Page Denied

Next 1 Page(s) In Document Denied

[illegible]

[illegible] (1-3)

[illegible]

[illegible]

[illegible]

[illegible]

 STAT

The dependence of pulsations periods on the dimensions of the magnetosphere can be traced also, analysing the ratio of periods of simultaneously occurring pulsations on the sunlit side and the nightside of the Earth. It is well known, that Pc are characteristic for the day and Pi-2 for the night. If we adopt that both of them belong to the pulsation type of oscillations, then the periods of these oscillations will reflect the dimensions of the magnetosphere on the dayside and on the nightside. Then, the ratio of periods of these simultaneous pulsations, may be regarded as a criterion of asymmetry of the magnetosphere. The changes with time of this ratio reflects for instance the changes of the intensity of corpuscular streams and the deformation of the cavities of the magnetosphere. All the abovementioned regularities, obtained by comparison of Pc periods with Kp index, by the analysis of the ratio of simultaneously occuring pulsations on the day and the night side of the magnetosphere, etc. can be used to trace and describe the processes developing in the space surrounding the Earth.

STAT

List of figures.

STAT

R E F E R E N C E S

1. Kato Y. Akasofu S. Sci. Rep. Tôhoku Univ. Ser. 5. 7, N 3, 103-104,

2. Obayashi T., Jacobs J.A. Geophys. Journ. 1958, 1, N 1, 53-63.

3. Jacobs J.A., Westphal K.O. Geophys. Journ. 1962, 6, N 3, 360-376.

4. V.A.Troitskaya Report presented to the IGY Symposium Los-Angelos, 1963.

5. Cahill L.J. and P.G. Amazeen. J.Geophys. Res. 68, 1835-1843, 1963.

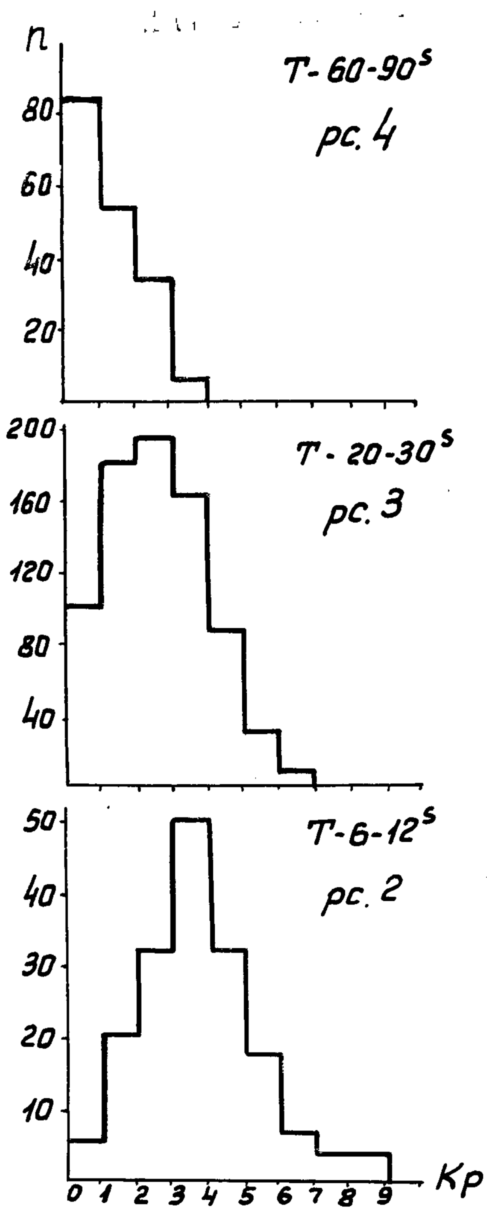

n
80
60
40
20
T- 60-90^s
pc. 4
200
160
120
80
40
T- 20-30^s
pc. 3
50
40
30
20
10
T-6-12^s
pc. 2
0 1 2 3 4 5 6 7 8 9
Kp

Fig. 1

St. Petropavlovsk.

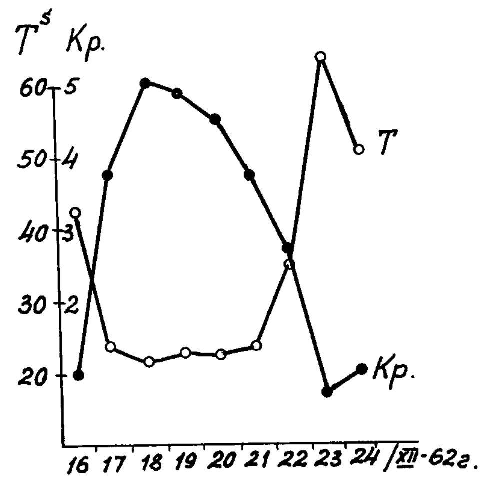


Fig. 3

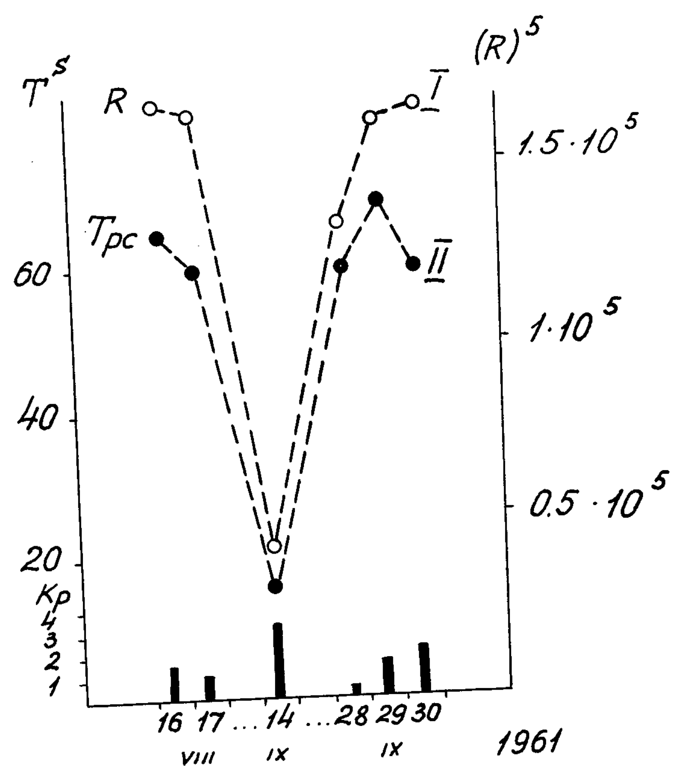


Fig. 2.

Declassified in Part - Sanitized Copy Approved for Release 2014/02/25 : CIA-RDP80-00247A003600190001-0

A possible scheme of transmission of solar corpuscular stream energy with force-free magnetic field to the magnetosphere and ionosphere of the Earth

E.I. Mogilevsky

Institute of Terrestrial Magnetism, Ionosphere and Radiowave propagation of the Academy of Sciences, USSR, Moscow.

1. A solution of the question on excitation of oscillations and waves within a lowfrequens range in the magnetosphere requires an adoption of a definite scheme of energy transmission to the magnetosphere from a solar corpuscular stream. The latter in its turn depends on the adopted conceptions on a plasma structure and the magnetic field of a corpuscular stream. A widespread approach to the solution of the task on energy transmission from a corpuscular stream to the magnetosphere is reduced to the analysis of non-linear phenomena (a shock wave appearance and "turbulence" in the intermediate zone between a shock wave and a magnetopause boundary), arising when a rarefied plasma of the corpuscular stream runs into the magnetosphere. The role of the magnetic field of the stream is practically not taken into account here. Another approach when energy transmission to the magnetosphere from a plasma solar stream occurs with the help of the magnetic field of the stream itself with a force-free structure is possible.

(2). The measurements of the magnetic fields in the active regions on the Sun [1] at the photosphere (the full magnetic vector) and chromosphere level allow to find out the active centres, in which there are parts of plasma with its own magnetic field. The analysis of the observations for the field structure and the general properties of the magnetized plasma in the chromosphere and corona result in the conclusion about a force-free structure of such isolated fields. When the processes are active (variation of the magnetic moment of the active regions, flares) a quasidiamagnetic outburst of plasma clouds with force-free magnetic fields forming a sequence of clouds of the general corpuscular stream is possible. The characteristic sizes of such plasma coaxials x) are $10^{11} - 10^{12}$ sm. When such μ - elements move through very rarefied interplanetary space, they carry along an extensive region with interplanetary gas ("solar wind"). The analysis of the magnetic field and plasma in a solar corpuscular stream, in keeping with observations of "Mariner-2", gives a satisfactory agreement with such model [2]. A corpuscular stream, consisting of separate μ - elements with force-free magnetic fields, not

---

x) A spacial structure of solar plasma clouds might be various: axisymmetrical magnetic field in a sphere, ellipsoid and other oneconnected bodies (with surfaces) or, that is more probable, toroidel (smooth or twisted) plasmas with a force-free magnetic field.

only takes off a number of difficulties, connected with generation and especially with the outcome of corpusculars streams from the Sun atmosphere, but permits a most effective energyreturn to the Earth magnetosphere. In this case the energy of a moving solar plasma may be given by the magnetic field from the largest part of $\mathcal{M}$ - element volume, connected by a system of force lines of a force-free magnetic field. This suffeciently (2 ÷ 3 order) exceeds the kinetic energy which is contained in the region which the magnetosphere passes in a corpuscular stream.

(3). Geomagnetic variations, observed on the Earth surface, consist of three parts:

a) The field variations within the period from 10 to 10^3 sec, reflected a spatial structure of the magnetic field of corpuscular stream plasma $\mathcal{M}$ - elements, crossing the magnetosphere boundary. These variations of the magnetic field are transmitted with alvens velocity V_A and not connected with energy transmission to the magnetosphere.

The detailed comparisons of the magnetic field observations in $\mathcal{M}$ - elements of the stream during the geomagnetic disturbance of 7-8.X.1962 with the geomagnetic disturbance, registered at a number of geomagnetic observatories [3], registrations of sudden commencements of the storms beyong the magnetosphere and on the Earth [4] as well as previous observations of the geomagnetic disturbance on "Pioneer-5" confirm a possibility of such geomagnetic variations.

b) Relatively slow ($10^2 < \tau < 10^4$ sec) variations of the geomagnetic field, arising in transmitting kinetic energy of separate $\mathcal{M}$ - elements to the magnetosphere with the help of the magnetic field $\mathcal{M}$ - element stream, whose field can be approximated by the field of the effective dipole, passing close to the magnetosphere, induced in the magnetosphere an additional current (in a current ring), discribing the main average characteristics of a geomagnetic disturbance. The scheme of this main energy transmission is like an effect arising in electrodynamic shock tubes. Unhomogeneous magnetic field of the stream $\mathcal{M}$ - elements, onrunning to the magnetosphere, produces a magnetic piston in the transitory (boundary) zone.

This condensed, magnetic field, moveng into the magnetosphere (upto the distance of $\sim 3 \div 4 R_E$) with $V \gtrsim V_A$, forming a system of shock and automodel waves. A wave dissipation from the "piston" substantially heats the plasma of the upper magnetosphere and results the origing of abovethermal particles, intensifyng a quasiring current the Earth. The estimate of the magnetosphere energy return from the stream $\mathcal{M}$ - elements [5] agrees with the typical peculiarities of geomagnetic storm energy.

c) A system of short periodical waves, arising due to a plasma instability at different levels of the magnetosphere (from $8-10 R_E$ to $2-3 R_E$). In the region of the upper magnetosphere ($L \gtrsim 3 R_E$), where $V_A \gg V_S$ magnetohidrodynamic waves ($\omega < 10 - 10^2$ Hz.) propagate without a substantial fading.

Dissipation of alfvens waves in this zone cannot take place by them. In the region of the magnetosphere where $V_A \lesssim V_S$

By $\omega \gtrsim 10^2 Hz$ the are a dissition within the times $\gtrsim \frac{3V_s}{V_A\omega}$. Wave dissipation with $\omega \gtrsim 10^2$ Hz of a large amplitude ($\gtrsim 5.10^{-4}$ e) takes place in the upper atmosphere ($\lesssim 10^8$ sm with the maximum at the altitude of ~250-300 km).

(4) The main morphological peculiarites of general planetary-ionospheric disturbance can be qualitatively discribed in a scheme of gydromagnetic wave dissipation and the accompaning addition heating of the ionosphere (from 10^2 to 10^3 °K depending on the geomagnetic latitude). The variations of coefficients of recombination and photochemical reaction velocity depending on the observed variations of electron concentrations at the level of the region-F2 maximum and the general electron content through all the thickness of the ionosphere. The latter follows from the solution of ionized equilibrium equation in which time dependences in the ionized function are taken into consideration. With respect to the scheme considered a correspondence of separate active periods of general-planetary ionospheric disturbance to the analogous active period of the geomagnetic disturbance, reflected the scheme of "storms-family" [6, 7]. The latter give a general structure of magnetic fields in a solar corpuscular stream, consisting of separate plasma $\mathcal{M}$ - elements with force-free magnetic fields.

References

1. E.I. Mogilevsky, B.A. Ioshpa, V.N. Obridco. Proc. 4. Intern. Sc. Symp. COSPAR, Warschaw, 1963.

2. E.I. Mogilevsky, Geomag. and Aeron., 1964, 4, N2, 213.

3. V.I. Afanaseva, J.D. Kalinin, E.I. Mogilevsky, Geomag. and Aeron., 1964, 4, N4.

4. N.D. Ness (CS Scearce, JB Seek), Proc. 5. Intern. Sc. Symp. COSPAR, Florence, 1964.

5. E.I. Mogilevsky, Geomag. and Aeron., 1963, 3, N6, 1901.

6. V.I. Afanaseva, Geomag. and Aeron., 1961, 1, 59; 1962, 2, 313; 1962, 2, 510.

7. V.I. Afanaseva, E.I. Mogilevsky, J.D. Kalinin, Geomag. and Aeron., 1962, 2, N4, 659.

A.I.OHL

LONG-PERIOD GIANT PULSATIONS OF GEOMAGNETIC FIELD

(Paper submitted to the Symposium on ULF Electromagnetic Fields to be held at Boulder, USA, I7 to 20 August I964)

Results of some statistical investigations of regular synusoidal oscillations of the geomagnetic field singled out on magnetograms of the Soviet polar observatories are outlined in / I /, / 2 / and / 3 /. These oscillations have amplitudes from tens to hundreds of gammas and periods from 2 to IO minutes; they were called by the author long-period giant pulsations (P_{gl}). In accordance with the international classification of pulsations they should be referred to the type of Pc-5. Similar pulsations were observed by Sugiura at College (Alaska) / 4 /.

Main properties of P_{gl} are as follows:

I. They occur at geomagnetic latitudes from $\sim 65°$ to $75°$, i.e. near auroral zones.

2. The P_{gl} occurrence frequency has a well pronounced diurnal variation with maxima near 08^h and $I6^h$ LGT (Local Geomagnetic Time). Pulsations occurring near 08^h and $I6^h$ have different properties:

a/ period of the 08^h pulsations is less than the period of the $I6^h$ pulsations;

b/ 08^h P_{gl} occur in winter more frequenly than in summer, whereas for the $I6^h$ pulsations reverse relationship is true;

c/ 08^h and $I6^h$ P_{gl} have different polarization;

d/ near the northern boundary of the auroral zone (in the Northern Hemisphere) only 08^h pulsations are observed, and near the southern boundary of the zone 08^h and $I6^h$ P_{gl} are observed equally often.

3. From the narrowness of maxima on the diurnal variation curve of the P_{gl} frequency follows the locality of their sources (effective radius of action is about I500 km); this is confirmed by the comparison of magnetograms of remote stations.

4. P_{gl} periods increase with the increase of Φ (approximately in proportion to the value of $\frac{I}{\cos^2\Phi}$). In this respect P_{gl} differ from usual giant pulsations P_g which period is about I00 sec and it does not change with latitude.

5. P_{gl} more often occur some hours later;after magnetic bays on the phase of diminishing activity of the world-wide magnetic storm.

6. P_{gl} often occur simultaneously at magnetically conjugated points of the Earth's surface.

These peculiarities of P_{gl} made it possible to suggest / I - 4/ that P_{gl} are the concequence of hydromagnetic waves originating near the boundary of the magnetosphere and travelling to the Earth's surface along the lines of force of the geomagnetic field. In the ionosphere these waves are absorbed, generating electromagnetic waves which are registered at the Earth's surface as P_{gl} pulsations.This suggestion just accounts for the geographic distribution of P_{gl} and their simultaneous occurrence at conjugated points, as the lines of force coming from the boundary of the magnetosphere end in both auroral zones.

To account for the locality and diurnal variation of the P_{gl} occurrence frequency it is necessary to suggest that hydromagnetic waves appear not in the whole part of the magnetosphere facing to the Sun, but only in two force tubes lying in the 08^h and $I6^h$ meridians.It appears that only these tubes are filled in with charged particles having densities enough for generating of hydromagnetic waves and play a role of waveguides for them.

The relationship of P_{gl} with magnetic bays and the lack of P_{gl} during severe magnetic storms shows that for producing a hydromagnetic wave in addition to a generating agent in a form of corpuscular stream it is necessary to satisfy one more condition: the form of a magnetic force tube should not be very distorted with rapid changes of the geomagnetic field occurring during magnetic storms.

The main feature of P_{gl} - the increase of their period with latitude - is connected with the increase of the length of the force line (crossing the point of the Earth's surface with the geomagnetic latitude φ_o) with the increase of φ_o .This relationship may be obtained on the basis of the analogy suggested by Obayashi / 5 / between the force line of the Earth's magnetic field and an elastic string; then

$$T = 2 \int_{-\varphi_o}^{+\varphi_o} \frac{ds}{V_A} \qquad \ldots\ldots \quad / I /$$

STAT

where ds - an element of the length of the force line, V_A - Alfvén's wave velocity; $V_A = \frac{H}{\sqrt{4\pi\rho}}$, where H - strength of the geomagnetic field, $\rho = m_H n$, m_H -proton mass, n - concentration of protons.Thus, to determine the relationship $T(\varphi_o)$ it is necessary to know the distribution of n along the force line.For this purpose the distribution obtained by Parker / 6 / on the basis of rather general suggestions on the movements of charged particles in the magnetic field was used.This distribution is as follows:

$$n(s) = n(0)\left[\frac{H(0)}{H(s)}\right]^{\frac{\alpha-1}{2}} \quad \text{.......} \quad / 2 /$$

where n(s) and n(0) are plasma concentration in a certain point s of the force line and in an initial point, respectively; α - parameter characterising the distribution of particles about the pitch-angles (α = I corresponds to the isotropic distribution). Substituting / 2 / into /I / we find:

$$T = \frac{8\sqrt{\pi m_H}\, r_o}{H_o} \frac{\sqrt{n_e}}{\cos^8\varphi_o} \int_0^{\varphi_o} \left\{\frac{\cos^{3/2}\varphi}{(1+3\sin^2\varphi)^{1/8}}\right\}^{\alpha-1} \cos^7\varphi \, d\varphi \quad \text{.........} \quad / 3 /$$

where r_o - the Earth's radius, H_o = 0,33 oersted, n_e - charged particles concentration in the point of crossing of the geomagnetic equator plane by the force line.By means of numerical integration it has been found that the value of integral in / 3 / poorly depends on the latitude φ_o (for $\varphi_o > 35°$) and parameter α ; with the change of α from 0 to IO and φ_o from 35° to 85° the value of the integral varies from 0,25 to 0,50.Assuming that near the magnetosphere boundary the relationship $\frac{n_e m_H v^2}{2} \sim \frac{H_e^2}{8\pi}$ is true, we find $n_e \sim H_e^2$ i.e. $\sqrt{n_e} \sim \cos^6\varphi_o$ (because $H_e = H_o \cos^6\varphi_o$).Substituting this relationship into / 3 /, we shall have $T = \frac{\text{Const.}}{\cos^2\varphi_o}$ in full agreement with P_{gl} observations.Then the difference between periods of the 08^h and $I6^h$ pulsations may be ascribed to the asymmetrical form of the magnetosphere (relative to the Sun-Earth line),because the force tube, lying in the $I6^h$ meridian, will cross the geomagnetic equator plane over a greater distance away from the Earth,and has,consequently, a greater length than the 8^h tube.At present, it is generally accepted that solar corpuscular streams have a curvilinear form (Fig.I),the angle ϑ between the noon meridian and the stream axis near the Earth beeing about 30 - 40°.If inside the

STAT

stream the force lines of the interplanetary or solar magnetic field obtain the same curvilinear form, then the form of the cavity cut by the Earth's magnetic field in the stream will be asymmetric relative to the noon meridian. The cavity radius r_e in the plane of 16^h meridian will be greater than in the plane of the 08^h meridian, the hydromagnetic wave periods vary respectively (as far as $T \sim r_e$). Proceeding from the cavity form obtained in the paper by Midgley and Davis / 7 /, it was found that the observed relation of periods ($\frac{T_{16}}{T_8} = 1{,}35$) agrees well with the stream angle $\vartheta = 27°$.

Wilson and Sugiura / 8 / arrived to the same conclusion, proceeding from the character of polarization of the long-period pulsations occurring during sudden commencements of magnetic storms.

In the paper / 2 / it was pointed out that periods of P_{gl} increase at the epochs of high solar activity. A more detailed study has shown that a close positive correlation exists between mean annual values of the P_{gl} period and the Wolf's numbers. A correlation diagramm between T and W for the 08^h P_{gl} at Cape Chelyuskin (according to data over 12 years) is shown in Fig.2. There is the same correlation for the 16^h pulsations too. The diagram in Fig.3 presents simultaneously the dependence of the mean period of the 08^h pulsations upon the Wolf's numbers and upon the geomagnetic latitude, corrected by Hultqvist. While constructing the diagram in Fig.3, we used both the data of the Soviet polar observatories and the data of a number of stations situated in the Canadian - American sector of Arctic, as well as the Antarctic stations records. It was also found that not only the mean P_{gl} period depends upon the level of solar activity but also does the character of the pulsations distribution according to their periods.

The curves of the P_{gl} distribution according to their periods for high, medium and low solar activity are given in Fig.4. It follows from this figure that in the years of high solar activity pulsations are generated in a wide range of periods, while in the years of minimum - in a very narrow band.

The increase of the P_{gl} periods with the increase of the Wolf's numbers may be connected with the fact that near the solar activity maximum there are many magnetic storms with well pronounced storm-time variation caused by the equatorial ring current. The magnetic field of this current distorts the geomagnetic field, the length of the force lines of the Earth's magnetic field being appreciably increased which results in the increase of the P_{g1} pulsation period

Thus, the study of the long period giant pulsations may give some important information about the distribution of charged particles in the exosphere of the Earth, as well as about the form of the force lines of the geomagnetic field in the Earth's environment.

Artic and Antarctic Research Scientific Institute.

References

I. Ohl A.I. Pulsations of the geomagnetic field in high latitudes. Trans. Arctic and Antarctic Institute, I962, v.24I, 39-64.

2. Ohl A.I. Long-period giant pulsations of the geomagnetic field. Geomagn. and aeronomy, I963, v.3, N I, II3-I20.

3. Ohl A.I. Pulsations during sudden commencements of magnetic storms and long-period pulsations in high latitudes. Journ. Phys. Soc. Japan, I962, v.I7, Suppl. A-II, 24-26.

4. Sugiura M. Evidence of low-frequency hydromagnetic waves in the exosphere. J. Geoph. Res., I96I, v.66, N I2, 4087-4095.

5. Obayashi T. Geomagnetic pulsations and the Earth's outer atmosphere. Ann. Géophys., I958, t.I4, N 4, 464-474.

6. Parker E.N. Newtonian development of dynamical properties of ionised gazes of low density. Phys. Rev., I957, v.I07, N 4, 924-933.

7. Midgley J.E. and Davis L.Jr. Calcukation by a moment technique of the perturbation of the geomagnetic field by the solar wind. J. Geoph. Res., I963, v.68, N I8, 5III-5I23.

8. Wilson Ch.R. and Sugiura M. Hydromagnetic interpretation of sudden commencements of magnetic storms. J. Geoph. Res., I96I, v.66, N I2, 4097-4III.

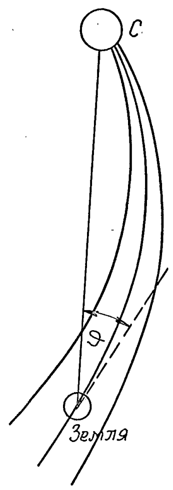
The list of the Figures

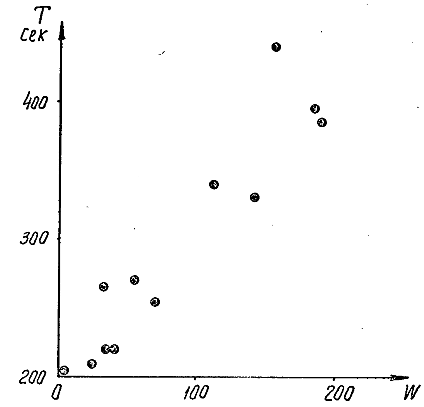
Fig.I. The solar corpuscular stream of a curvilinear form; ϑ - the angle of the stream.

Fig.2. The relationship between the average periods of the 08^h P_{gl} at Cape Chelyuskin and the Wolf's numbers.

Fig.3. The dependence of the average periods of P_{gl} upon the geomagnetic latitudes and Wolf's numbers. The figures above the lines are the periods of 08^h P_{gl} in seconds.

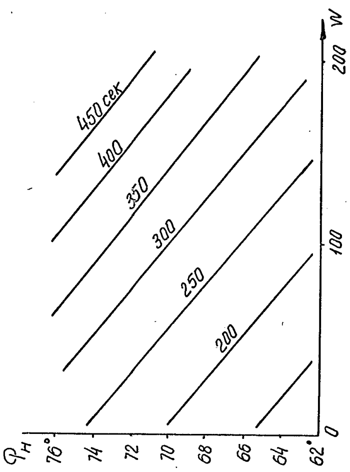
Fig.4. The curves of distribution of 08^h P_{gl} at Cape Chelyuskin for different levels of solar activity.

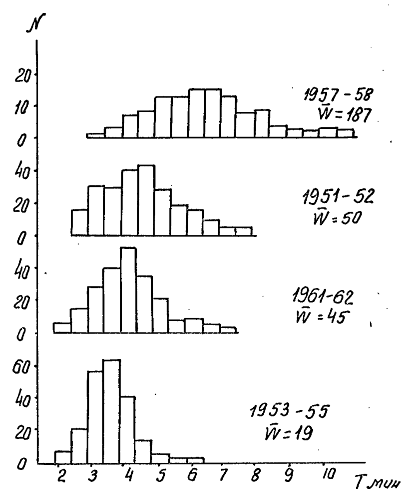




STAT

STAT





Declassified in Part - Sanitized Copy Approved for Release 2014/02/25 : CIA-RDP80-00247A003600190001-0