AUTOMATION OF THE CONTROL OF THE HORIZONTAL TELESCOPE FOR A MAGNETOGRAPH

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Abstract: The principle of an automatic pointing and scanning device of the horizontal telescope feeding the magnetograph at the Ondřejov Observatory, is described. Further, we describe the spectroheliograph controlled by the same automatic device.

Active regions of the solar surface have been observed by means of a photoelectric magnetograph at the Astronomical Institute of the Czechoslovak Academy of Sciences in Ondřejov since 1972. The instrument, which we obtained from the Siberian IZMIRAN in Irkutsk, is designed to measure the total vector of the magnetic field of the Doppler velocity, the intensity in the centre of the line and in the continuum. Since the output of the magnetograph has as yet not been fully adapted to the computer, from the point of view of evaluation only the longitudinal component of the magnetic field is being measured.

The magnetograph's spectrograph is fed by the horizontal telescope, focal distance 35 m and mirror diameter about 450 mm.

The optical pattern of the instrument is the following: The light ray is incident on the coelostat mirrors 1, 2 (Fig. 1), from where it propagates to the main mirror 3, focal distance 35 m, and then to the auxiliary mirror 4 and the input spectrograph slit 5. Beyond the slit there is an electro-optical modulator 6, the collimator mirror 7, the spectrograph grating 8 and the camera mirrors 9 and 16. Mirror 16, reflecting the spectral line into the plane of the exit spectrograph slit 17, is used for photographic methods of measurement. Mirror 9 reflects the spectral line onto the input slit of the magnetograph photo-multiplier block 11. Between them there is a planeparallel plate 10 for measuring the Doppler velocities by the compensating method.

The measurements are carried out by the classical methods of modulating polarized light of a split spectral line and by dividing geometrically the signal from the line wings at the input slits of the photo-multiplier block. In order to obtain magnetic maps by this method, it is necessary to secure defined scanning of the measured region of the Sun. For this purpose a scanning pointing system of controlling the horizontal telescope was developed in our Institute.

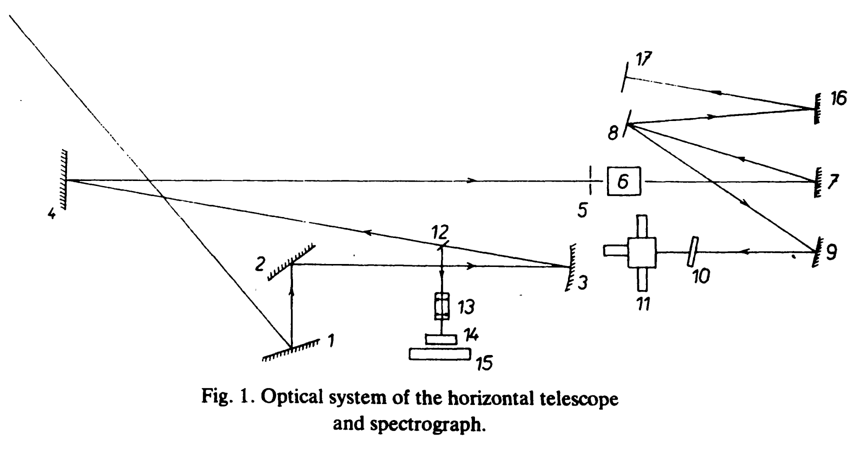

Fig. 1. Optical system of the horizontal telescope and spectrograph.

The pointing automatic device operates on the principle of an electro-optico-mechanical feedback. Part of the beam, reflected from the main mirror 3, is deflected above the glass prism 12 to the side. The optical system 13 reflects the solar disk, diameter 21.5 mm, onto the photoelectric sensor 14, the position of which can be varied in two mutually perpendicular directions.

The error signal, the magnitude of which is proportional to the deflection of the solar disk from the mean compensated position, is taken from the output of the sensor.

After processing in the electronics block, the error signal controls the step motors of the auxiliary mirror of the coelostat 2, so that the error deviation in the sensor is decreased. Since the optical surfaces 4 and 12 are mutually immobile, the position of the solar disk on the input slit 5 of the spectrograph will be determined by the position of the photoelectric sensor 14.

The design of the electronics block is determined by the specific properties of the motors. The step motors are subject to eight-phase control by impulses via reversible counters.

The error signal whose polarity determines the direction of the deflection of the solar disk from zero position, is amplified in the operational amplifier 2 (Fig. 2). The amplified error signal controls

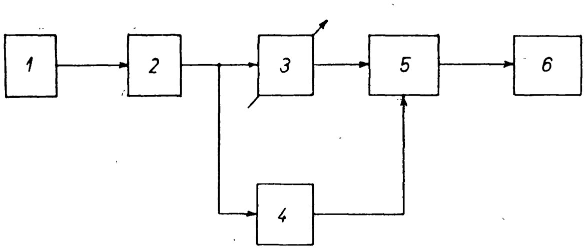

Fig. 2. Electronics block diagram of the automatic pointing device.

the frequency of generator 3 and, thus, also the rpm's of the step motor. The voltage level at the output of circuit 4 determines the direction of rotation. In dependence on the polarity of the input signal, the output voltage level of circuit 4 changes at a jump.

The revolutions of the step motor are proportional to the error signal within certain limits (upto 10″). For larger deflections the frequency of the generator remains constant and it is determined by the properties of the step motors (maximum acceleration).

The deflections of the solar disk as a result of shocks, etc., are compensated rapidly, without oscillations around the zero position. Slow variations due, e. g., to inaccuracies of the transmission, are compensated unnoticably. The automatic scanning pointing device operates with an accuracy of $\pm 1''$. This limit is not determined by the electronics, but by the quality of the image and the mechanical transmissions.

For scanning and manual pointing of the telescope the photoelectric sensor is shifted by the step motors independently along two mutually perpendicular coordinates. The shift rate can be controlled in the range from 0.5″/sec to 250″/sec.

In the course of all displacements the automatic pointing device retains the disk in the middle of the photoelectric sensor.

The scanning programme, i.e. the length of the line and the distance between lines, can be set on the counter with an accuracy of 1 impulse, which represents 0.25″ of arcsecs. The automatic device can be used to scan any rectangular region, and if necessary even the whole solar disk. The scanning was usually conducted at a rate of 3″/sec with a 3″×3″ slit, or a 3″×6″ slit. All sections were conducted in one direction. The reverse travel was effected at maximum speed.

Later the scanning device was also controlled by a spectroheliograph, which can be fixed to the spectrograph at the output slit 17. The automatic shift of the solar disk across the slit, as well as of the photographic plate along the output spectrograph slit can be selected in steps with an accuracy of 1 impulse. After each shift of the photographic plate and of the solar image, automatic exposure follows.

A spectroheliogram of calcium in H_3 is shown in Figure 3. The width of the input spectrograph slit was about 2″.

The map of the magnetic fields of the same region is in Figure 4. The full line represents positive polarity, the dashed line negative polarity. The magnetic field levels are staged roughly in steps of 30 Gauss. The input spectrograph slit in measuring the magnetic fields in the 5250 A line was 3″×6″.

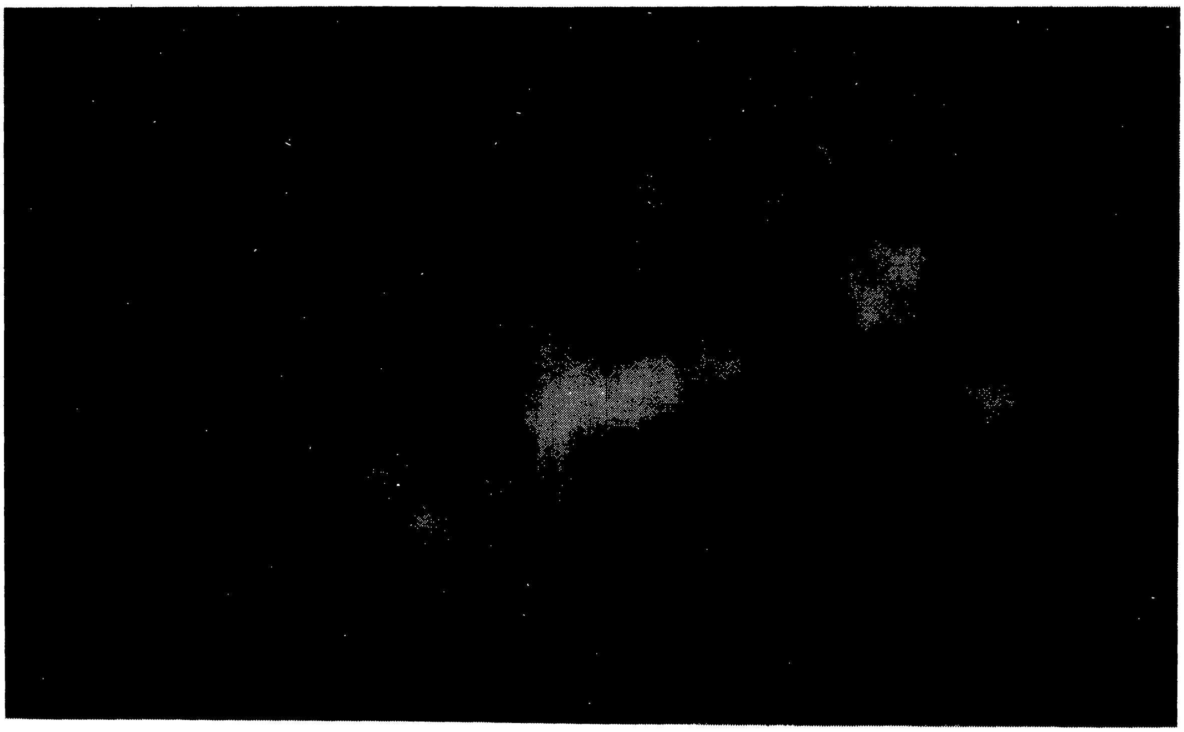

Fig. 3. Spectroheliogram of calcium in the H_3 line.

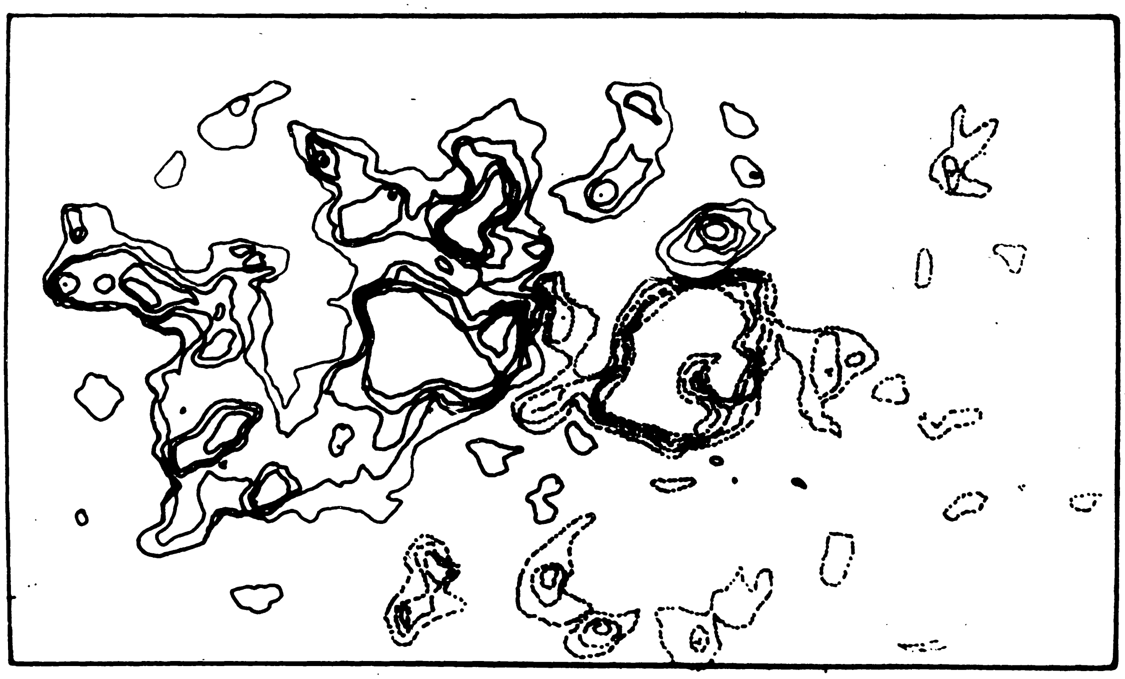

Fig. 4. The map of magnetic fields corresponding to Figure 3.