USING A MOTOR DELTAPLANE FOR STUDYING THE OPTICAL AND METEOROLOGICAL PROPERTIES OF THE ATMOSPHERE

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We present here a description of the motor deltaplane, equipped with scientific instrumentation for optical-meteorological sounding of the atmosphere. The measurement results obtained during flights are also presented. The items of the information on peculiarities of installation and operation of the instrumentation on this kind of airborne platform are given.

The global change of climate due to the change of radiation budget of the planet, caused by increasing of emissions of the greenhouse gases into the atmosphere, predicted by some scientists, requires a detailed study of the interaction between electromagnetic radiation and air during its transfer from the Sun to the Earth's surface. It is rather expedient, that such a research be carried out in 4-dimensions (space plus time).

As a matter of fact there is, a system created on the planet for monitoring the propagation of solar radiation through the atmosphere, starting from ground based posts and stations and finishing by space vehicles. However, the data collected with it not always satisfy the researchers as concerning the spatial or temporal resolution. Therefore for obtaining the results, which are necessary in that or other experiment, different carrier platforms are used, on which sensors are installed and which move in space (balloon-sondes, aircrafts, rockets, etc.). From this list, as is shown in the review,[1] the instrumented aircrafts are most useful and fulfilling the most strict and diverse requirements. Among the disadvantages of this method it is with mentioning only the fact, that it is rather expensive and requires certain infrastructure to support its performance. Therefore the search for new kinds of platforms for installation of sensors continues. In this paper we describe the experience of using a motor deltaplane for that purpose.

An MD-2 motor deltaplane produced by Taganrog aviation enterprise was used as a platform for the deployment of optical and meteorological sensors. The following sensors and devices were installed on it: a photoresistive cloud irradiance sensor, an M-10M radiation budget meter, the M-15M pyranometers for measurement of up going and down going total radiation, sensors of temperature and humidity of air, a pressure sensor for obtaining data on reference heights, nephelometer, and filter setups. The arrangement of sensors on the deltaplane is shown in Fig. 1. The power supply of the whole complex came from a car battery. A car vacuum cleaner was used as an air flow stimulator. The sensors were connected with the onboard recording system through the preliminary amplifiers.

Such an arrangement of sensors on the deltaplane was caused by its design features, on one hand, and methodical requirements to measurements of one or another parameter, on the other hand.

The radiation budget meter and pyranometers collect radiation from the top or bottom hemi-sphere. It is natural, that pendant part of the deltaplane, including the pilot are within their fields of view. Therefore the block of radiation budget meter and pyranometers was fastened to the tube, which continued the building part of the wing axis. During the flight, this block was put ahead by means of this tube to 2 m, that allowed to reduce the influence of pendant part and pilot on the readings of sensors of the up going radiation.

For correct measurements of air temperature and humidity and collecting aerosol the sensors and collectors should be placed in the front part of the vehicle, in the undisturbed zone. The design of motor deltaplane with the pushing air screw located in the rear part of the machine, has partly facilitated this problem. At the same time the low placement of the deltaplane relative to the ground surface has complicated it. The dust from a fore wheel at the take off and landing could hit the aerosol collector. Therefore a removable cover was put on the collector, and the pilot removed it in flight. Hence, the sensor block and collector should be placed so that a pilot could easy reach it.

Nephelometer with the external working volume was fastened to a special frame, which was connected to the rigid part of the pendant construction on the left side from the pilot.

The battery, preliminary amplifiers, pressure sensor and the recording system were mounted on the passenger seat, behind the pilot seat, in a special container. Because of the danger of hitting the elements of a measuring complex by the screw blades, when

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arranging the aforementioned devices, special safety measures were undertaken to provide damage protection, such as: unfastening of all wires and parts of the complex.

In spite of our experience in equipping the aircraft-laboratories,[2,3] we were faced two problems, that required some additional efforts for their solution. They are strong vibration of the pendant part of the deltaplane, which resulted even in a destruction of sensors in trial flights, and electromagnetic incompatibility of the scientific instrumentation and radio tools of the deltaplane.

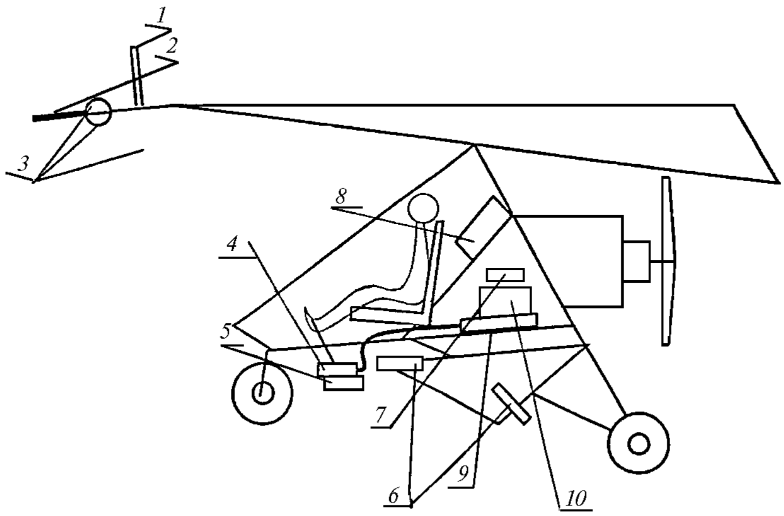

FIG. 1. Arrangement of scientific instrumentation on the deltaplane: 1) cloud irradiance sensor, 2) radiation budget meter, 3) pyranometers, 4) the block of sensors of air temperature and humidity, 5) filter setup, 6) nephelometer, 7) pressure sensor, 8) onboard recording complex, 9) air flow stimulator, and 10) battery.

The first problem was solved a classical way, i.e. by fastening of the devices using materials suppressing vibration and by strengthening of the structure.[4] We have not succeeded in solving the second problem even by double or threefold shielding of blocks and connectors. Therefore the radio exchange in flight was reduced to a minimum, and no data were recorded in these periods.

The data obtained in air were recorded with a specially developed recording complex. The detailed description of the complex is given in Refs. 5 and 6.

Let us give a brief characteristic of the nephelometer, because it was developed especially for the installation on a deltaplane.

The appearance of the device is shown in Fig. 2. It is intended for measurement of scattered radiation (including intended in clouds) at a rate of 1 Hz. The nephelometer operates under control from the onboard recording complex and measures the scattered radiation at the angle of 45°, since the scattering coefficient for this angle best of all correlates with the total scattering coefficient.[7]

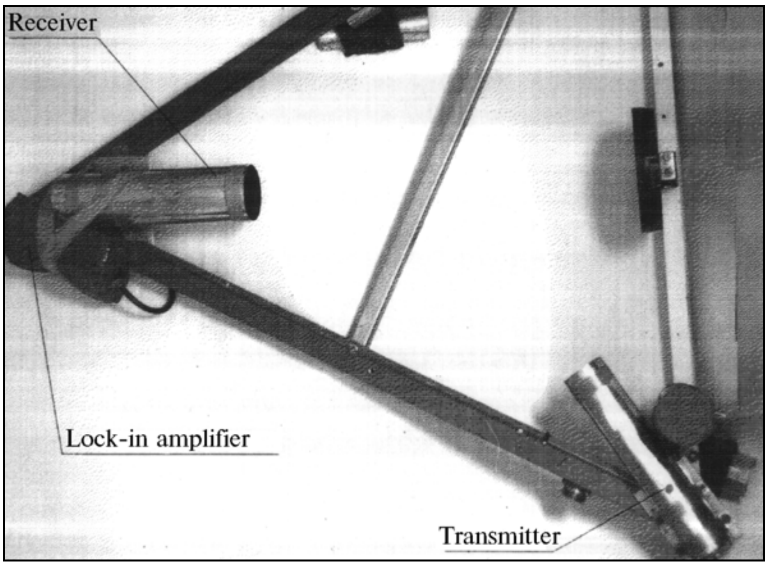

FIG. 2. External view of the nephelometer.

The device was mounted on a light rigid frame made from duraluminium. The middle part of the device is open, that allowed the nephelometer to operate in any position.

The lens transmitter and receiver of the nephelometer were supplied with elongated blends, which simultaneously are the protective cases. Black screens were placed opposite each receiver for suppressing the level of parasitic background illumination. Compact electronic blocks of the transmitter and receiver were mounted directly on the device frame (see Fig. 2).

The software of the nephelometer provides two modes of operations. The first one is the basic, when the functional units of the device, such as the transmitter, evaluation and synchronous detection of signals from the photoreceiver, and the output of the data are managed by the recording complex. The second mode of operation of the nephelometer is to test the operation ability of all units of the device.

The nephelometer is described in Ref. 8 in a more detail.

Specifications of the motor deltaplane

Height of flight	up to 3000 m
Flight time	up to 3 hours
Velocity relative to air	50–60 km per hour
Vertical velocity	1–2 m/sec
Useful loading	80 kg

Parameters measured

Temperature of air	–50 ... + 50 ± 0.1°C
Humidity of air	10 ... 100 ± 10 %
Pressure of air	800 ... 300 ± 1 mm Hg
Down going and up going total solar radiation (λ = 0.4 ... 2.3 μm)	0 ... 1368 W/m^2 ± 10 %
Radiation budget (λ = 0.4 ... 14 μm)	0 ... ± 800 W/m^2 ± 10 %
Scattering coefficient	0 ... 10^4 rel. units.
Cloud irradiance	0 ... 100 rel. units
Volume of pumped air	0 ... up to 150 m^3

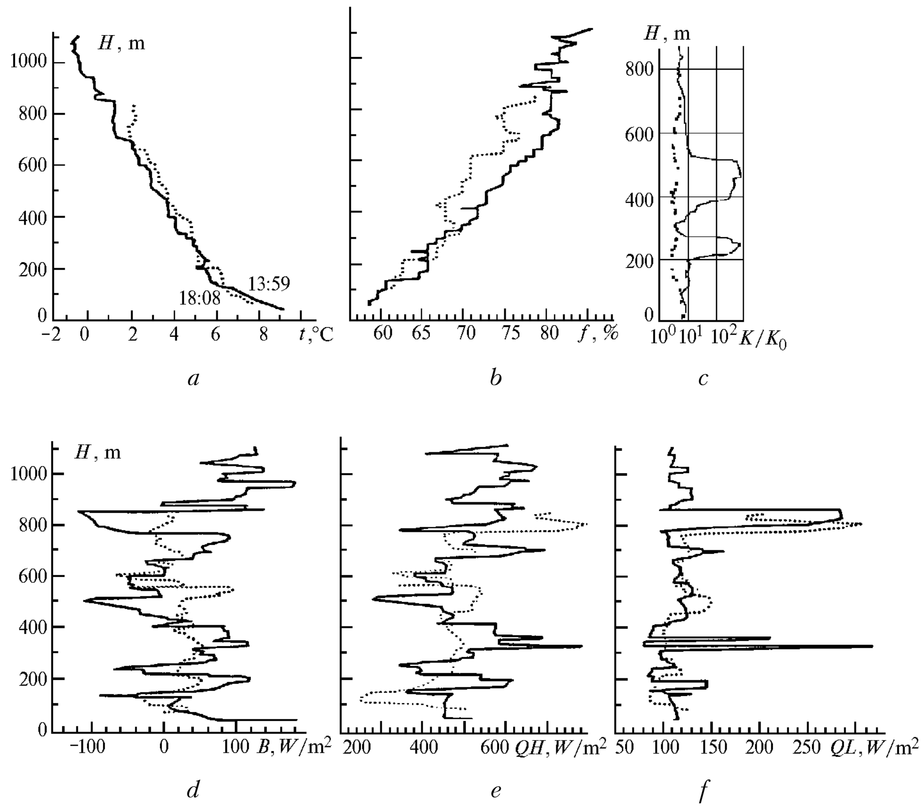

FIG. 3. Vertical profiles of temperature (a), humidity (b), scattering coefficient (c), radiation budget (d), down going radiation (e), and up going radiation (f) on September 29, 1996 over Tomsk: solid lines – ascent of the deltaplane; points – descent.

The tests of the motor deltaplane equipped with the aforementioned instrumentation were carried out since August 26 till October 10 1996 in the vicinity of Tomsk under the following program:

– switching on the recording complex and record during 5 sec;

– start of the deltaplane engine, switching on the data recording, driving and take off;

– ascend up to 100 m, 11 minutes of horizontal flight at this altitude along a square route;

– performing similar horizontal flights at the altitudes of 200, 400, and 800 m, and at 1600 m, if cloudiness was high;

– rise up to a bottom of clouds and switching on of the vacuum cleaner for 30 minutes to collect aerosol on a filter;

– sharp descent with the velocity of about 4 m/sec and landing;

– switching off the data record, disconnecting the recording block from the sensors without switching on the energy supply, and carrying it to the laboratory room;

– reading of the data from a PC-card of the recording block into a computer through a serial port;

– switching off of the energy supply of the block;

– charging of the battery of the recording block.

A flat field of the size 1500 × 1500 m on the left coast of the river Tom' was used as a take-off strip. The horizontal flights at the altitudes of 100, 200 and 400 m were carried out with the purposes of safety of flight over this territory. The flights at higher altitudes were performed over the city and its vicinities.

The vertical profiles of some parameters obtained during one of the flights are shown in Fig. 3. It is seen from this figure that it is possible to record rather a thin structure of vertical distribution of optical and meteorological parameters using a deltaplane. At the same time not all features of the fine structure in the curves obtained during the ascent and descent of the deltaplane coincide, especially in the radiation data. Apparently, it occurred because the flights were performed over a non-uniform surface with different albedo, that effected the results of measurements.

The tests of the deltaplane have also revealed a number of disadvantages, which are to be removed in the further development. In particular, a more reliable sensor of pressure is needed for a precise height scaling of the data. Additional measures are necessary to overcome the influence of vibration on the devices and neutralization of electromagnetic interference on the scientific instrumentation. For radiation measurements a more uniform underlying surface is desirable.

ACKNOWLEDGMENT

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