a tremendous stride forward in development. Flights of aircraft over great distances and at very high speed became possible through the development of powerful jet engines. However, the limitations of the operating parameters (specific impulse, combustion period, useful load, specific weight) of a jet engine utilizing the chemical energy of a fuel restrict the range of flight.

Extensive scientific research work is being done abroad on the development of powerful jet engines that will sustain operation for a long period of time in space craft and ballistic rockets, surface-to-air guided rockets, and anti-missile, antisatellite and antiheavy-aircraft missiles.

Most promising from the power engineering standpoint, according to foreign experts, are the nuclear and plasma-jet engines. They will be superior to chemical fuel engines because of their higher specific impulse (800 sec at present with a possibility of increasing to 10,000 sec in the future) and a much smaller fuel weight carried aboard the space craft.

Unlike chemical fuel jet engines, these engines have an energy source separate from the thrust producing substance. In both types of engines, the thrust is generated by the efflux of a mass. However, in the nuclear of plasma-jet engines, the quantity of effluent mass is much smaller for the same rated power because the thrust generating substance can be accelerated to much greater velocities. Besides, in such jet engines, the thrust generating substance can be accelerated and its rate of efflux can be varied.

In nuclear and plasma-jet engines, the thrust generating effluent substance is a plasma produced by the ionization of atoms. This process takes place at a very high temperature where the fusion of light nuclei or the fission of heavy nuclei begins. The plasma can be produced by heating atoms to a very high temperature with an electric arc, by compression, with solar or nuclear energy or a high-voltage electrical discharge. Plasma can also be produced by the action of electromagnetic high-frequency induction or by a bombardment of atoms with particles at low pressure, i.e., electron emission from a hot cathode or radiation from a radioactive isotope.

Plasma is an ionized, highly heated gaseous substance with atoms separated into ions and electrons. A plasma is rarely fully ionized; usually it contains some neutral atoms. A plasma consisting of positively and negatively charged particles as well as neutral atoms is, as a whole electrically neutral, but under certain conditions it may acquire the properties of a conductor. This later property is utilized in order to obtain a high velocity of efflux of the gaseous plasma products from the nozzle of a plasma-jet engine.

Plasma-jet engines are divided into electrostatic, electromagnetic and electrothermionic types. In the first type of engine, the positively and negatively charged particles are accelerated by an electrostatic field. Depending on the nature of the thrust generating substance, these engines are again divided into ionic and colloidal types. In the ionic engines, the positively charged ions and negatively charged electrons are accelerated. The ionization of the thrust generating substance (cesium or rubidium vapors) is produced through contact with a heated surface of a metal such as tungsten or platinum. The cesium and rubidium atoms have a low ionization potential, but heated tungsten and platinum have a high ionizing capability. Besides, ionization may occur as a result of a bombardment of the atoms of the thrust generating substance by electrons. In colloidal plasma-jet engines, the particles are larger than the ions, but they do not exceed one micron in diameter.

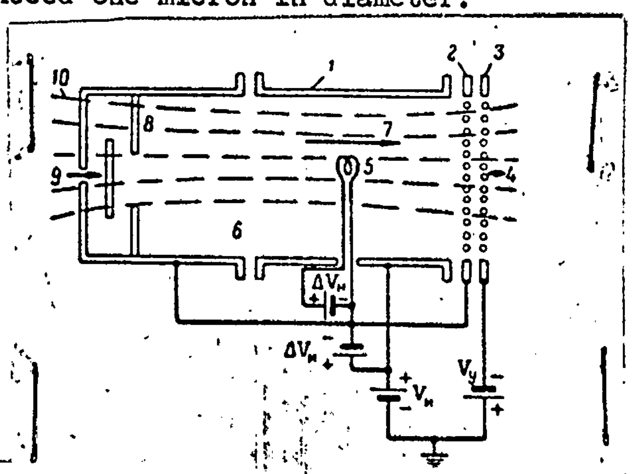

Fig. 1. Schematic Diagram of an Ion Plasma-Jet Engine

1. anode
2. grid
3. accelerating electrodes
4. stream of ions
5. filament (cathode)
6. ion chamber
7. lines of force of magnetic field
8. distributor
9. entrance for thrust-generating substance
10. magnetic lines of force

ΔV_n - potential difference at the filament

ΔV_i - potential difference at the ion chamber

V_i - potential at ion chamber

V_u - potential at the accelerating electrodes

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In the plasma-jet engine shown in Fig 1, mercury vapors are used as the thrust generating substance. An ionization of these vapors occurs as they enter the opening 9 as the result of bombardment with fast electrons (20-100 v) emitted from filament 5. Heater grid 2, distributor 8 and the negative end of the filament are at the same potential. Therefore there is no movement of electrons along the axis of the ionization chamber. Parallel to the chamber axis is a magnetic field 10 which prevents the penetration of fast electrons into the chamber walls before they have collided with the particles of the thrust generating substance. Part of the ions formed as a result of such collisions pass through grid 2 of the ion chamber, are accelerated by electrodes 3, and form a beam 4. The flux of ions ejected from ion chamber 6 creates a thrust.

The diameter of this engine is 10 centimeters. For an efficiency of 0.27, the specific impulse is 4,500 kg/sec/kg and for an efficiency of 0.33, the specific impulse is 5,500 kg sec/kg. In improved engines, the efficiency can be raised to 0.52 - 0.69 for the same specific impulse.

A plasma-jet engine with 19 ion jets has been built abroad. Cesium vapor is used as the thrust generating substance. The maximum thrust of each jet is 15.5 mg and the specific impulse is 6,600 kg sec/kg. Tungsten is used as an ionizer. The engine thrust is regulated by varying the amount of thrust generating substance admitted to the ion chamber and the potential of the electrostatic field. During such a regulation there is obviously, also a change of engine efficiency. (See Missiles and Rockets, No 19, 1960).

In plasma-jet engines or, as they are also called, magnetohydrodynamic engines, the plasma produced by an electric arc or induction heating is accelerated by a magnetic field. These engines are divided into pulse-jet and continuous-jet engines. Figure 2 shows a continuous action plasma-jet engine which operates on the principle of interaction between a high-frequency electric field and a uniform magnetic field. As a result of such interaction, the plasma is rotated and accelerated in the direction of the magnetic nozzle which, in turn, transforms the spiral motion into a rectilinear motion. The operation of such an engine is given below. With the aid of a special device 3, the thrust generating substance (plasma) is introduced into the nozzle. Under the action of a high-frequency electric radiator 1 and winding 2, the ions and electrons of the plasma are accelerated. The ejection velocity reaches several kilometers per second.

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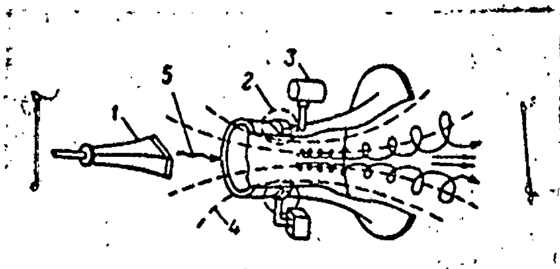

Fig 2. Schematic Diagram of a Continuous-Action Plasma-Jet Engine

1. high-frequency horn type radiator
2. winding for producing a uniform magnetic field
3. introduction of the thrust-generating substance (plasma)
4. uniform magnetic field
5. high-frequency electric field

In the engine (pulse-jet with traveling magnetic field) shown in Figure 3, the plasma is accelerated by means of a magnetic "piston" formed by successive discharges of a series of capacitors through induction coils located along the engine. The engine operates as follows. The plasma is introduced into the nozzle by a special device. A series of capacitors with induction coils 3 form a traveling magnetic field, the so-called magnetic "piston" (4), inside the nozzle. Under the effect of this field, the ions and electrons of the plasma are "twisted" and ejected with high velocity. According to reports in the foreign press, velocities up to 38 kilometers per second for plasma ejection were obtained in these experiments.

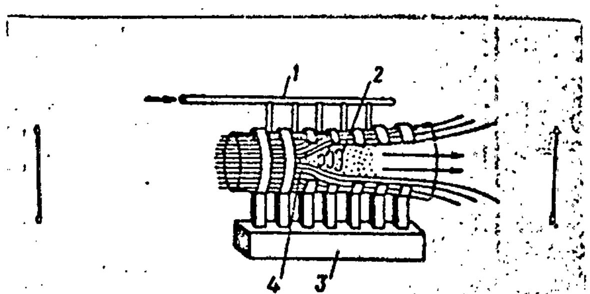

Fig. 3 Pulse-Jet Engine

1. inlet of the thrust-generating substance (plasma)
2. induced electric currents
3. a series of capacitors with induction coils
4. magnetic "piston"

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A foreign firm has designed such an engine for use in satellites and space craft. In the opinion of the foreign experts, it will control the trajectory of satellites and other space ships and control their movement under conditions of weightlessness. Solar cells will be used as a source of energy to charge the regular batteries which, in turn, will charge the capacitors located along the nozzle. The capacitor discharges, following in a sequence of 2-10 per second, will act as a magnetic "piston," i.e., will push backward small jets of highly heated ionized gaseous nitrogen. As a result, the thrust will reach a value of 45 g. Such a thrust, in the opinion of the experts, will be sufficient for an effective flight of a craft in space. A small nitrogen tank will be sufficient for operating such an engine for a period of two years. (Popular Science, Dec 1961; Aviation Week, No 13, 1960) According to reports in the foreign press, a more powerful magnetohydrodynamic plasma engine has been designed at the Laboratory for the Investigation of the Technical Problems of Intercontinental Flights USA. Hydrogen, deuterium, and lithium are used as thrust generating substances.

In nuclear jet engines, a large quantity of energy is liberated in the course of the nuclear reaction. The thrust generating substance, generally a light gas, passes through the reactor core, is heated to a very high temperature and partially ionized, and then ejected from the nozzle at high velocity to produce a thrust. A schematic diagram of such an engine is shown in Figure 4. The thrust generating substance (7), hydrogen with a high-ionization capacity, is pumped into the outer jacket of the nozzle (1) where it is heated by cooling the nozzle. The heated hydrogen is admitted to the reactor (2) which consists of uranium rods and a graphite moderator. A controlled nuclear reaction takes place in the reactor core (3) to generate a considerable quantity of energy for a long period of time. As the hydrogen moves along the reactor core, it becomes heated and ionized. The highly ionized and heated hydrogen (plasma) passes from the high-pressure chamber at high velocity into the nozzle and then is ejected from the nozzle, thus generating the thrust.

The electrothermic jet engines operate in the following manner. Plasma produced by electric arc discharges or with a laser is fed to the nozzle and ejected from it at high speed, thus generating a thrust.

A power source is needed to ensure the operation of plasma-jet engines. Solar cells, chemical batteries, radioisotope batteries, and nuclear reactors are suggested as possible sources.

In 1960, US industry began producing solar cells with efficiencies of 0.12 - 0.15 and in 1962, the production of power installations with solar ray collectors was initiated (Popular Science, Dec 1961). It was reported that the use of collectors increased the capacity and reduced the weight by 20%. Film type solar cells with high specific power capacity are also being developed in the United States. Such cells are to be installed on the outside of aircraft. The US Air Force and Atomic Energy Commission consider possible the development of nuclear engines with capacities of 300 - 1,000 kw for use in satellites and space craft, and 50X1 the use of the electricity of the moon as a power source. (Missiles and Rockets, No 4, 1962).

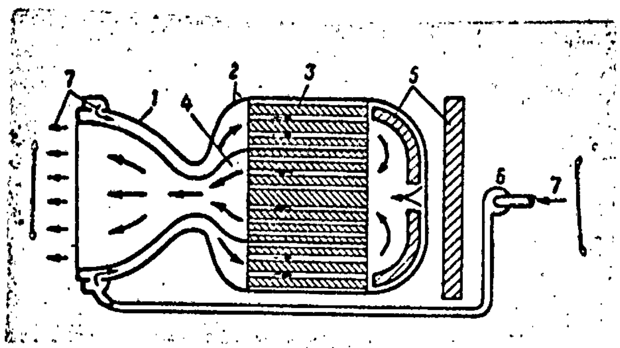

Fig 4. Schematic Diagram of a Nuclear-Jet Engine

1. nozzle
2. reactor
3. core of the reactor
4. high-pressure chamber
5. radioactive shielding
6. pump
7. thrust generating substance

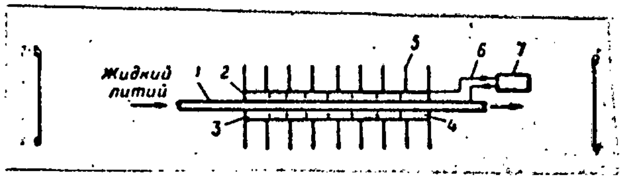

Fig 5. Schematic Diagram of a Thermionic Energy Converter

1. cathode (tungsten tube)
2. anode (molybdenum tube)
3. interelectrode space with cesium vapors
4. " " " " "
5. heat dissipating ribs
6. external electric circuit
7. electric energy consumer

According to American experts, the most reliable power generating unit is one employing a thermionic conversion of energy. As can be seen from Figure 5, such a converter consists of a tungsten tube cathode (1) inserted into a molybdenum tube anode (2). The 0.25-millimeter interelectrode space (3) is filled with cesium vapors for the purpose of neutralizing the space charge. The outer surface of the anode has ribs (5) to dissipate heat. Liquid lithium heated in the heat exchanger of the reactor to a temperature of 1,176 - 1,243 degrees centigrade is circulated through the internal tube by a centrifugal pump. The heated cathode emits electrons which are admitted to the anode, then through an external circuit (6) to the electric energy consumer (7), and then back to the anode. 50X1

This converter underwent a test that lasted 20 hours at a pressure of 10^{-5}mm Hg. An output power of 74 watts was obtained. According to the US press, a nuclear power generating unit on the navigational satellite "Transit 4A" has been in operation for more than a year and has generated 23,56 kwhr of electrical energy during this time. The power generating capacity of this unit (2.7 watts) has not deteriorated during this period (Missiles and Rockets, No 6, 1962).

In the opinion of foreign military experts, nuclear and plasma-jet engines will be fully capable of maintaining in a desired orbit artificial earth satellites and other craft designed for global military reconnaissance, transmission of data on a military situation to installations for anti-rocket and antispace defense, as well as for the interception and destruction of ballistic rockets and other flying devices. It is believed that space ships will have a multistage power generating installation. The existing reactive engines with chemical fuel will be used in the first stages of space craft. The schematic diagram of such a craft is shown in Figure 6.

The development of new types of jet engines shows that the aggressive circles in the United States continue to conduct extensive research on the creation of new offensive weapons.

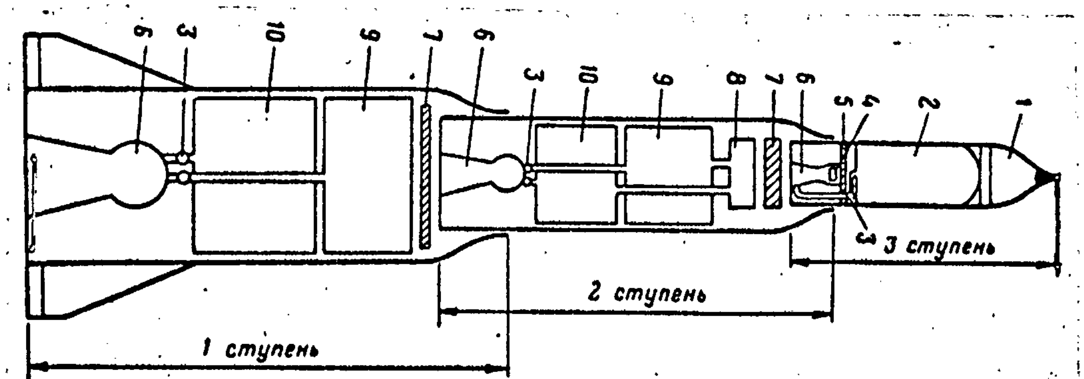

Fig. 6. Schematic Diagram of Space Craft

1. payload
2. tank with hydrogen or other light gas
3. turbocompressor
4. nuclear reactor
5. radioactive radiation shielding
6. nozzles of the liquid-fuel jet engine and nuclear powered jet engine
7. instrument compartment
8. fuel and oxidant supply system
9. fuel tanks
10. oxidant tanks

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ROCKET DEFENSE

Target Tracking and Missile Guidance Radars -- by Engr-Col G.S. SAFRONOV, Candidate of Technical Sciences, and Engr-Capt V. I. KUZNETSOV (Pages 72-74)

Text:

(According to foreign press materials)

It is common knowledge that the Nike Zeus antimissile complex developed in the United States uses four radars: an acquisition radar, a discrimination radar, a target tracking radar, and a missile guidance radar. The complex also includes a computer that processes the guidance commands for the missile up to target intercept. Figure 1 shows the functional relationships between the radars and other sections of the Nike Zeus complex. Figure 2 shows the nature of the problems handled by the radars and the distribution of functions among the radars up to the time of target intercept.

The acquisition radar must have a range of some 2,000 - 2,500 kilometers in order to provide a scanning of a given sector of space in a period of time measured in seconds and to direct the target tracking radar to the selected target with great accuracy. The discrimination radar will have approximately the same range and high resolution. It must analyze the signals reflected from each of the targets entering into its scanning zone.

The missile tracking radar plays a special role in the Nike Zeus complex. Although its effective range is much shorter than that of the acquisition radar, it can measure the coordinates of the target with extreme accuracy. Its errors in the measurement of target coordinates must not exceed a few meters with respect to range nor a few tenths of a minute of arc with respect to coordinate angles. Such an extreme precision of coordinate measurement is necessitated by the fact that the lethal range of the antimissile missile is comparatively small. If, for example, we assume that the maximum admissible miss distance in guiding the missile to intercept is 50 meters, the mean square linear error in guiding the missile to intercept, if the kill probability is to be reliable, must not exceed 10 meters and the systematic error must not exceed 20 meters. The error components here are the error in the measurement of the target coordinates, the error in the measurement of the missile coordinates, and the instrumental errors of the computer. If we break down the errors among the components of the system where they originate, the admissible mean square error and systematic linear error of target coordinate measurement for the missile will be, respectively:

$$el_{mse} = \frac{10}{\sqrt{3}} \approx 6 \text{ meters}, \quad el_{sys} = \frac{20}{3} \approx 7 \text{ meters.}$$

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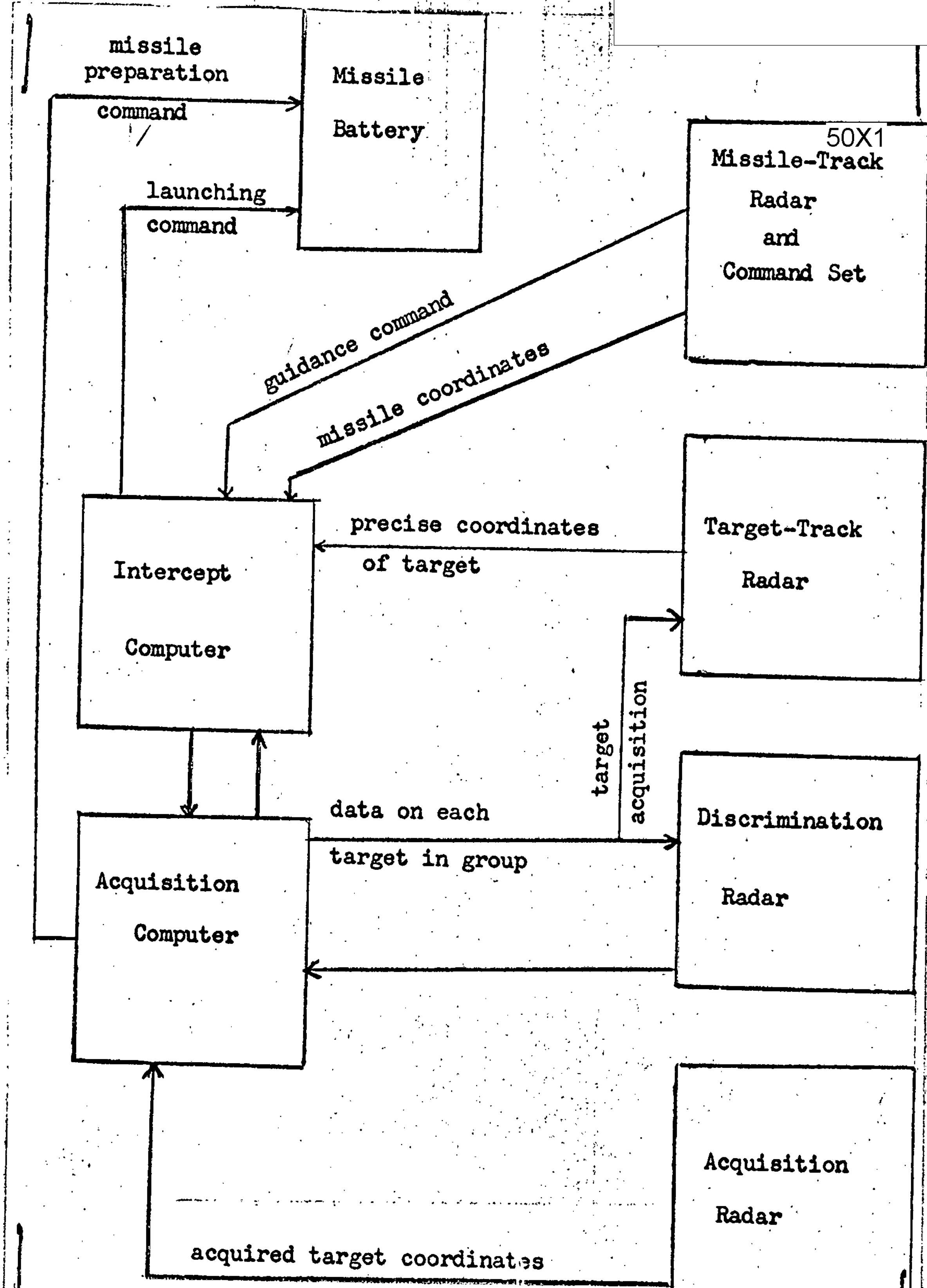

Fig. 1. Functional Connections of Radars in Nike Zeus Complex

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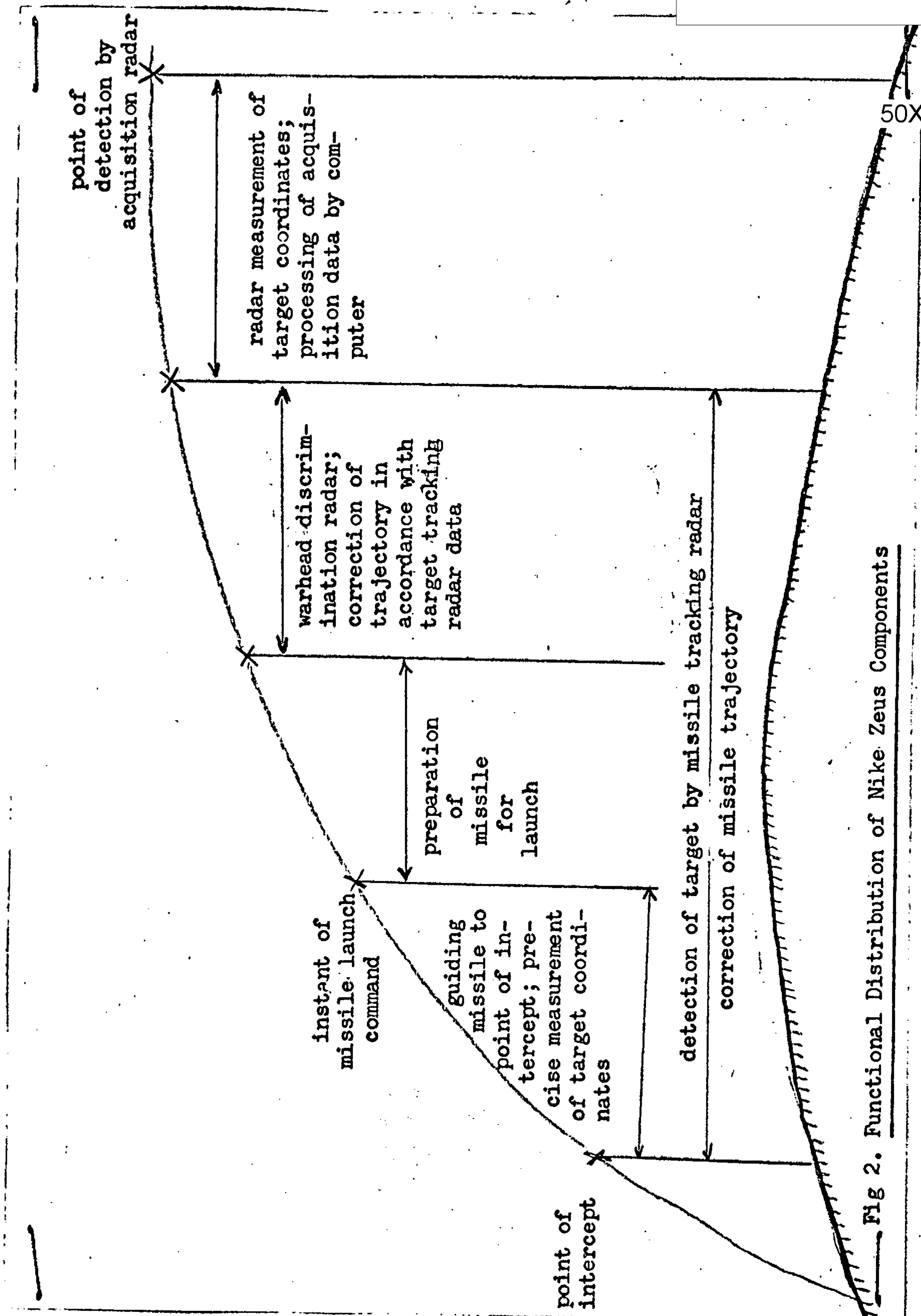

Fig 2. Functional Distribution of Nike Zeus Components

[redacted]

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Since the guidance of the missile begins when the target is located at a distance (L) of 600-800 kilometers from the point of intercept, then, for an accurate processing of guidance commands, the admissible mean square and systematic errors for the measurement of the angular coordinates of the target are determined by the equation:

$$\Delta\varphi = \frac{el}{L} = \frac{7}{8 \cdot 10^5} = 0.9 \cdot 10^{-5} \text{ radians or } 0.3 \text{ minute.}$$

As reported in a foreign publication, a guaranteed, well timed interception of a ballistic missile warhead necessitates a target tracking radar range of 1,000 - 1,200 kilometers, i.e., the target tracking radar must have not only high accuracy, but also a long range capability. The target tracking radar for the Nike Zeus system is a monopulse radar that determines the direction to the target by comparing the target signals picked up simultaneously by two pairs of primary radiating elements. Figure 3 shows a simplified diagram of a monopulse radar capable of measuring one of the coordinate angles.

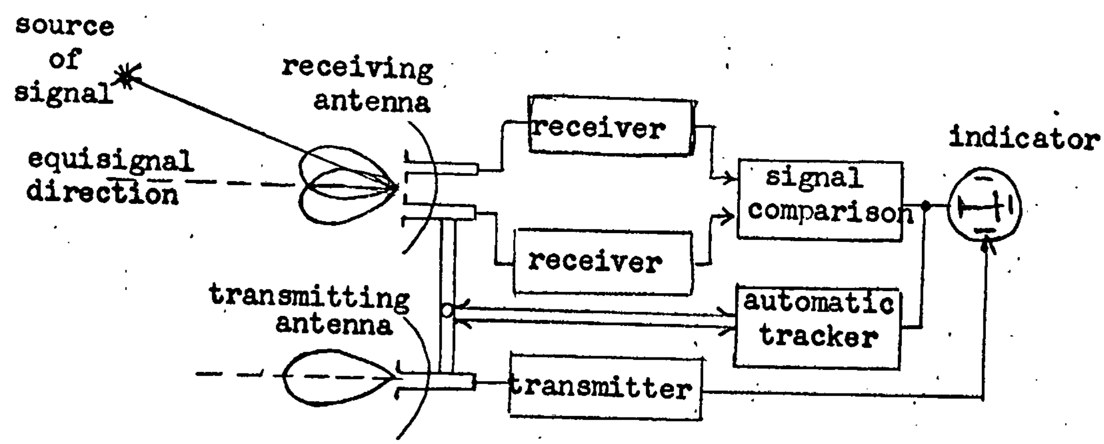

Fig 3. Simplified Diagram of a Monopulse Radar

Tracking a target in space necessitates measuring the angles of arrival of its signals in two mutually perpendicular planes. The monopulse radar is specially designed for measuring the angular coordinates of each pulse reflected from the target, which means special receiver and antennas. The typical antenna system of monopulse radars consists of a parabolic reflector with four primary radiators positioned in the vicinity of the neutral point. When the radiator drifts to the side of the focus by a small distance Δx, the amplitude diagram deviates from the equisignal direction by an angle equal to $\Delta x/F$ where F is the focal distance. A pair of radiators drifting symmetrically from the focus (neutral point) produces symmetrically overlapping directivity amplitude diagrams which afford a basis for determining the precise angular coordinates if the equisignal direction is oriented on the target.

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The parabolic antenna of the target tracking radar of the Nike-Zeus system is 7.6 meters in diameter and is enclosed in a radiotransparent radome 12 meters in diameter, which eliminates the wind load on the antenna and thereby increases the accuracy of the measurement of the coordinates. If we assume that the target tracking radar operates in a waveband somewhere around 10 centimeters, then, with such a reflector diameter, the antenna system will form a directivity diagram with a beam width at half-power

$$\theta_{0.5\,r} \approx 70\,\frac{\lambda}{D} = 70\,\frac{0.1}{7.6} \approx 1^{\circ},$$

where D is the diameter of the antenna reflector.

With such a narrow directivity pattern, the target tracking radar is not capable of rapidly scanning a given sector of space nor of seeking out a target and therefore requires assistance in target acquisition.

The antenna has an amplification factor of 35,000. This can be confirmed if we compute it according to the formula

$$G = K\frac{4}{2}S,$$

where K is the antenna cross-section utilization factor equal to 0.6 and S is the geometric cross section of the antenna aperture. If the radar is to detect targets with small effective reflection surfaces at ranges of 1,000 - 1,200 kilometers, the target tracking radar must have a high-powered transmitter. Thus, with an effective reflection surface of the target $\sigma = 0.1\ m^2$ and a receiver noise factor equal to two, the energy of the emitted pulse should by 50-100 joules. This would be sufficient to form pulses of long duration in the transmitter of the target tracking radar.

High resolution is obtained by the method of pulse compression ("chirp" method). If, for example, we assume that the pulse compression factor in the target tracking radar is equal to 30, a resolution of about 50 meters can be guaranteed for a pulse length of 10 microseconds. In this case, in order to guarantee a pulse energy of 50-100 joules, the pulse power of the transmitter should be about 5-10 megawatts which is completely attainable in practice. As an example, we point out that the experimental transmitter of the antimissile system devised at the Cornell Aviation Laboratory has an output power of 50 megawatts (<u>Missiles and Rockets</u>, June 1958)

The missile guidance radar is based on the guidance radar for the Nike Hercules surface-to-air missile and is analogous to the target tracking radar in principle of operation. The special feature of this

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radar is the fact that it does not pick up signals reflected from the target, but signals from the responder in the missile. These signals are much stronger than the receiver noise, thus affording the possibility of an accurate measurement of the coordinates of the missile even when the latter is at maximum range from the radar. Early in 1961, a project was suggested for increasing the range and altitude of the Nike Zeus missile. Plans were also made to employ it against satellites orbiting at altitudes up to 1,900 kilometers. In this connection, it can be expected that the missile guidance radar will be modernized to guarantee the indicated ranges.

[redacted]

FROM THE HISTORY OF PVO TROOPS

True Sons of Their Native Land -- by V. M. MIKHAYLOV (Pages 75-77)

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Abstract:

Relates a military history of the Komsomol from the years of the Civil War through World War II. (A captioned photograph dated 1942 of Capt D. OSKALENKO, fighter pilot, appears on page 75 and a captioned photograph dated 1941 of Jr Lt V. SAMODUROV, flight commander; Sgt K. YEVSTRATOV, pilot; and Jr Lt V. TALALIKHIN, squadron commander and HSU, appears on page 76.)

Komsomol Flight -- (Page 78)

Abstract:

Discusses a World War II combat sortie flown by Lt N. ZABELIN's flight. Lt A. LIPILIN and Jr Lt I. CHULKOV are identified as the other members of the Komsomol flight. (A photograph of the three pilots accompanies the article.)

Defending the Fatherland -- by Col A. D. ZHARIKOV (Pages 79-80)

Abstract:

Describes an exploit performed by Aleksey RYAZANOV, twice HSU, during the World War II aerial defense of Moscow and notes that he participated in battles over Kuban', the Bryansk forests, the Baltic Sea, and East Prussia and that he fought in the battle of Berlin. RYAZANOV is a graduate of two military academies and successfully passes on his experience to young pilots. (A photograph of Aleksey Konstantinovich RYAZANOV appears with the article.)

Subscription Continues for the Journal, Herald of Antiaircraft Defense, for 1964 (Page 80)

Text:

The journal is intended for officers and generals of PVO Troops. Its primary sections are: Party-Political Work and Military Education, Combat Training, Equipment and Its Use, Rocket Defense, Cybernetics and Automation, and From the History of PVO Troops.

The most important questions of Soviet military development based on decisions of the 22nd Party Congress and the new Party Program are discussed in the journal; progressive methods of commanders and political workers, party and Komsomol organizations, engineering and technical personnel of chasti and podrazdeleniya, and military educational institutions on the problems of training and political and military educational problems are publicized; sketches on outstanding officers, and articles to aid those studying equipment and weapons are printed; and consultations are given on problems of developing and improving training materials.

The journal acquaints the reader with the state and development of means of air and space attack and air defense in foreign countries.

Materials from the history of PVO Strany Troops are regularly published in the journal. Appearing in the Reviews and Bibliography section are reviews of books on rocket, aviation, radio and radar equipment.

Herald of Antiaircraft Defense is published once a month. Subscription prices are: for 1 year -- 3 rubles, for 6 months -- 1 ruble 50 kopecks, for 3 months -- 75 kopecks.