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INVESTIGATING THE UPPER ATMOSPHERE WITH THE AID OF ARTIFICIAL ELECTRON CLOUDS

by

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А а	*А а*	A, a	Р р	*Р р*	R, r
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В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

To investigate the processes of the formation of electron clouds at the initial stage of their development and for determining the diffusion factor [2, 3, 7, 10-12], we built a coherent-impulse radar unit (KIR). It was proposed that analysis of the movement of a cloud under the influence of wind be made with the aid of two automatic ionospheric stations (AIS).

The distances of the AIS from the projection of the cloud onto the earth was 30 kilometers (first point) and 70 kilometers (second point). Both points of observation and the place of cloud projection onto the earth were located almost on a straight line.

The distance of the KIR from the cloud's projection onto the earth was 70 kilometers.

Results of Observations and Their Discussion

On 19 October, at 0700, and on 25 October at 0715 we created artificial electron clouds by ejecting atomic potassium at altitudes, respectively of 115 and 133 kilometers. In both experiments the appearance of a cloud was registered by ionospheric stations several minutes after operation of the carrier mechanism. The maximum frequency of a reflected signal in the first experiment was 4.6 MHz; in the second - 3 MHz. The duration of the existence of reflections from both clouds was approximately 20 min. Judging from the results of observations, the issue of atomic potassium apparently did not exceed one per cent, i.e., one mole. As a result of the relatively low level of electron density in the clouds, the coherent-impulse radar did not register the signals reflected from them.

On 25 Octover, at 1735 we attempted to create an electron cloud by means of ejecting atomic cesium at an altitude of 130 kilometers. But the cloud was registered neither by the AIS, nor by the KIR, although in this experiment, just as in the two preceding, all of the equipment operated normally. It is interesting to note that in the last experiment a small shining cloud was generated in the infrared area of the spectrum.

Figure 1a, b, and c shows several ionograms obtained at the first point, with images of the cloud created on 19 October. The vertical lines on the ionograms are 1 MHz frequency marks; the first line on the left corresponds to 1 MHz and the horizontal lines are altitude tags applied after 50 kilometers; the altitude reading is made from the wide band down.

Knowing the maximum sensitivity of the AIS reception and recording equipment, it is possible to evaluate (using a radio detection formula) the minimum effective diffusing surface σ_{min} of the given clouds, if the reflections from them have been registered by the AIS. At a frequency of 2 MHz, at a distance to the cloud of 150 kilometers, $\sigma_{min} \approx 50\ m^2$. Inasmuch as the signal being reflected by the cloud (judging from recordings on the ionograms) somewhat exceeded the minimum detectable by the AIS, the quantity σ of electron clouds in our experiments was on the order of several hundreds of m^2.

Wind. An analysis of the ionograms shows that the distance from the electron cloud to the ionospheric stations changes with time. This testifies to movement of the cloud under the influence of wind. Figure 2 shows a graph of the dependence of the distance from ionospheric stations to the cloud in a time function in the second experiment (1 - first point, 2 - second point). From these data an estimation has been made of wind velocity, on the assumption that the cloud moves horizontally. This condition, for our calculations, is entirely correct, since at altitudes of 110-140 kilometers the vertical component of wind velocity usually is considerably less than the horizontal component [9].

If we maintain that a projection of the trajectory of cloud motion onto the earth is an extension of a line which joins the first or second points with the projection of the cloud to the earth at the moment of its appearance, then the average wind velocity at these altitudes is from observations at the first point, 40 m/s; at the second - 41 m/s. During cloud movement perpendicularly to this direction, the average wind velocity from observations at the first point is 62 m/s, and at the second - 80 m/s. The true value of the

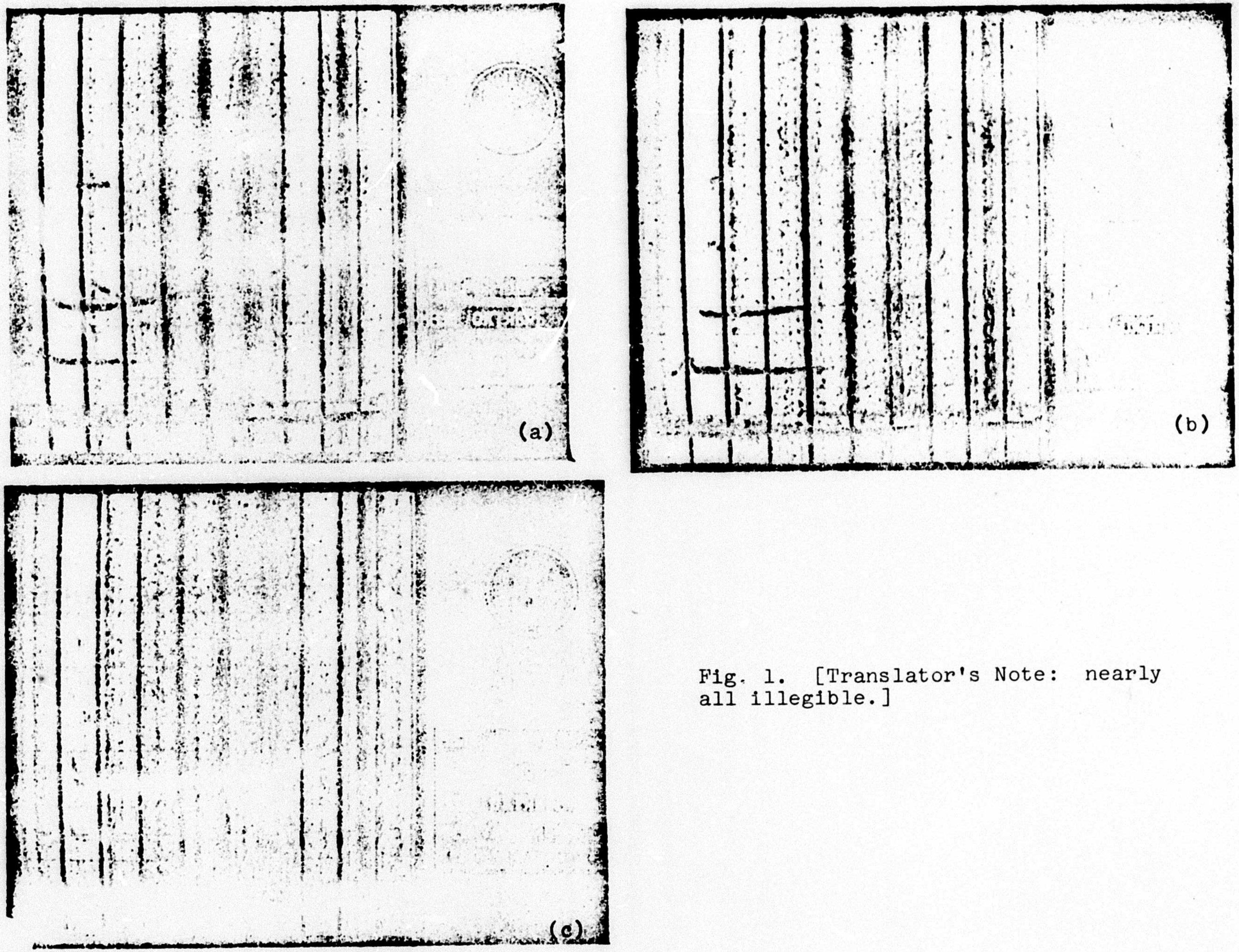

Fig. 1. [Translator's Note: nearly all illegible.]

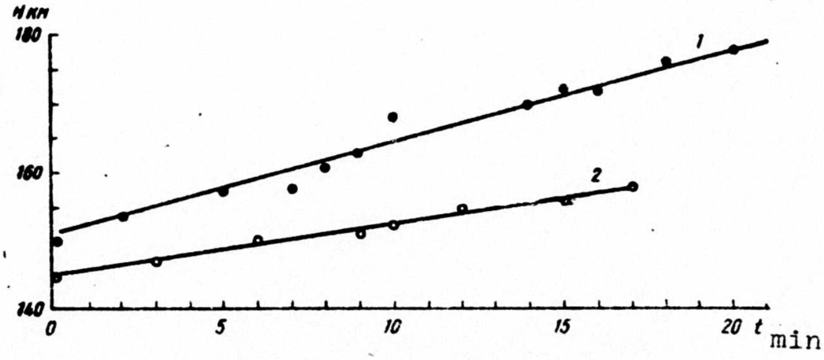

Fig. 2. H_{km} = altitude, in km.

amount of wind velocity under the conditions of our second experiment is, within the limits of 40-60 m/s.

Diffusion. After the formation of an electron cloud, the maximum frequency of the reflected signal declines with time (Fig. 1). This occurs as a result of diffusion, since the value of the other processes which reduce the electron density (adhesion, recombination, etc.) is low for the "life" of the cloud ($2\text{-}5 \cdot 10^3$ s), beginning at an altitude of approximately 110 kilometers [2].

Let us find the diffusion factor from our experimental data, assuming in this case that the following conditions have been met.

1. The distribution of electron density, n, in a function of the distance from the center of the cloud, r, is continuous. In actuality, the cloud consists of a large amount of clusters of ionization [7]. However, the amount of these clusters is very small, and the distances between the neighboring heterogeneities of ionization and their dimensions are less than the shortest wave in our experiments [7]; therefore, function $n = \phi(r)$ can be considered continuous.

2. The electron cloud is in thermodynamic equilibrium with the environment, i.e., the temperature, pressure, and consequently, the density within and outside the cloud are identical. This condition is accomplished several minutes after formation of the cloud [10].

3. Expansion of the cloud as a result of diffusion does not disturb the dynamic equilibrium of the processes of photoionization and recombination of discharges within it.

4. The basic reason for expansion of the cloud is molecular diffusion. This is explained by the fact that the influence of turbulent processes on the expansion of the cloud, beginning at altitudes of 115-120 kilometers, as asserted by a number of investigators [9, 11, 12, 14], is substantially less than of molecular diffusion; the role of ambipolar diffusion, as is shown in [3], several minutes after cloud formation is also comparatively small. During this time, of dominant value already is the diffusion of neutral particles which subsequently undergo photoionization.

Thus, it can be considered that several minutes after cloud formation the above statements are usually executed. In this instance the connection of the electron density in the cloud, *n*, with the diffusion factor, *D*, is described by the equation of molecular diffusion

$$\frac{\partial n}{\partial t} = D\nabla^2 n. \qquad (1)$$

Further let us assume that the initial form of the clouds, in the first approximation, is close to spherical and we shall ignore their bending under the influence of a geomagnetic field [13] or of a wind, the velocity of which changes with altitude. For a spherical cloud solution (1) is expressed by the following formula (14]

$$n(r,\ t) = \frac{N}{(4\pi Dt)^{3/2}} \cdot e^{-\frac{r^2}{4Dt}}, \qquad (2)$$

where *N* - the total amount of electrons in the cloud, *n* - the electron concentration in it at moment *t*, at a distance of *r* from its center.

The issue of atomic potassium from the containers was about 1%, therefore $N \approx 10^{23}$.

From the results of observations of electron clouds given in [3, 5], we found the values r - the radius of that part of the cloud which reflects the maximum frequency of signal f_m in from 6-10 min after its formation (during observations with an automatic ionospheric station). Thus, for instance, at the 8th min the values of the radius are equal to approximately 3 and 4 kilometers, respectively, for clouds created at altitudes of about 120 and 130 kilometers.

The connection between f_m and n of that part of the cloud which reflects oscillations with a frequency of f_m is as follows:

$$f_m = 10^3\sqrt{80.8\,n}\ \text{Hz} \qquad (3)$$

Graphs of dependence $f_m = \psi(t)$, plotted from the results of our experiments, are given in Fig. 3 (1 - first point, 25 X; 2 - second point, 19 X). From these data we find the amount of the diffusion factor from (2). In the first experiment (at an altitude of 115 kilometers) $D \approx 5\cdot10^7$ cm^2/s; in the second (at an altitude of 133 kilometers) $D \approx 1.3\cdot10^8$ cm^2/s. A comparison of these values D with those given in [3, 6, 11, 14] indicates that our results are close to the amounts of D directly found by experimental means at the appropriate altitudes.

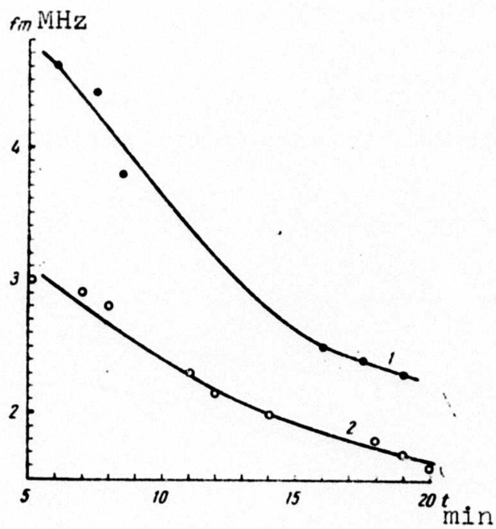

Fig. 3.

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13. ABSTRACT

For the last decade, investigations have been conducted abroad of the physical processes in the upper layers of the atmosphere, using artificial electron cloyds. Similar experiments have been initiated at the Institute of Experimental Meteorology (IEM). In accordance with programmed work, during October of 1967 artificial electron clouds were created over a point located in the central zone of the territory of the USSR. The goal of this stage of the work was to obtain experimental data for selecting the procedure of investigating physical processes in area E of the ionosphere.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Lubricating Oil						
Luminescence						
Diesel Engine						
Lubricant Additive						
Physical Chemistry Property						
(U)GAZ51 Diesel Engine						
(U) YAMZ238NB Diesel Engine						
(U) Putter RAU 1 Diesel Engine						
(U)SB3 Lubricant Additive						
(U) INKHP21 Lubricant Additive						
(U)BKF Lubricant Additive						
(U)PMSZ00A Lubricant Additive						
(U)388 Lubricant Additive						