Automated precipitation collector

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We describe the design and operating principle of an automated precipitation collector intended for being operated at warm and cold air temperatures. The precipitation collector is capable of accumulating dry and wet precipitations.

Introduction

Since Russia is now a member of Acid Deposition Monitoring Network in East Asia, there is an urgent need in precipitation collectors operating efficiently and reliably under extreme climatic conditions of Siberia and Far East. Initially, it was proposed to use an OS-232 device made in Japan. However, its one-year operation showed that this precipitation collector fails to operate at cold temperatures. In this connection, an automated precipitation collector was designed in 2001 at the Institute of Atmospheric Optics SB RAS. Here we describe this precipitation collector, which can be used at any point of Siberia and Far East.

Principle of operation and applications

The automated precipitation collector is designed for collection of dry and wet atmospheric precipitations for their further chemical analysis.

The collector operation consists in automatic detection of precipitation and collection of any, as well as in prevention of ingression of solid particles (dirt, dust) in a receiving tank in periods between the precipitations.

The standby state is the basic state of the collector. In this state a collecting funnel is tightly closed. The funnel surface is placed by more than 70 mm higher than all other collector units to prevent ingression of splashes. The funnel and moisture sensor are heated to provide for flow of precipitation at freezing temperatures.

The collector can be operated either manually or in automatic mode. It is controlled by a control unit. If the funnel head has been opened manually, the collector must automatically return into the standby state.

Design and description of the collector

The layout of the precipitation collector is shown in Fig. 1.

The frame of the collector body is made of rectangular steel section and covered by detachable side and upper panels that reliably protect the inner space from moisture. The body is equipped with a sealed hatch.

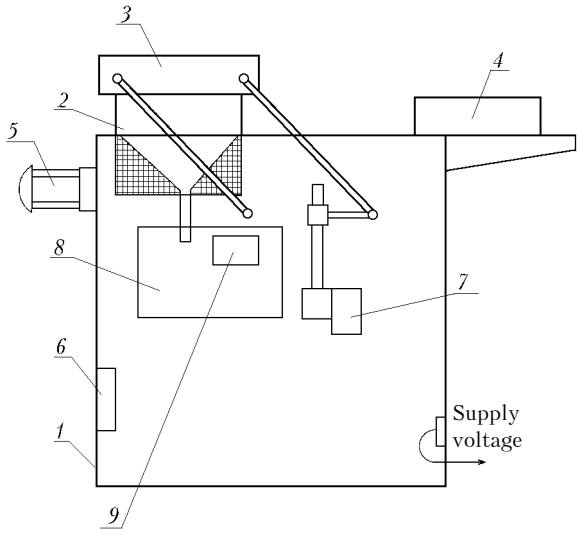

Fig. 1. Precipitation collector: body *1*, collecting funnel with a heater *2*, funnel head *3*, head support *4*, precipitation indicator *5*, electronic unit *6*, electric drive *7*, switching unit *8*, and control unit *9*.

A 1.5-kW heating element is fixed on the outer side of the conical stainless steel funnel. To improve the heat transfer to the funnel body, the heating element is covered by concrete with corundum inclusions. On the outer side, the heating element is covered with a stainless steel pan filled with heat insulator (mineral cotton). The heater is turned on forcedly by a toggle switch on the control panel.

The stainless steel head is supplied with a floating spring-backed gasket for better joining to the funnel. A caprolan ring prevents the head from freezing-on at cold temperatures. The stainless steel support safeguards the head against pollution in the period of precipitation.

The precipitation indicator is intended to fix the time of beginning and end of dry (snow, hail) and wet precipitation. The operating principle of the indicator is

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based on conductivity variation in a gap between two conductors in the presence of water. To increase the effective area, the indicator is made as a couple of conductors (wire 0.1 mm in diameter) wound around a cylinder. The indicator layout is shown in Fig. 2.

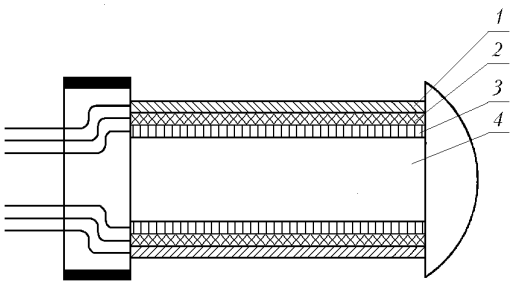

Fig. 2. Precipitation indicator: precipitation detector *1*, temperature sensor *2*, heater *3*, and frame *4*.

For fast evaporation of water after termination of precipitation, as well as for melting water ice precipitation, the indicator is equipped with a heater and a temperature sensor to maintain the temperature at the level of 45–50°C. The structure scheme of the precipitation collector is shown in Fig. 3.

The electronic unit serves to control indicator parameters and to send a control signal to executive chains of an electric drive (open–closed). The signal to close the head after termination of precipitation is generated with a 2-min delay after evaporation of water from the surface. The delay is introduced to exclude unwanted motion of the head at low-intensity precipitation. The electronic circuit is made out of wide-utility operational amplifiers, and the heater is switched with the use of thyristors. The electronic circuit is placed in a heat-insulated body. For reliable operation of the collector at cold temperatures, the electronic unit includes a thermal stabilization system, which maintains the temperature inside the unit within 19–21°C. For this purpose, additional heater and temperature sensor are provided.

The electric drive of the head includes an electric motor, reduction gear, screw pair with a link, power shafts with levers, and a stack of end switches.

The switching unit is located on the front panel and is intended for switching the electric motor chains (start, stop, reversal) by signals from the electronic unit. The switching unit houses a power supply unit, which generates voltages needed for the electronic unit and for the precipitation detector. The switching unit is made of wide-utility electromagnetic relays.

The control panel is located on the front panel and is made as a single device with the switching unit. The control panel includes control and indication units, as well as safety fuses.

Operation modes

Automatic mode

The funnel head is closed. As a drop (any amount) of water or a snowflake falls on the detector, the head opens. Once the precipitation detector has dried, the head moves back, with a 2-min delay, into the "closed" position and the collector returns into the standby state. The precipitation detector is continuously heated up to 45–50°C.

Manual mode

This mode is provided to forcedly open (close) the head. To pass on to this mode, one should set a gang switch to the starting position (open, closed) and push the Start button. The head begins to move to the corresponding position until actuation of the end switches. When the Start button is released, the head movement terminates in an intermediate position.

Operation with water-ice precipitation

In this mode, the collector is operated by an operator. As precipitation sampling is completed in the cold season (at the air temperature below 0°C), the collecting funnel should be heated to melt precipitation and transport into a cooler. To turn the heating element on, one should move the switch "heat" to the upper position. The corresponding indicator begins to light.

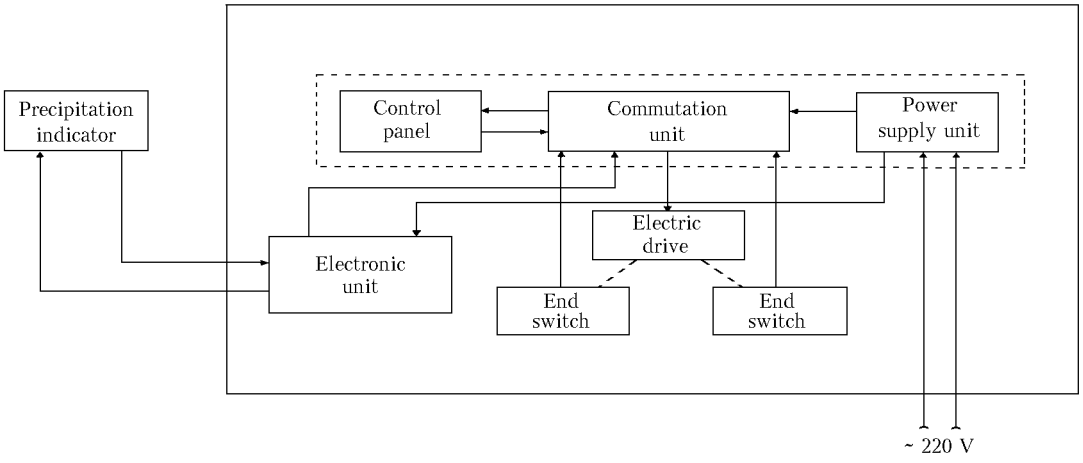

Fig. 3. Structure scheme of the precipitation collector.

Specifications

Diameter of the collecting funnel	357 mm
Head movement modes	automatic, manual
Time of head movement	30 s
Delay for head closure after precipitation termination	2 min
Supply voltage	220 V, 50 Hz
Power consumption (without heater)	250 V·A
Heater power consumption	1500 V·A
Dimensions	280×550×980 mm
Weight	no more than 65 kg
Connecting cable length	10 m

The collector can be operated under following weather conditions: ambient temperature from –30°C to +40°C, relative air humidity up to 80% at +25°C, atmospheric pressure from 84 to 107 kPa (630–800 mm Hg).

Two precipitation collectors of this design have been manufactured by now. One of them has been in use at the Limnological Institute SB RAS since July 2001. Another one was passed to the Far East Branch of the Russian State Hydrology and Meteorology Committee in 2002. The appearance of the automated precipitation collector is shown in Fig. 4.

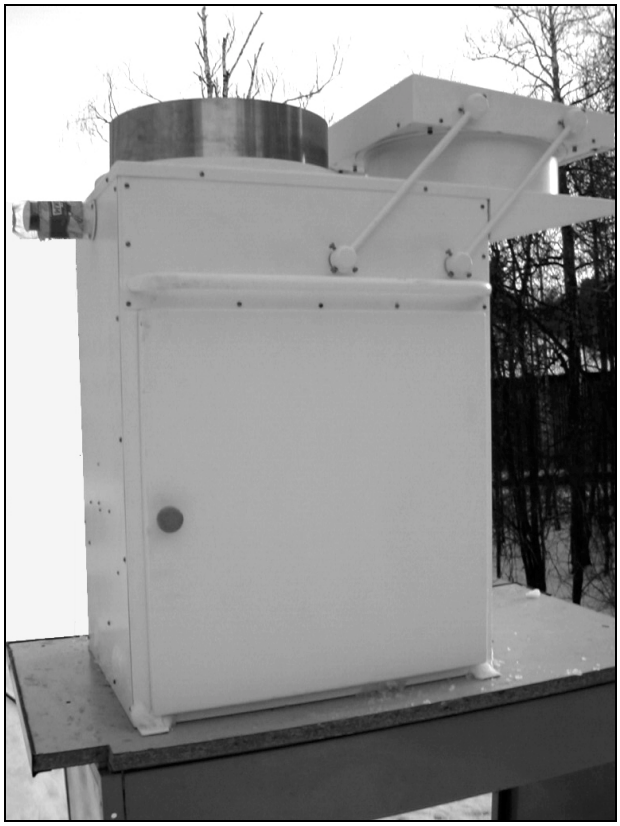

Fig. 4.