MEASUREMENT OF THE SOLAR CONSTANT (SOLCON)
(E021)

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The objectives of this investigation are: (1) to measure the absolute value of the solar constant with improved accuracy, and (2) to detect and measure long-term variations that may exist in the absolute value of the solar constant.

The solar constant is the total irradiance of the Sun at a distance of one astronomical unit. This will be measured directly in space by an absolute self-calibrating radiometer with an absolute accuracy estimated to be of the order of ±0.1 percent and a sensitivity better than 0.05 percent.

The values for the solar constant obtained by measurements since 1960 lie between 1353 ± 20 W/m^2 and 1392 ± 14 W/m^2. This dispersion is caused by the inaccuracies and scale problems of the instruments which have been used and the need to correct measured values for atmospheric attenuation. The use of an absolute radiometer removed from the effects of the atmosphere with its calibration tested in situ is the only way in which a truly accurate measurement of the solar constant can be made. Through the use of such space borne instruments, the situation is now improving.

The need for an accurate measurement of the solar constant has been recognized for some time, and improvement of the value has been strongly recommended by several scientific bodies. The absolute value of the solar constant is a critical element in the determination of the Earth's radiation budget as well as for the studies of Earth albedo. In addition, it is one of the main components in the energy balance equation for the Earth and its atmosphere, and is responsible for the dynamic behavior and circulation of the atmosphere and, thus, also the climate. For climatology and atmospheric physics, the importance of an accurate knowledge of the value of the solar constant and its variations over long time periods cannot be overstressed.

The special feature of this radiometer (Fig. II-3) is that it has two channels which enable the detection of and compensation for any degradation of the black surfaces, and the determination in space of the self-consistency of the radiometric system. The radiation measurement will be made by using a heat balance system automatically driven by a feedback system. The precise knowledge of the electrical, optical, mechanical, and thermal characteristics makes this radiometer an absolute instrument which does not need to be calibrated by radiative sources.

Each of the two radiation sensors has an independently controlled shutter. The radiometer is operated by using various combinations of open and closed shutters and a reference electrical power source which has a stable and known output.

At the beginning and end of each measurement sequence, the correct behavior of the radiometer system is ascertained by having the shutter of both channels closed, applying the reference power source to one heater, and using the servosystem to adjust the power applied to the other until heat flux balance is achieved. The roles of the channels are then reversed and the same procedure followed. The measurement of the electrical power applied to each channel for the two cases gives a value for the

precision of the servosystem. Because the power of the reference electrical source is already known, this is a simultaneous check of the data processing system.

The actual radiation flux measurements are made by pointing the radiometer to the Sun's center and opening the shutter of the channel to which the servosystem power is attached. The servosystem compensates for the extra heat input until heat flux balance is achieved again. The shutter is then closed, and the servosystem should adjust the power back to its previous value. The difference in the power applied with the shutter opened and closed is a function of the incident radiation flux. The absolute total irradiance can be calculated from the known characteristics of the instruments. This sequence of opening and closing the shutter will be repeated several times, always using the same channel for the measurement.

On the first and last measurement sequences of the mission, the roles of the channels will be reversed for just one step, and the shutter of the channel that is normally closed will be opened. In this way the radiation measurements of the two channels can be compared to detect and compensate for any aging of the black paint of the absorption surface that is repeatedly exposed to the Sun.

The strategy for these long-term observations using the proposed absolute radiometer is as follows: (1) direct and absolute measurement of the solar constant on the first Spacelab mission which flew in 1983; (2) repetition of the measurements using the same radiometer on subsequent flights; and (3) ground based comparison between flights of the radiometer with spare models and other absolute radiometers, ascertaining the link with the new International Radiometric Reference.

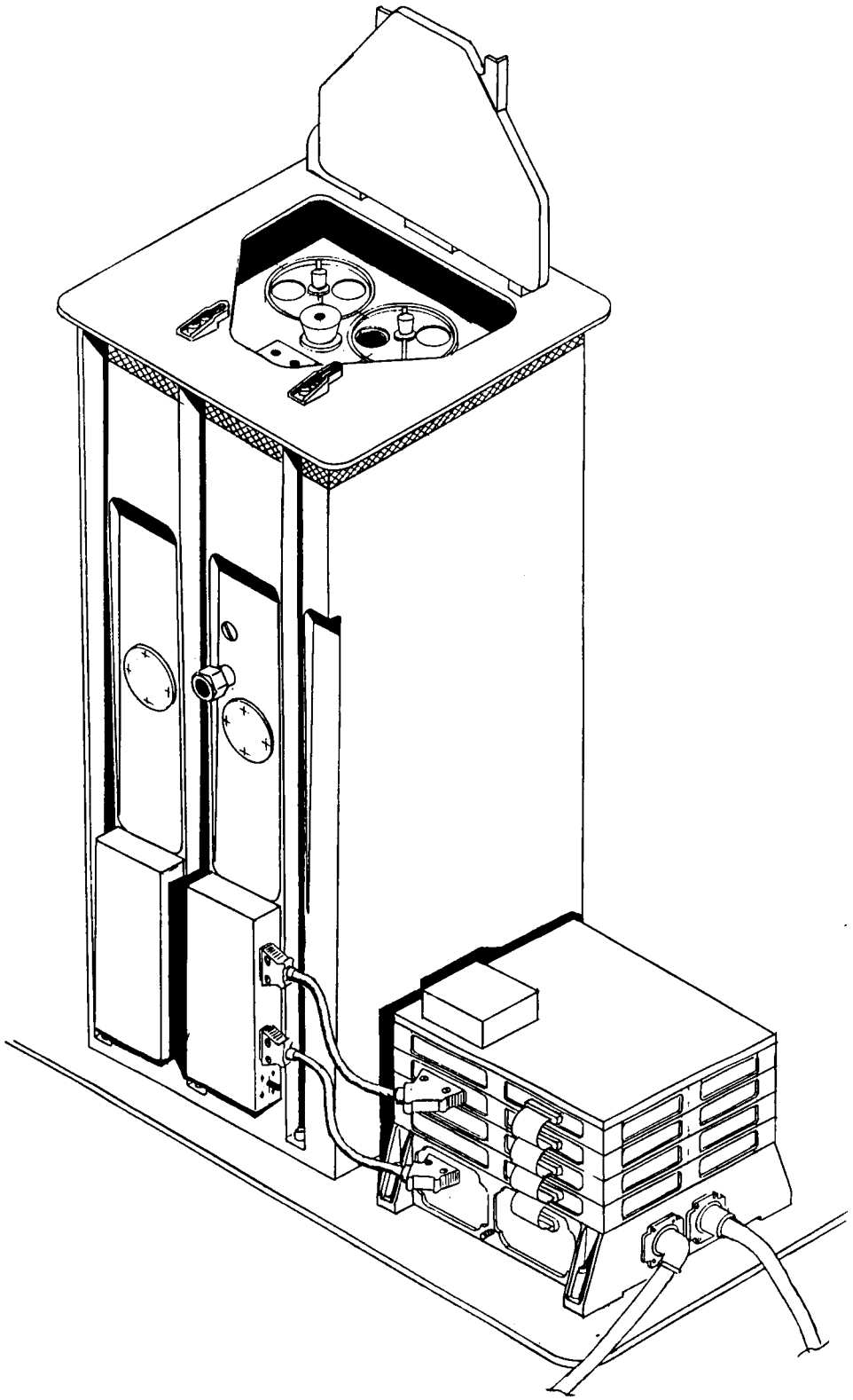

Figure II-3. SOLCON radiometer.