Meteorological study of the course of radioactive debris

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ABSTRACT

An attempt has been made to follow the course of radioactive debris produced during nuclear explosions by drawing trajectory lines where the probability of finding the radioactive cloud is greatest. The paths are circumpolar and the highest speeds of displacement correspond to the speeds of polar jets. The course of these hypothetical trajectories has been observed at several stations.

This paper discusses the distribution of artificial radioactivity of the atmosphere during September 1961 and October 1964 in the following stations:

	Latitude	Longitude
(*a*) Chilton	52° N	01° W
(*b*) Moosonee	51°16′ N	80°39′ W
(*c*) Heidelberg	49°24′ N	08°41′ E
(*d*) Paris	48°52′ N	02°18′ E
(*e*) Pic du Midi	42°56′ N	0°08′ E
(*f*) Corfou	39°37′ N	19°55′ E
(*g*) Valence	39°28′ N	0°22′ W
(*h*) Washington	38°50′ N	76°57′ W
(*i*) Athens	38° N	23°36′ E
(*j*) Miami	24°49′ N	80°17′ W
(*k*) Tamanrasset	22°47′ N	05°31′ E

(*a*) Measurements made by Health Physics and Medical Division-Harwell. (*b*) (*h*) (*j*) Measurements made by U.S. Naval Research Laboratory. (*c*) Measurements made by University of Heidelberg (Physics Institute). (*d*) (*e*) (*k*) Measurements made by Laboratoire de Physique de l'Atmosphère (Measurements are supported by Service Electronique Physique of Commissariat de l'Energie Atomique). (*g*) Measurements made by Centro Meteorologica de Levante. (*i*) Measurements made by Laboratoire de Physique de l'Atmosphère. (*f*) Measurements made by Ionospheric Institute of Athens.

The Soviet nuclear experiments in September 1961 after two quiet years during which there was little activity in the air, has enabled us to follow the trajectory of radioactive particles resulting from these tests.

This study is concerned with horizontal movements at the level of 300 mb, representing a general flow and not taking into account any downward diffusion. As we have the date of the explosion, in theory it is enough to plot the trajectory of the mass of air which is at the point of the explosion on the given date, to show the regions which are subsequently crossed by the radioactive cloud. But this is insufficient, as apart from the uncertainty of the date it has been established that certain kinds of flow do not fit into the scheme. In fact, if one considers for example a zone of diffluence, a frequent configuration on altitude charts, one sees that the determination of the radioactive cloud leads to any number of solutions. We have thus been obliged to abandon the trajectory formed by a succession of points and to choose "a line where the probability of finding the radioactive cloud is the greatest" (Fig. 1). It has been assumed that there was a definite radioactive cloud corresponding to each experiment which was carried away in the general atmospheric circulation, and that each subsequent explosion was produced in a new mass of air, which seems likely in these explosions and in the Chinese Nuclear test of October 1964. Figs. 2, 3, 4, show "the lines of probability" of the radioactive cloud of the explosions on September 1st, 4th and 10th 1961.

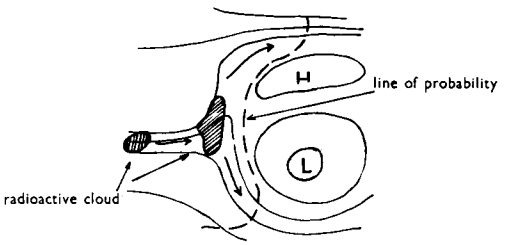

FIG. 1

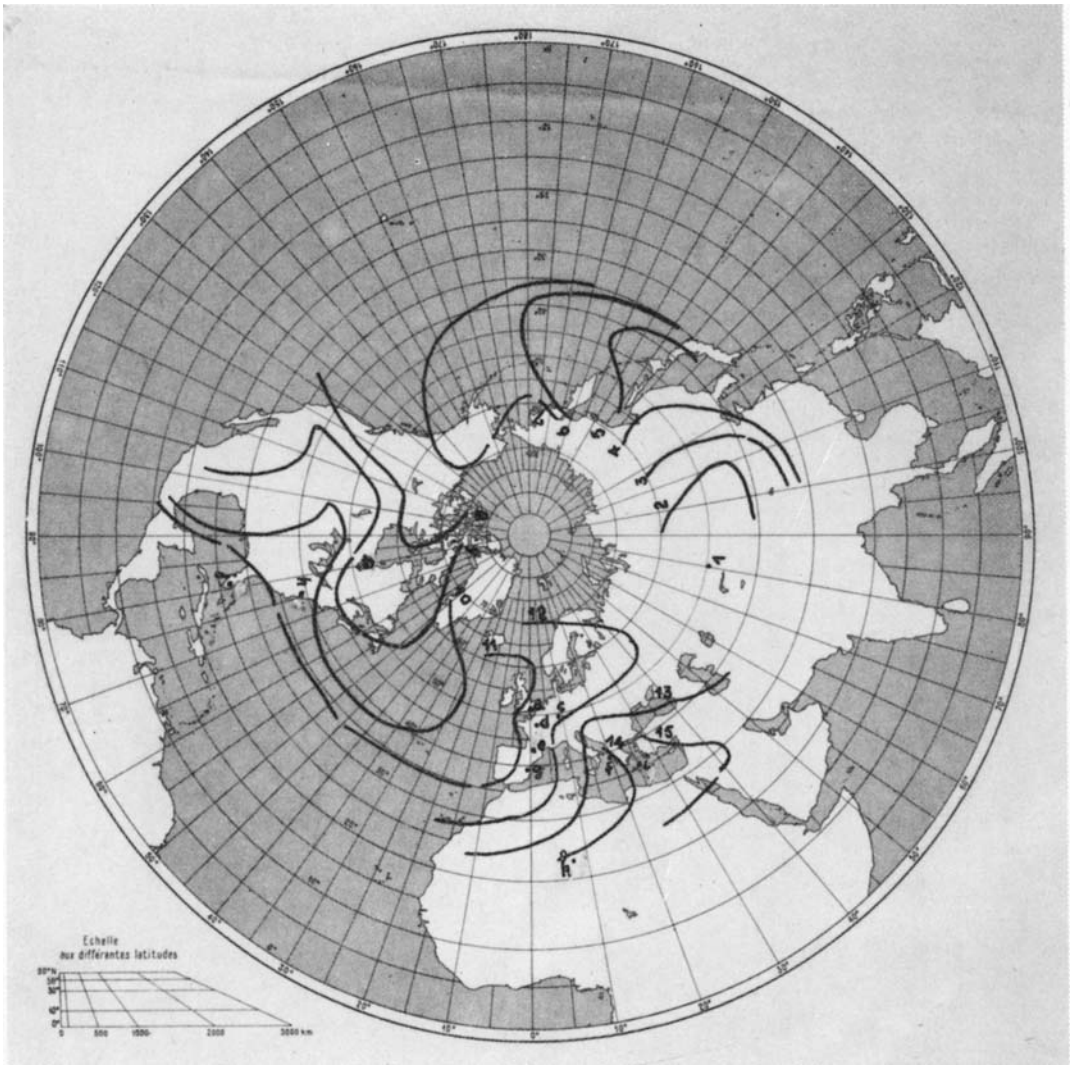

FIG. 2

These figures show that the development of these "lines of probability" is sometimes considerable, on the other hand one realizes that the trajectories are circumpolar, the greatest speeds of displacement corresponding to polar jets.

The activities of September 1961 plotted in the seven stations in question are given with reference (Fig. 5) to the time as well as the dates of the passage of the "fronts of probability".

Fronts 1 and 2 correspond to the explosions of the 1st and 4th of September at Semipalatinsk and front 3 corresponds to the beginning of experiments in Novaya Zemlya.

An examination of Fig. 5 shows that the passage of fronts 1 and 2 corresponds to a first but feeble increase of radioactivity at the stations which were investigated. Only the Washington station records an increase in the order of 4 pCi/m^3 of air. Front 3 seems to coincide in the different stations with the beginning of an important increase of radioactivity which reached 5 and even 9 pCi/m^3 of air.

Fig. 6 shows that the passage of front 4 cor-

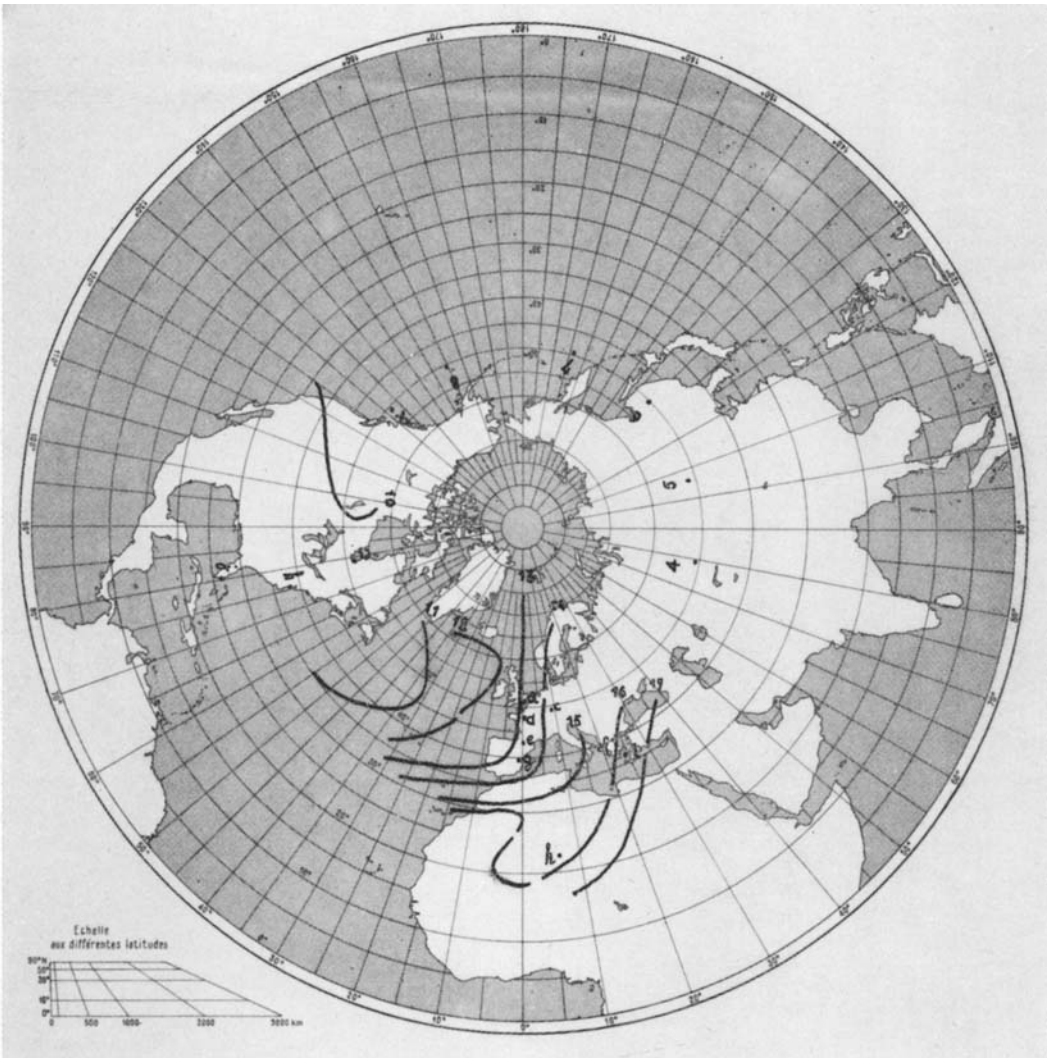

FIG. 3

responds to the Chinese Nuclear test, front 4 shows that between October 23 and 24 the polar jet of north to north-west coming from south of Groenland with radioactivity clouds is divided in two currents, the first is devided to Scandinavia and the second passed through Mediterranean from west to east. Spain, Greece, the French Pyrenees, and the north of the United Kingdom (Fig. 7) are placed under the influence of these two currents, presented an increase of activity, but at Paris and Heidelberg the increase of radioactivity is not so high as they are placed under the influence of only one current.

These results are not so clear as those of 1961 for not having daily American measurements data, but one can see that the activity of the air is more important in the region of jets. It is interesting to note how these "lines of probability", which are arbitrary, seem to have a physical reality, as their passage can be traced at stations as far apart as Paris and Washington for 1961 nuclear tests.

The circumpolar route is probably the spe-

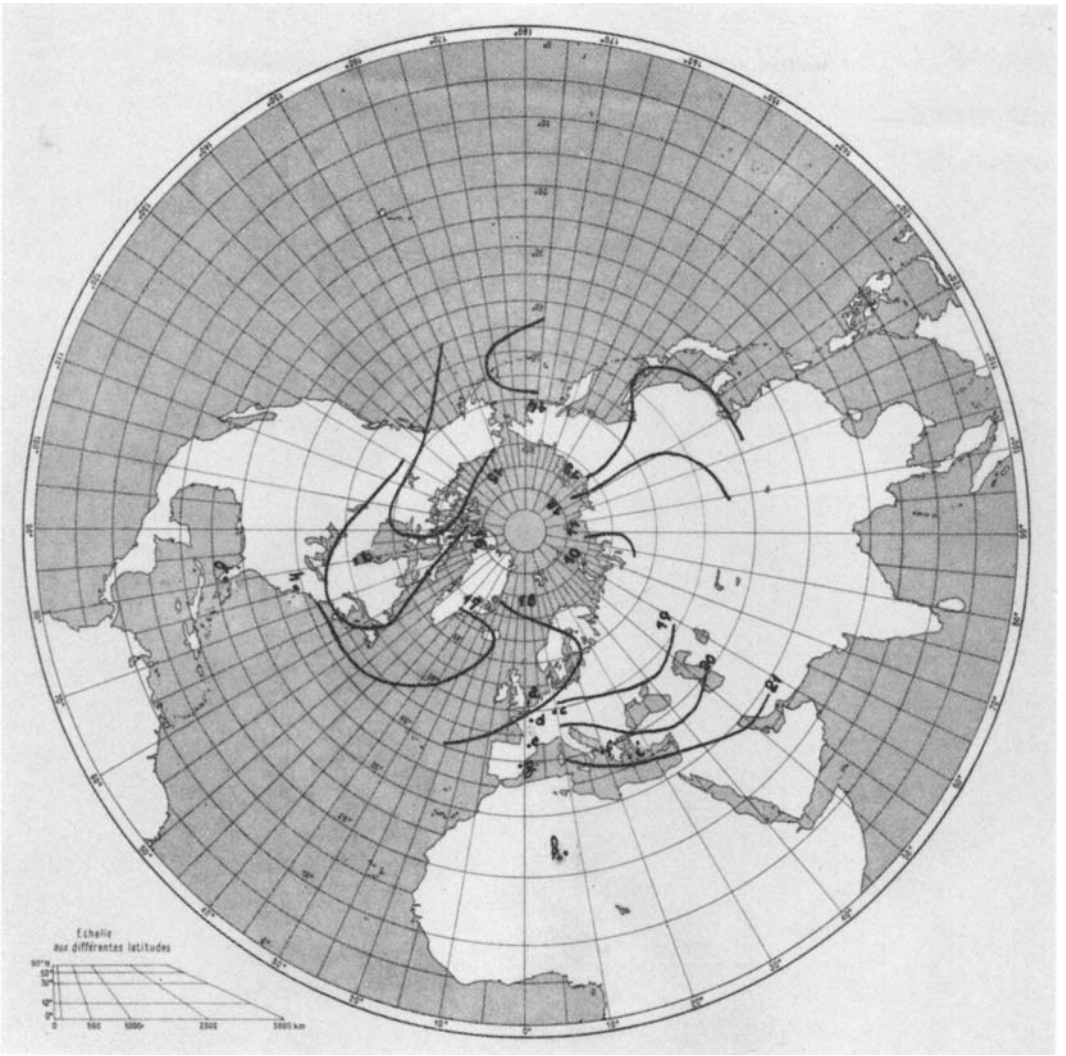

FIG. 4

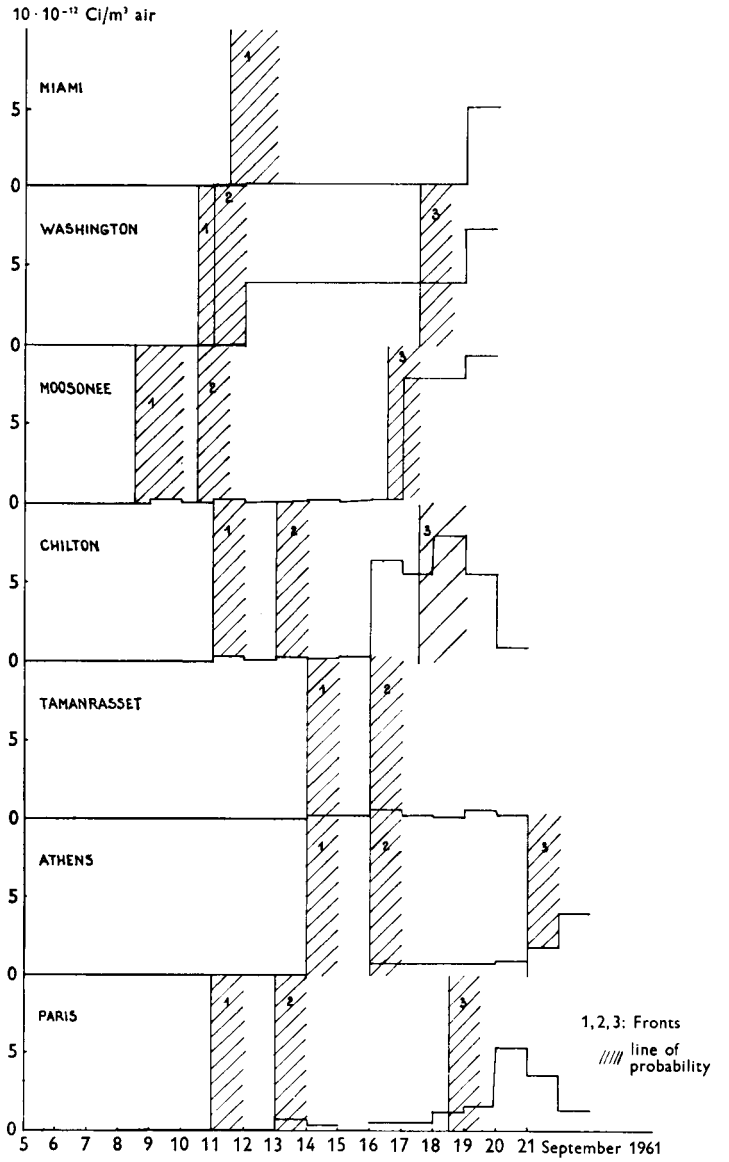

FIG. 5

cial course of radioactive clouds which are dragged from the west to the east by the polar jets. Israeli scientists (GAT *et al.*, 1963) come to similar conclusions by a slightly different method which makes use of inverse trajectories. On the other hand, if it is not possible to discover the processus of vertical diffusion, it would seem that deformation of the field of movement plays a fundamental part in horizontal diffusion, in giving each successive wave a shape like those which often sweep across large surfaces.

Acknowledgement

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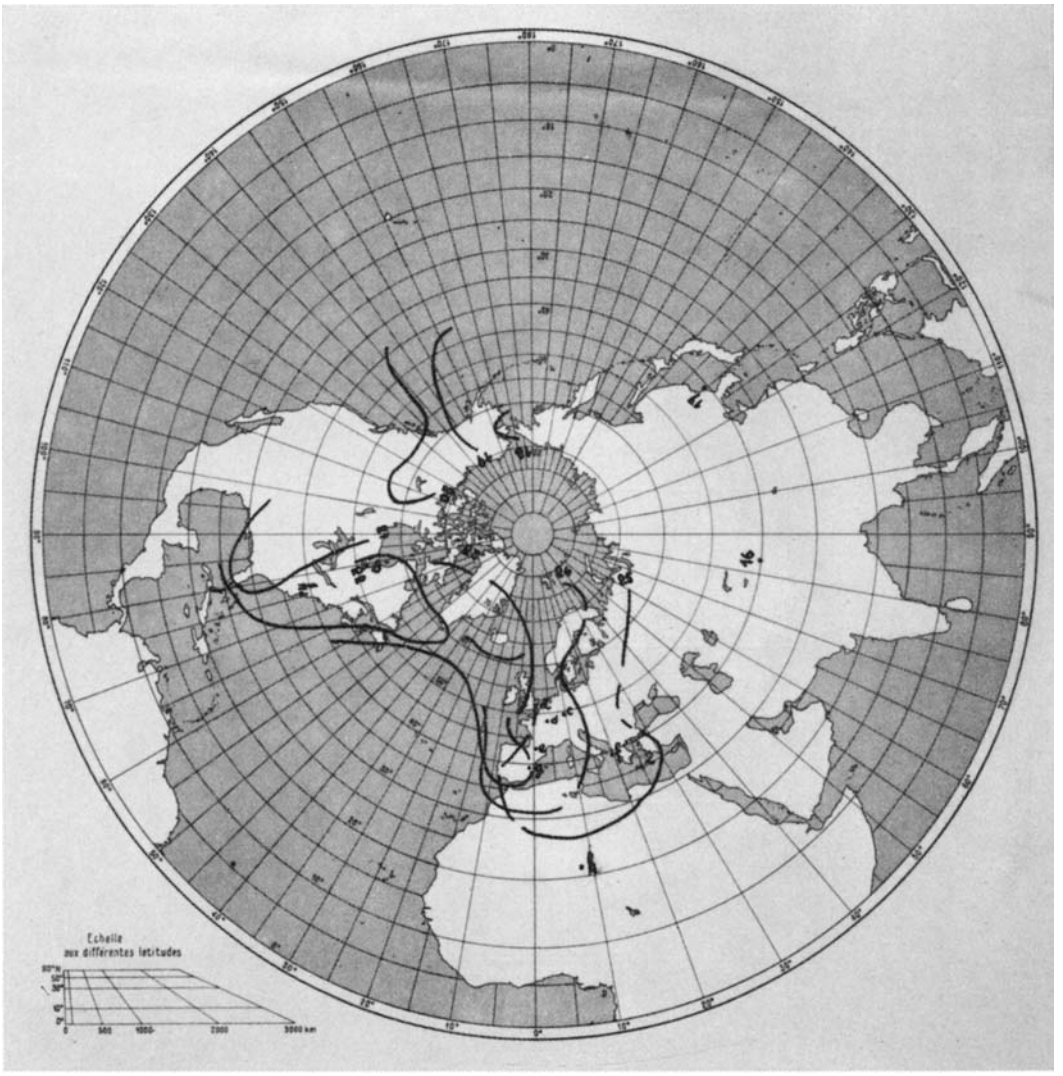

FIG. 6

RÉSUMÉ

Pour suivre le transport des particules radioactives provenant des explosions nucléaires on a été amené à tracer les lignes où la probabilité de trouver le nuage radioactif est maximum; les trajectoires sont circumpolaires, les plus grandes vitesses de déplacement correspondant à des jets polaires. Le passage de ces lignes de probabilité a pu être repéré dans plusieurs stations.

REFERENCES

GAT, J. R., FEIGE, Y., PAZY, N., and ROSINTAL, N., 1963, *Tellus*, 5, pp. 89–95.

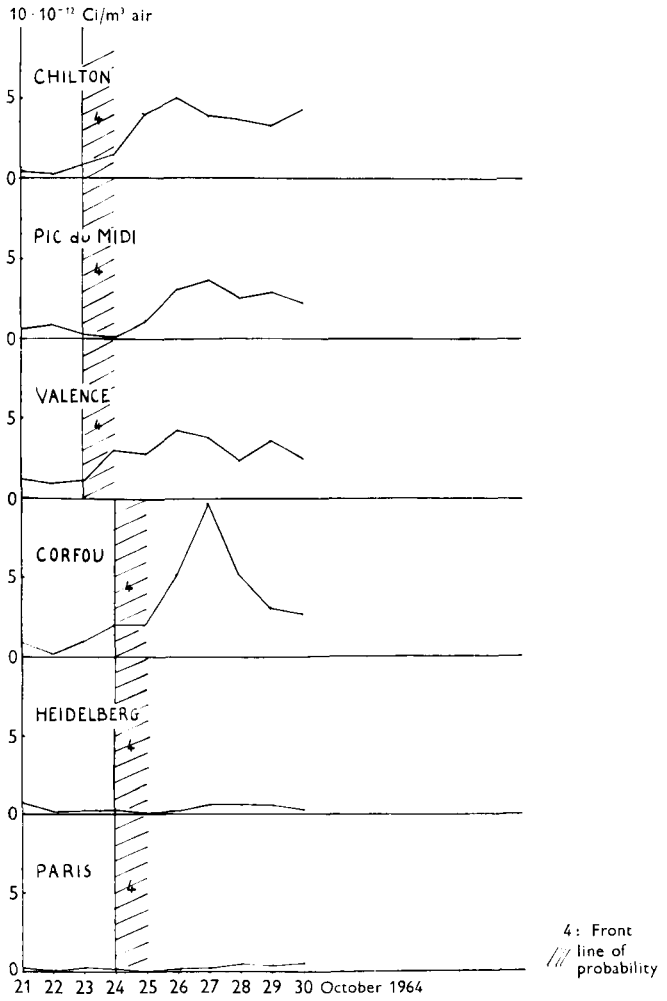

FIG. 7

МЕТЕРЕОЛОГИЧЕСКОЕ ИЗУЧЕНИЕ РАСПРОСТРАНЕНИЯ РАДИОАКТИВНЫХ ОСТАТКОВ

Сделана попытка проследить курс распространения радиоактивных остатков, образующихся во время ядерного взрыва, с помощью изображения траекторий линий, на которых вероятность нахождения радиоактивных облаков наибольшая. Движение происходит вокруг полюса и наибольшие скорости перемещения соответствуют скоростям полярного потока.

Курс этих гипотетических траекторий наблюдался на различных станциях.