

## Use of satellite pictures in comprehensive studies of West Antarctic

### 1. Introduction

Studies of papers presenting a polar research resulted in a conclusion that a use of satellite information for analyses of physical states of atmosphere in these areas conduced to interesting and unusual remarks (Streten 1973, Lucenko and Lysakov 1976 and others) that could be used in other geographical latitudes. Keeping that in mind the workers of Laboratory of Meteorology, Military Technical Academy, decided to carry through such investigation during organized polar expeditions. The studies were to be of a preliminary type, particularly in the first expedition were supposed to point out the future works in the matter. For that reason in two consecutive expeditions (January — March 1978 and December — February 1979) the possessed instruments enabled to receive a set of several hundred pictures from stallites, at the Antarctic station named after Arctowski (King George Island, South Shetland Islands). For a reception of pictures from meteorologic satellites of NOAA-5, METEOR-2-2, 2,33 and TIROS-N the instruments made in German Democratic Republic (WES-2) and in the Soviet Union (NEWA) were used.

Considering a geographical position of King George Island (62°S, 58°W) most satellitary broadcasting programmes from polarorbiting satellites were received and the obtained pictures allowed for a current investigation of evolution of basic systems and in many cases, for forecasting of the weather in the area. In spite of frequent bad quality of the received images, caused by unexpectable difficulties resulting from a lack of experience in the work in the polar areas, their usefulness was proved and in many cases they were indispensable in weather forecast in the West Antarctic.

After a preliminary analysis of the data brought to the country a current opinion (Musaeljan and Aprauševa 1976) was supported of a scientific usefulness of satellitary information. The analysis enabled to fix several preliminary direction of applying such pictures for ecological and meteorological studies. The ecologists are mainly interested in a radiational balance in different spectrum ranges what is closely connected with organism evolution

in the seas. The balances are strongly influenced by a kind and a state of clouds. Such information from above the seas can be received systematically from meteorological satellites and occasionally from ships. Therefore, in the Laboratory of Meteorology an attempt of application of satellite pictures for finding the radiational balances in Drake Strait area was realized. Another interesting problem included meteorologic studies over the physics of the atmosphere. The problem is very extensive and needs a defining of research methods i.e. to define the interpretational methods of physical phenomena. For the lack of interpretational experience of photographs from polar areas the defining a range of processes to be analyzed is now under consideration. It seems that the pictures can be useful for studies over:

- the orography influence on transformations of baric system and of atmospheric fronts,
- the orography relief influence on structure and state of clouds,
- evolution of baric system and fronts in many day cycles,
- advection directions of air masses,
- position of ice fields.

Taking these phenomena into account it should be emphasized that the paper does not present results of a finished research programme but rather it marks the future ways of its evolution in agreement with already published results (Koffler, Gotis and Rao 1973, Malberg 1973, Anderson 1974). But there are some remarks to be presented. They include:

- receipt of satellitary information and gridding of images at Arctowski's Station,
- possibility of using the pictures for defining the radiational balance close to King George Island,
- possibility of interpretation of some meteorologic phenomena.

## 2. Receipt of satellitary information and its geographical gridding

Receipt of satellitary information in APT system in a form of images in a visible (TV) and in an infra-red (IR) ranges in Arctowski's Station caused much more technical problems than in the country (Poland). It was an effect of fluctuations in the energetic system of about and over 50 V, of frequent occurrence of satellitary programme and work of the radio transmitter at the base in the same time. Besides, the range of audibility of a satellite depended on elevations (altitude 500—600 m) close to the station. It was found during two successive expeditions that to eliminate the interferences (resulting in a worse quality of received information) some improvements should be applied (voltage equalizers, directional antenna to enable a beam receipt).

Satellitary information is not useful for prognostic and scientific purposes until its geographical reference is done. The latter includes an introducing of cartographic gridding on the photographs in agreement with a model (specific for every satellite) the quality of which depends on applied structure scheme. Up to nowadays the models applied in the country

meteorologic services have come from NASA and from Academy of Sciences of the Soviet Union. But as the time went by they became out of date due to natural changes of orbit parameters or due to new types of satellites at the orbits. A problem of scheme for construction of a lattice model for polarorbiting satellites has been solved in Laboratory of Meteorology (Małeckı 1979).

Closure of the present research period in the matter will enable as well to introduce a geographical grid to a picture with a use of xy recorder, taking into consideration the actual (for the orbit) co-ordinates of geographical sub-satellitary points of any satellite, recorded from messages of APT-PREDICT or FANAS. Application of the method is possible only in the case of prospects for calculations on EMC. Therefore, the period for present use of the model should not exceed 14 days (it is a cycle of propagation the parameters of a satellite in FANAS message). Precise gridding of a picture resulting from a possessed scheme, is very important for research as well as for prognostic works since many times the limited extent of meteorologic phenomena has been observed (on satellite pictures).

### 3. Use of photographs for evaluation of radiational balance

Energy of solar radiation is one of principal types of energy supplied for ecosystem. It is used by vegetation, among others by phytoplankton being a principal link of a feeding chain of many animals e.g. of cryl (Phillipson 1969). Ecologists have defined monimum amounts of this radiation needed for evolution and survive of elementary links of a feeding chain. On the other hand, an amount of solar radiation reaching the earth surface is known to be different, depending on a geographical position and on predominating meteorologic conditions — particularly on state and type of clouds. If taking a geographical factor only into account, a position of the area in low and mean latitudes fulfils a requirement of minimum solar radiation reaching the earth surface, needed for evolution of living organisms independently on meteorologic conditions. Instead, in subpolar and polar areas this requirement is frequently not satisfied, particularly in the areas over which there are the meteorological conditions that decrease considerably a transparency of atmosphere. The transparency does not depend only on a distance passed by sunbeams in atmosphere but also on its state, expressed among others by a quantity of natural aerosols, water vapour and type of clouds. Considering a great changeability in time and space of these elements a transparency of atmosphere is found to undergo great fluctuations so, a radiational balance at the earth surface is also submitted to great fluctuations as well. In result of that an amount of energy reaching the oceans at these geographical latitudes is frequently smaller than the ecologic minimum values. Thus, a necessity of studies over a radiational balance according to meteorologic conditions is quite understandable. Such studies are nowadays carried through in this area by research groups of many

countries: descriptions and results are included among others in Koffler, Cotis and Rao (1973), Trofinov (1976), Hoyt (1977). There are actinometric as well as model studies.

In a period of December 1978 — February 1979 the actinometric studies were started at the Antarctic Station named after Arctowski; they have been carried through for defining a radiational balance close to King George Island, according to geographical and orographic-meteorological conditions. Such studies are to be continued during the next antarctic expeditions. Primary results are now under consideration.

The studies over conditions that influence a radiational balance over vast sea areas are also important. In this case no stable measuring points make impossible to collect full actinometric data. A partial solving of the problem could be a result of installing the automatic measuring instruments at fishing ships. So, the model studies can be an important help. One of more interesting theoretical models of defining a spatial arrangement of energy coming from radiation is called the Arakava model (Gates et al. 1978). But it demands among others for the parameters that can be defined energy coming from radiation is called the Arakava model (Gates et al. satellite images that are received in APT channel are useful. Having an interpretational experience for polar areas the parameters needed for the Arakava model can be defined with a satisfactory accuracy i.e. a cloud level, their type and extent. An analysis of the pictures (Fig. 1) allows to find an occurrence of cloudiness of *AltoCumulus* type in the region A and of *Altostratus* type in the region B. There are also the cloudless areas of orographic origin — regions D, E. The region D is localized at the lee side of King George Island (coming from the west). The region E is a lee side of the Antarctic Peninsula.

Results obtained from the model using the satellite picture for finding the parameters of cloudiness should be verified by actinometric measurements what is included in the research programme of the Laboratory of Meteorology. Evaluation of the radiational balance with a use of models can become more reliable if getting a full satellitary information in Antarctic area (high resolution pictures and data of vertical profile of the temperature — Bristor and Ranyove 1977). It should result in creation of the bases for better use of images in making hypotheses of distribution of atmosphere transparency.

#### 4. Use of pictures for interpretation of some atmosphere states

For evaluation of a radiational balance a satellite pictures supplies only with an information of state and type of clouds but the picture itself includes much more information of an atmosphere state enclosed among other, in a cloud structure. The structure is expressed by its specific image in a form of strips, whirls, cells, etc. Identification of atmosphere states relies on competence in interpretation of a photograph. Such competence is

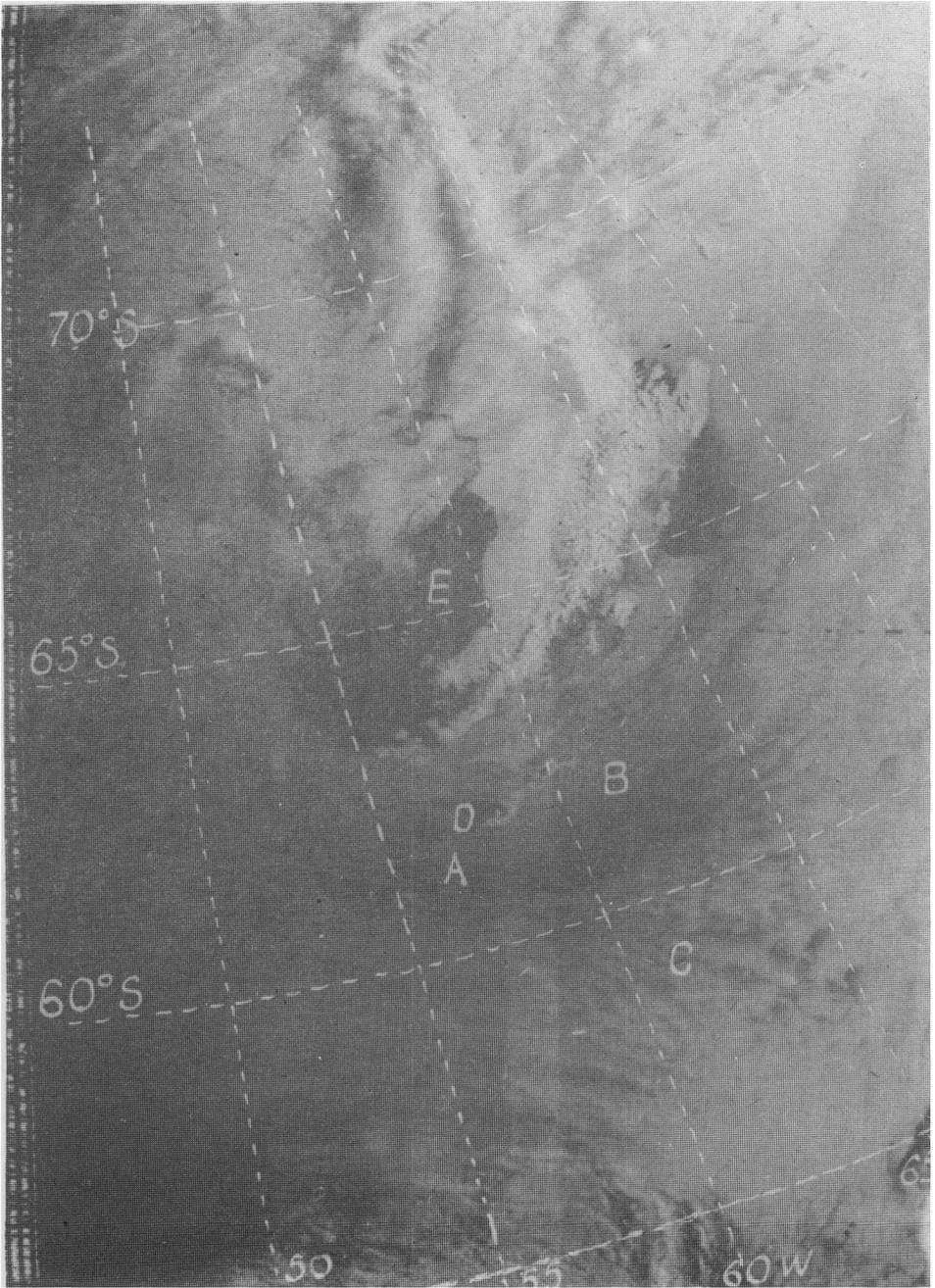


Fig. 1. TV picture from the satellite METEOR 2-2 (4 III 1978, 19.55 h LT) Photo by satellite.

necessary for comprehensive application of satellitary information in research studies and in short-term weather forecast, particularly in the areas of poor synoptic information i.e. especially in polar regions.

A preliminary analysis proved that on the ground of possessed pictures, the cloud structure enabled to:

- investigate an influence of Drake Strait on deformations of cyclones and fronts that pass it,
- define the advection directions of atmospheric masses and their transformation,
- define a zone of strong winds and of their direction and speed,
- investigate the cyclone trajectories in many day cycles,
- forecast the föhn phenomena according to direction of air mass movement over an obstacle,
- investigate the changes of ice field position, etc.

During the analysis of Fig. 2 it can be noted that the front between A-B in its middle part i.e. at C-D section is disturbed. It is caused by the mountains of Fire Island. Due to reaction of this area an orographic cloudiness is created in region E, with distinct streaks proving an increase of wind speed (Hubert 1976). In region F there are waves at the lee side of the island. In region G a repeated cloudiness can be observed at a considerable distance from the obstacle; it suggests an activation of an atmospheric front (Gunn 1976). In the Drake Strait itself an initial deformation can be observed in a point H, at the head part of a cyclone J; it is an evidence for an increase of speed of a flowing mass (long and short arrows) caused by orographic strait effect (Giles 1977). The analysis of many other pictures received in that area enabled to draw a conclusion that the Drake Strait influences a differentiation and dynamics of meteorological phenomena over the strait and over the surrounding areas. A scientific research, with a use of satellitary photographs, of meteorologic phenomena over the Drake Strait can be treated as model ones for an orographic strait effect occurring in other parts of the earth. Considering the mentioned dynamics of meteorologic phenomena and only few stations in that area, the satellite pictures enable the weather service to forecast better the weather states at fisheries there.

A similar analysis of Fig. 3 enables to define the directions of advection of air masses and their transformation. The air mass from the south direction of Antarctic continent (the thick arrow in C) flows towards the centre of a low at  $A_1$  and a secondary low at  $A_2$  moving with a high velocity over the ice field on the Weddell Sea at H. Thin arrows mark a direction of flow of air masses in a cool part of a low. This sector is limited by a cool front expressed by cloudiness  $B_1 - B_5$ . Successive transformational phases of the coming in continental-antarctic air over a warmer surface of a sea are expressed by differentiated cloudiness. In a zone D — no clouds but streaks in clouds in the neighbouring areas prove that the winds are strong there. Probably a thermic inversion occurs there. In the region E there is a conventional cloudiness of Altopcumulus type with distinct features of sub-inversive gravitational waves  $J_1$  suggesting an occurrence of still high wind speeds. In the region F there are highly

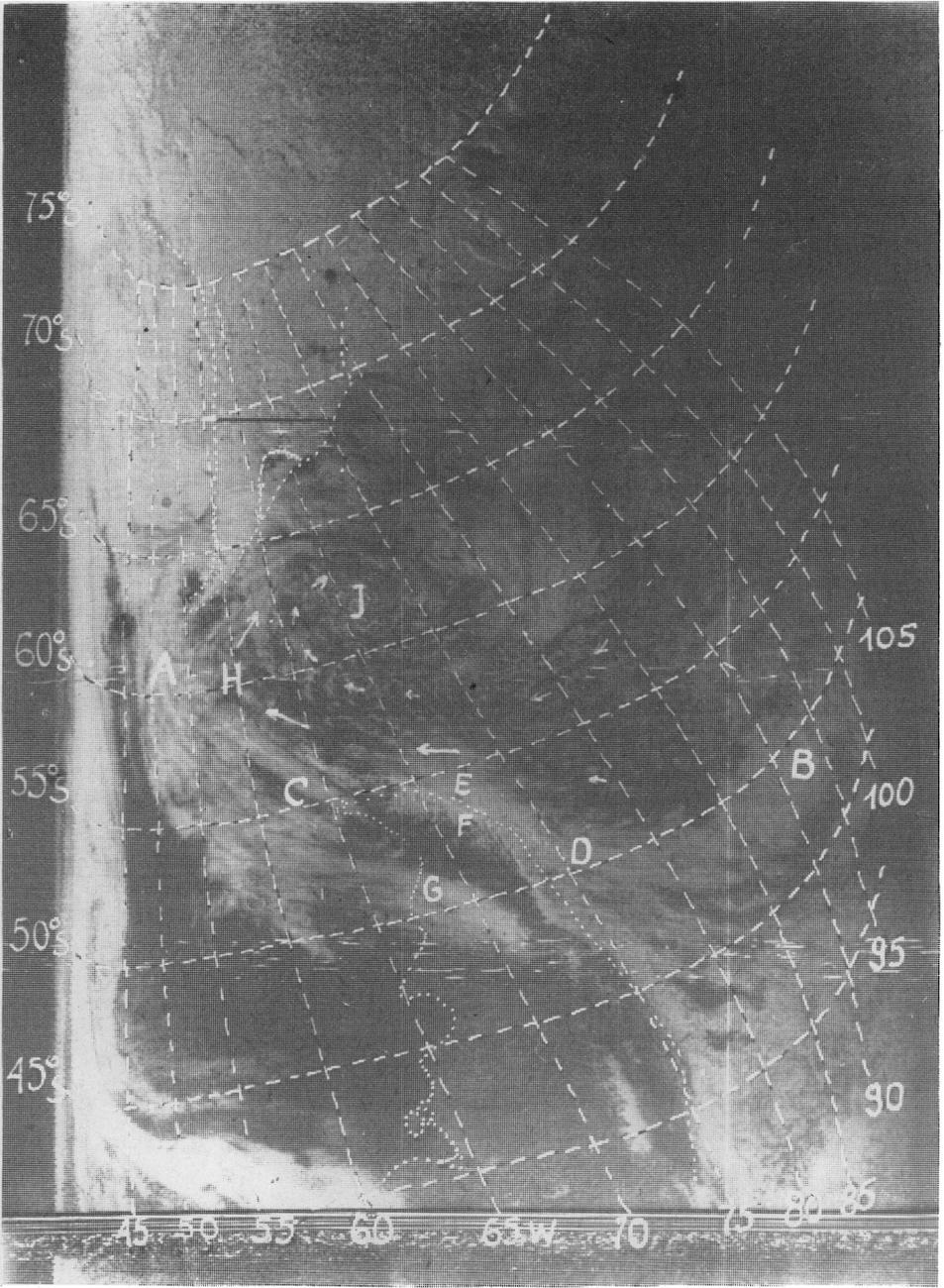


Fig. 2. TV picture from the satellite NOAA-5 (5 II 1978, 11.11 h LT) Photo by satellite.

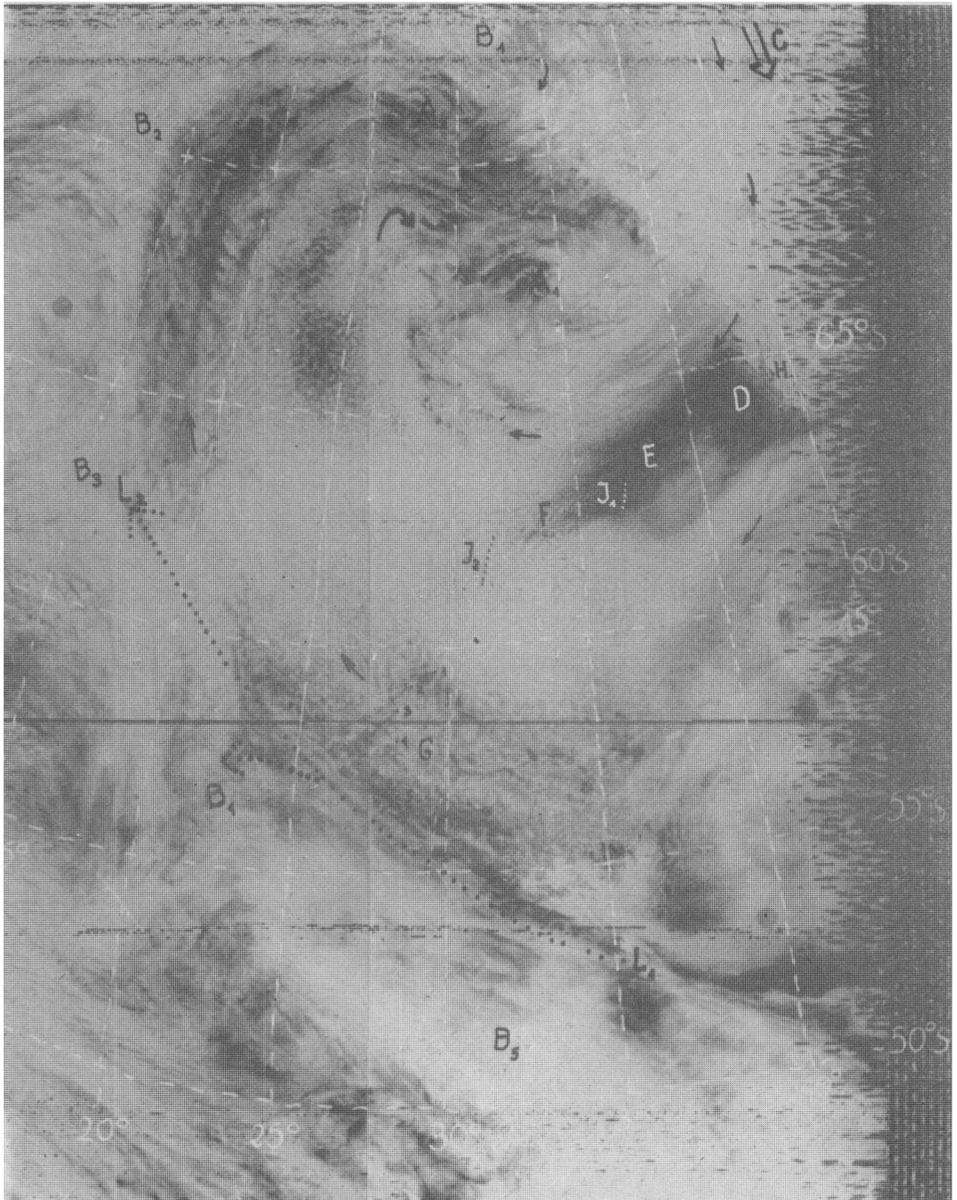


Fig. 3. TV picture from the satellite METEOR 2-3 (8 III 1978, 14.57 h LT) Photo by satellite.

expanded clouds of Cumulus type, gradually passing into Stratocumulus. There are also streaks  $J_2$  transversal to a direction of flow, proving an occurrence of gravitational waves of considerable lengths (30—50 km). In the region K small speeds of air streams allow for an intensive development of convection expressed by large-scale closed cells.

The arrow  $L_1 - L_2$  is localized in a zone a specific clouds marking an occurrence of a jet stream of varying intensity with a branch towards  $B_4$  direction. The gravitational waves observed at the lee side of South Sandwich Islands  $G_1 - G_2$  are an interesting phenomenon, well described for the northern hemisphere (Gjevik and Marthinsen 1978) and providing with many valuable information about the state of atmosphere. A direction west—east of the triangles of wind waves is not in agreement with a direction northwest—southeast of an air stream in this area. The air stream is disturbed by the islands  $G_{1,2,5}$ , of altitudes of about 500—700 m above sea level and it modifies the cloudiness. Instead, in the case of Montaque Islands  $G_3$  (about 1370 m a.s.l.) and Suanders Islands (about 1000 m a.s.l.) there are also disturbances in cloudiness arranged in agreement with a direction of advection (the arrow above the point G). Therefore, it can be concluded that the base of clouds in this area occurs at an altitude of about 900 m.

The presented analysis of the pictures is an example of possibility of their many-sided application for scientific investigation and for weather service. The application may be widened as an interpretation experience of meteorologic phenomena in the polar areas increases. But it should be considered to be a very difficult task that needs a complex knowledge of these phenomena in these latitudes.

This paper should be treated as an expression of opinions of research ways for applying a satellitary information in a form of pictures and of preliminary conclusions in the matter, as the studies need a collection of a suitable quantity of photographs and a certain period of time for their analysis.

The satellitary photographs have been in successive expeditions prepared by the workers of our Laboratory: K. Zubek and L. Kumoch. They were also used at the Arctowski's Station for present weather forecast at Scotia Sea and Drake Strait. In their analysis and application a group of other workers also participated that are supposed to present results of their studies in future papers.

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