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KISO INFORMATION BULLETIN

XIX. MEASURING MACHINE FACILITIES AT THE KISO OBSERVATORY

The Kiso Observatory is equipped with four measuring machines. They are a microphotometer, an irisphotometer, a blink comparater and an isophotometer. All were designed for measuring 14 inch (=35.6 cm) square plates taken with the Kiso 105 cm Schmidt telescope.

A giant versatile machine or a set of several instruments with different functions were the alternatives initially considered. Eventually we opted for the latter, intending to modify the four rather conventional apparatus above to accept large plates and to develop an automized operation and control system. Descriptions of each of these instruments will be given below together with some results of performance tests. The measurement programs carried out at the Kiso Observatory utilizing each of these four machines are listed in every odd number issue of the Kiso Information Bulletin.

A. THE MICROPHOTOMETER

1. Introduction

The mechanical and optical parts of the microphotometer were constructed in 1971, and the digital output unit was attached to it in 1972. It employs a conventional "null" method, while a digitizing mechanism is different from the classical machines. This is very simple but quite useful, and happens to be almost the same as that of Rutten and van Amerongen (1975).

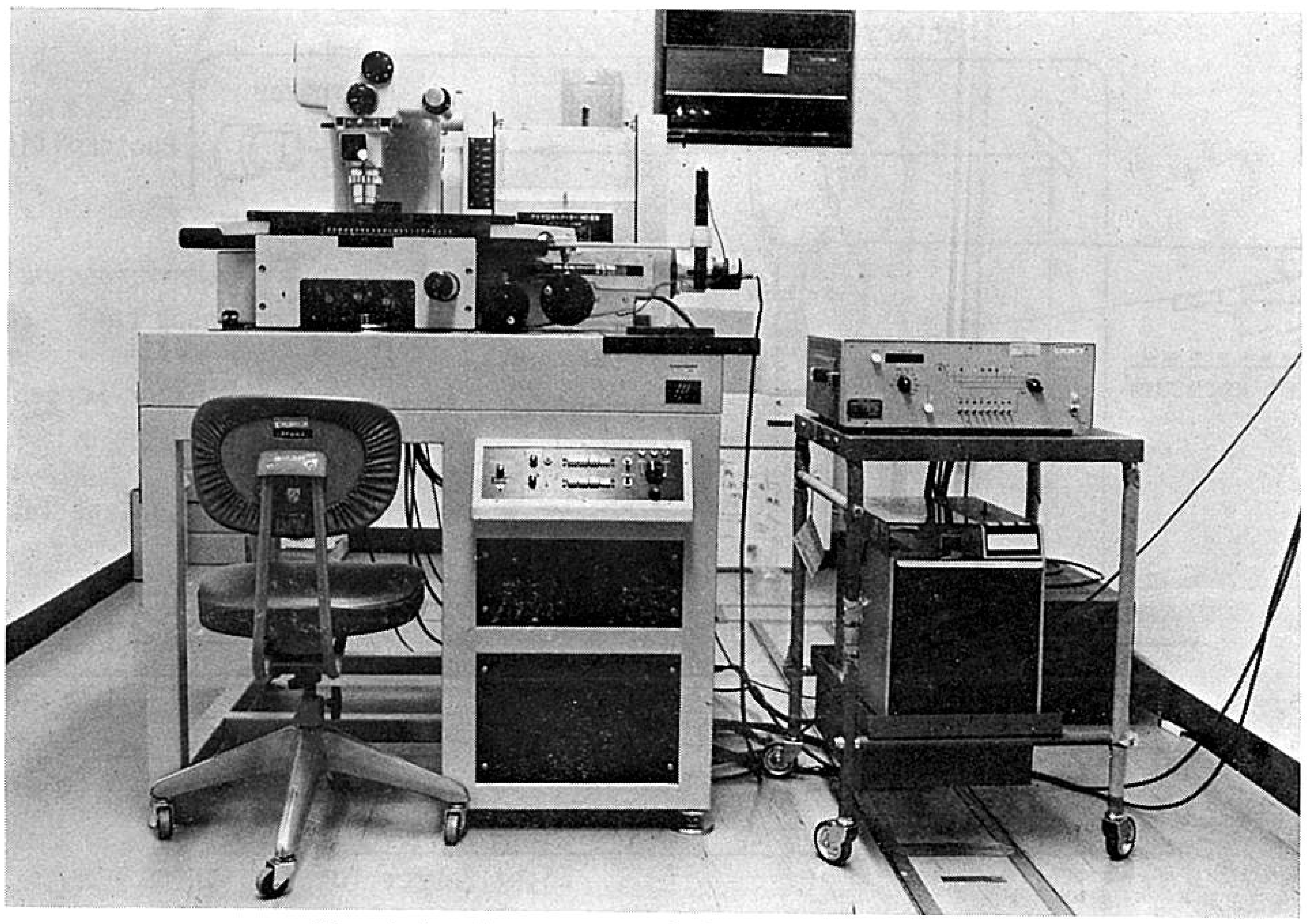

Fig. A-1. Appearance of the microphotometer

A general description including performance tests was given in Ishida, Maehara, and Ohashi (1974).

2. Mechanical Component

A photograph of the microphotometer is given in Figure A-1. The digital-output unit is separate and connected with electric cables. The optics of the machine are assembled on the steel bench inside which the electric components such as relays and amplifiers are housed. The plate carriage is driven in two axes either by manual operation or by electric control. The carriage table is 50 cm square in size and in the center of the table is a polished glass plate 23 cm square and 5 mm in thickness. Its range of motion is 22 cm along both axes. This makes it possible to measure any position on a 35.6 cm plate without having change the orientation but simply shifting it. The surface of the glass keeps photographic plates flat to within the depth of focus.

The measurement can be made in a raster scanning mode using the two microswitches along the scanning (X) axis and a Geneva gear along the other (Y) axis. The measuring speed may be selected from among 1.25, 2.5, 10 and 20 mm min^{-1}, and the pitch length in the Y direction from among 0.05, 0.1, 0.2 and 0.4 mm. The trace-indicator attached to the carriage indicates the measuring position on the plate if a contact copy is placed on the desk.

3. Optical System

The machine has double-beam optics, as is illustrated in Figure A-2. The light source is a 10 volt 70 watt iodine lamp. Measuring and comparison beams are switched at a frequency of 525 Hz. The measuring beam passes through the plate to the photomultiplier 1P21. Whereas the comparison beam reaches the same photomultiplier passing through the rotary diaphragm, which is controlled by a servomechanism to balance both beams.

The magnification of both objective lenses is 4, and their aperture number is 0.1. The measuring beam is projected through the beam-splitter onto a 30 mm square screen. The telemicroscope

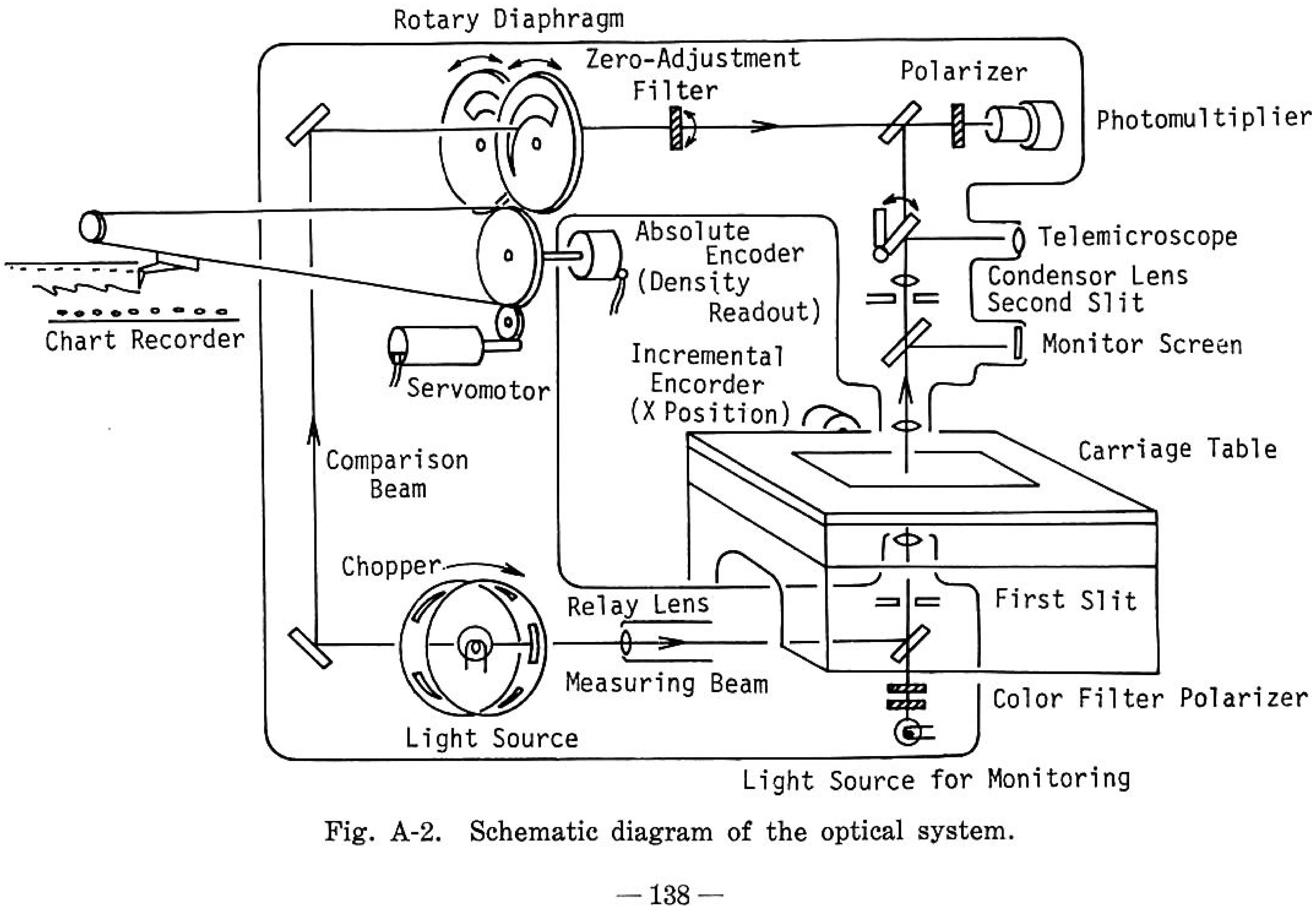

Fig. A-2. Schematic diagram of the optical system.

is used in order to adjust the slits and the foci of objective lenses. This machine obtains the semispecular density, which is converted to the diffuse density scale by multiplying by 0.65 (Noguchi, Takase, Soyano, and Koyano 1978).

4. Data-Output Unit

The analog output is obtained directly on a chartrecorder. The density range of 2.5 can be extended up to 4.5 by inserting neutral density filters. The chart may be driven at any of six speeds.

The digital value is read out from the 10-bit absolute encoder attached to the rotary diaphragm. This output is punched on a paper tape in an 8-bit binary code after the selection of upper, middle, or lower 8 bits is made. This selection yields a density resolution of 0.0112, 0.0056, or 0.0028, respectively. Though the latter two cases correspond respectively to a half and a quarter of the full range, overscaled data can be correctly processed by the software.

The position of the X axis is displayed in the units of the micrometer with the rotary encoder. The data sampling rate may be selected from among 1, 2, 5, 10, 20, 50, 100 and 200 μm. This method of data recording efficiently compresses the amount of output data by a factor of 4, when compared with the conventional method using a 3 digit decimal number.

5. Performance

The response of the machine to the density variations is not rapid because of the time required to balance the rotary diaphragm. The resultant time resolution is about 3.0D sec^{-1}. On the contrary, the stability of the system is maintained well allowing a long measurement time after the machine has attained to a thermal equilibrium. The relative displacement between the 1st and 2nd slits is ordinarily less than 10 μm. The reproducibility of the density is much better than 0.01D, and the long-term stability of the density is kept within about 0.01D.

The X axis is driven with a screw of 5 mm pitch whose error is about $\pm 5\,\mu$m. Since data are sampled in response to the output pulse of the rotary encoder, this error directly affects the sampling position. Therefore, the present machine produces an error so large that it cannot be used as a position measuring instrument. The replacement of the rotary encoder with a linear one is now being planned.

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Noguchi, T., Takase, B., Soyano, T., and Koyano, H. 1978, Tokyo Astron. Obs. Report 18, 400 (in Japanese).
Rutten, R. J., and van Amerongen, H.J. 1975, in 'Image Processing Techniques in Astronomy' (ed. C. de Jager & H. Nieuwenhuijzen), p. 261.

B. THE IRISPHOTOMETER

1. The Main Structure

The main feature of the structure of this apparatus is a rigid base frame having a wedge shape in which the mechanical, optical and electronic components are contained. In the front face are a control panel and a viewing screen, while in the back is a plate carriage. The peripheral apparatus including a paper-tape reader, a paper-tape puncher, and a high voltage power supply are connected to the main body. The structure is shown in a schematic diagram (Figure B-1) and photographs (Figure B-2(a) and Figure B-2(b)).

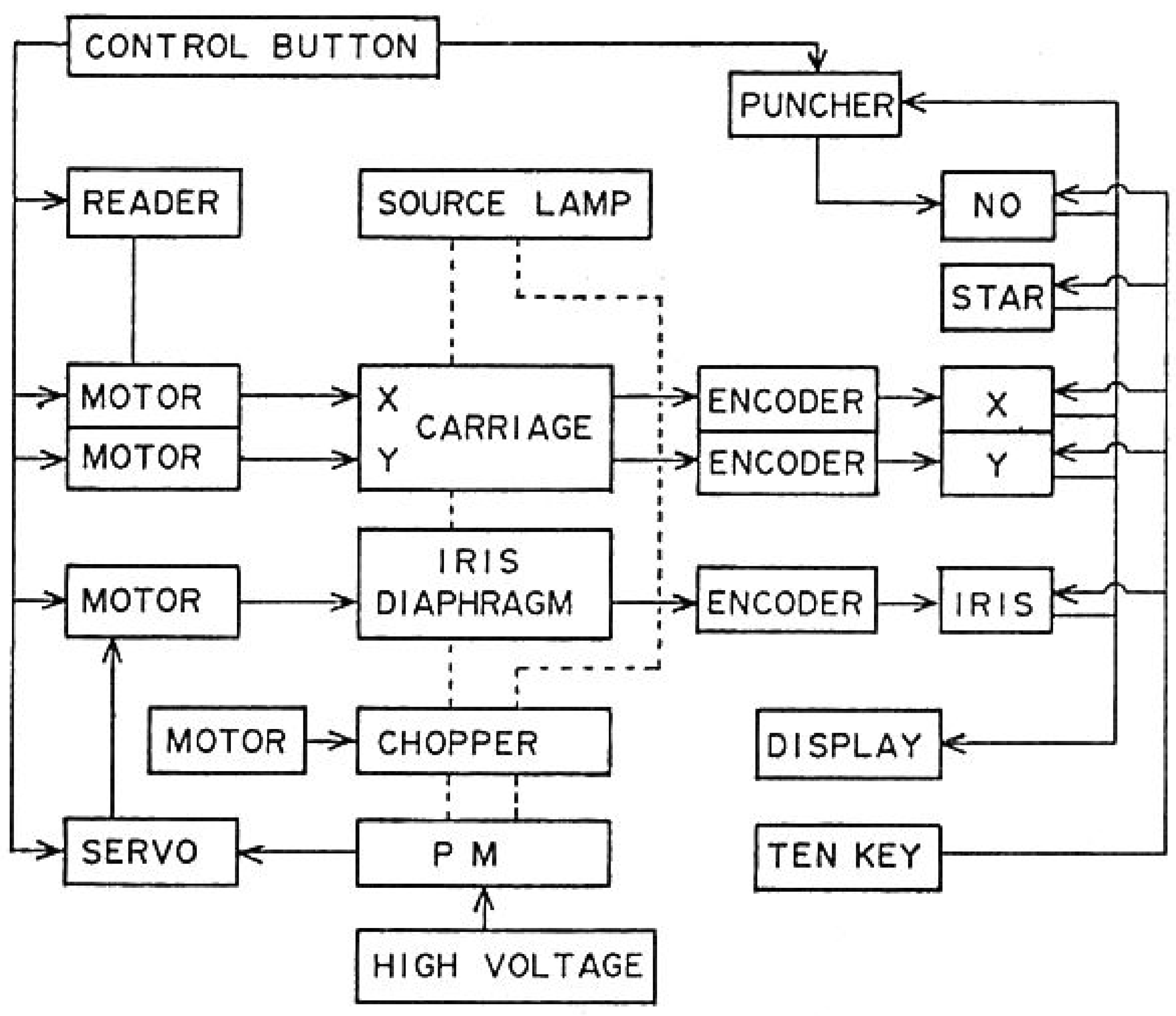

Fig. B-1. Schematic diagram of the structure of the Kiso irisphotometer.

(1) Mechanical design

It is hard to keep a glass plate, which is 35.6 cm square in size and 1 mm in thickness, strictly flat in a horizontal plane, because it bends under its own weight. To avoid this the present wedge-shaped structure has been designed. A plate holder is placed parallel to the inclined back surface, and is hung on the carriage, which is again hung on inclined surface of the base frame by means of a pulley with a counterweight. The movable range of the carriage is 36 cm in each of the orthogonal axes X (horizontal) and Y (parallel to the inclined surface), so the length of supporting shafts and guiding rails are 106 cm in both axes.

Sitting at the front of the machine, one can operate key buttons on the control panel and watch the image of the iris diaphragm or the star field of the plate on the viewing screen. The carriage is driven at one of three speeds, "Quick" (10 mm sec^{-1}), "Slow" (1 mm sec^{-1}) or "Fine" (produced by a reversible motor and an eccentric cam). The position of the carriage is read out by an optical linear encorder of an incremental type which is 40 cm in length and has 1 μm divisions.

(2) Optical path

The light source is an iodine lamp of 10 volt and 70 watt. It is housed in a box attached at the top of the main structure to avoid a heat radiation effect. The viewing screen is 15 cm square in size. One of two modes of the projection, either "Field" (10 magnifications for inspecting the star field) or "Iris" (30 magnifications for watching the iris diaphragm) is selected by pushing the respective buttons on the control panel.

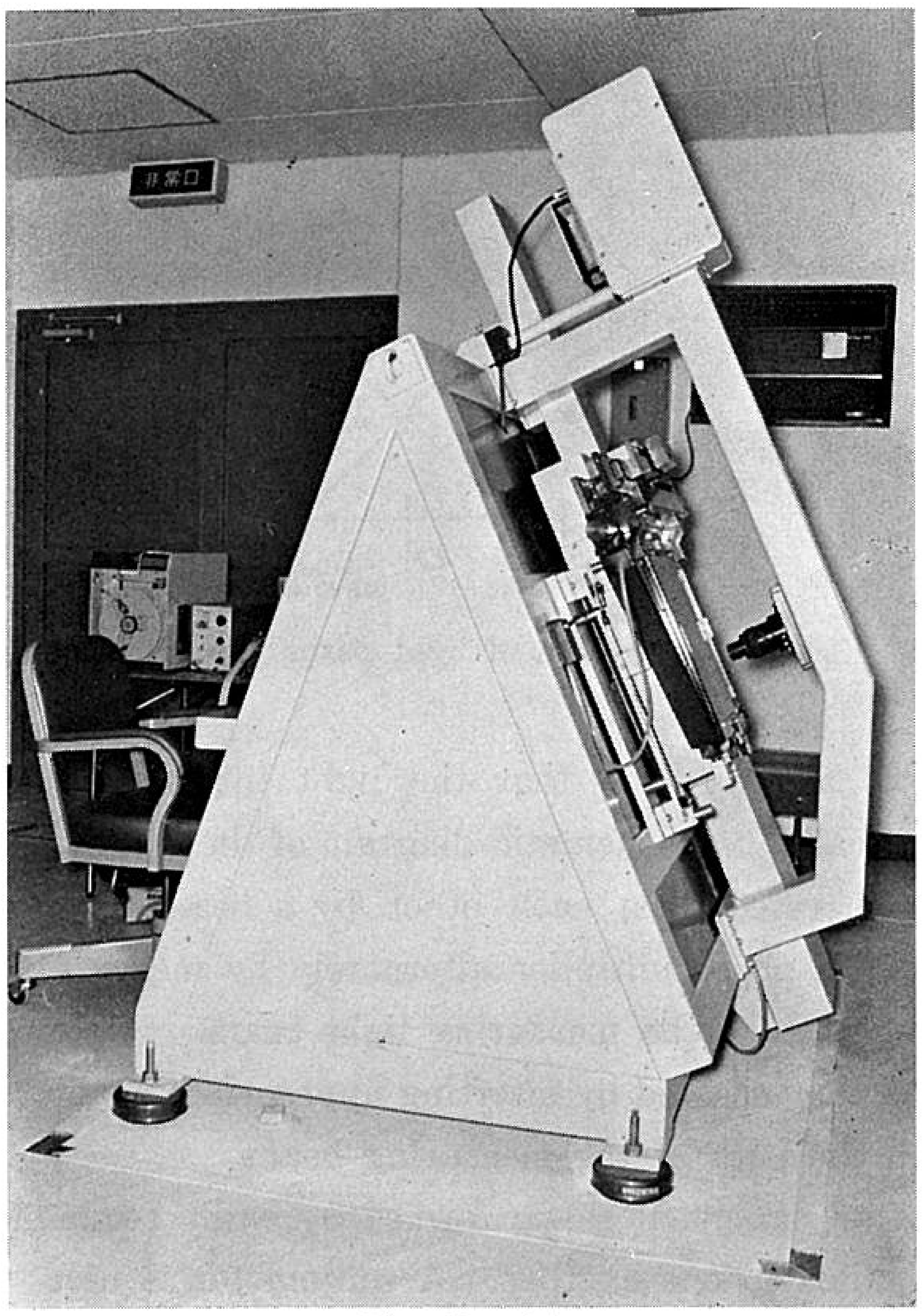

Fig. B-2 (a)

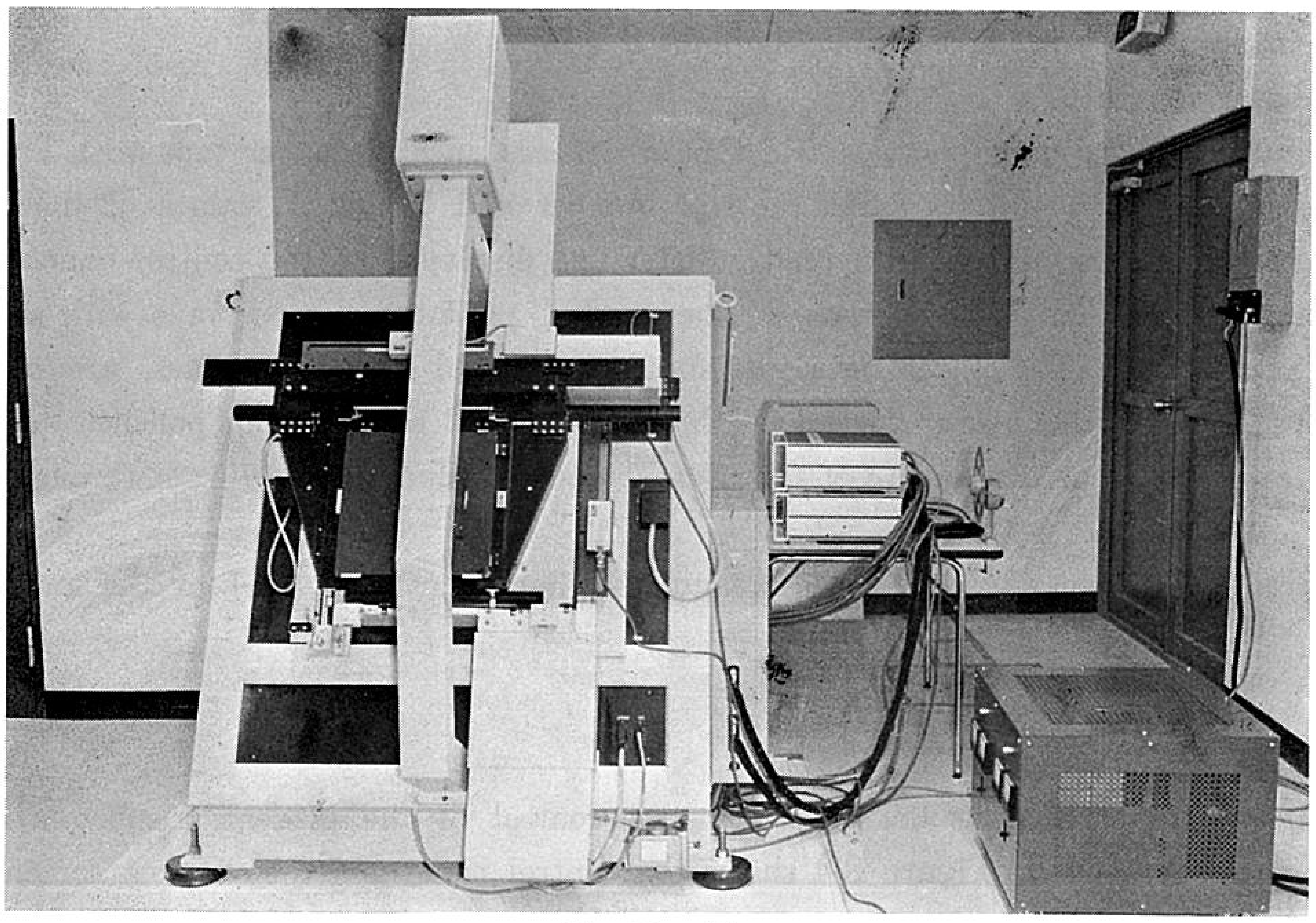

Fig. B-2 (b)

Fig. B-2. Appearance of the irisphotometer seen from (a) flank and (b) back face.

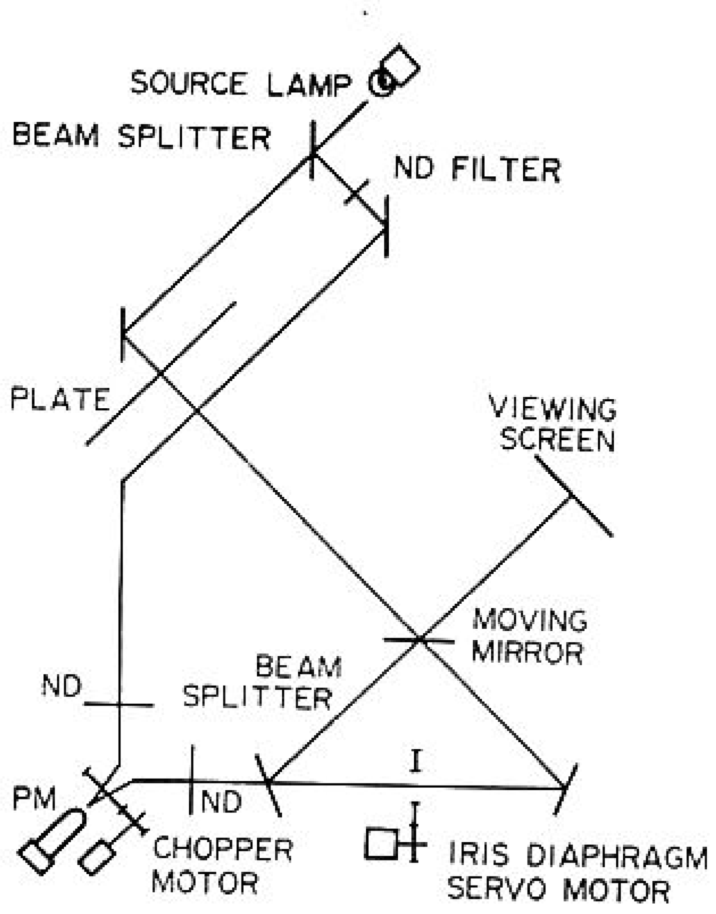

Fig. B-3. Schematic diagram of light paths in the irisphotometer.

The optical system is of a type such that the light intensities of measuring and reference beams are balanced automatically. A schematic diagram of the optical path is shown in Figure B-3. The two beams which are separated from each other by a beam splitter, follow their respective paths, and are finally lead to a photomultiplier alternately by means of a chopper wheel. An iris diaphragm is inserted in the path of the measuring light beam. Variation of the sky background density among plates can be compensated by inserting appropriate neutral density filters immediately before the chopper wheel in the path of the measuring beam.

The iris diaphragm has an octagonal shape formed by eight segments each with a knife edge, which are connected by a pulley to one another. A servomotor is used to adjust the opening size of the diaphragm, so that balance between the light intensities of the two beams is attained. The diameter of the iris diaphragm is read by an absolute rotary encoder of 13 bits in the gray code and is displayed as an iris value in four digit BCD code.

(3) Peripheral apparatus

A paper tape reader is of photoelectric type and reads an 8 bit paper tape with a speed of 50 characters per second. The input data, the star number and X and Y values of the object to be measured, are preset, memorized in a read register and displayed on the control panel.

A puncher of similar type to that of the reader, produces a paper tape with a speed of 60 characters per second. The output data, the star number and X and Y values, are memorized in the punch register and are also displayed on the control panel before being punched out. The output paper tape can be used as a preset tape for X and Y values, by feeding it through the reader again.

A high voltage power supply for the photomultiplier is usually used in the range 800-1000 volts.

2. Operation and Control

Several features concerning the operation and control of the present irisphotometer will be mentioned in the following. Figure B-4 shows the control panel and the viewing screen.

(1) Peak holding circuit

The key button "PEAK" is pushed to switch the peak holding circuit on, which holds the largest iris value in the punch register. The largest iris value occurs when the stellar image is precisely centered in the iris diaphragm, and the uncertainty in the centering is estimated by eye judgement to be about 3 μm. Therefore the peak holding mechanism is very helpful for minimizing

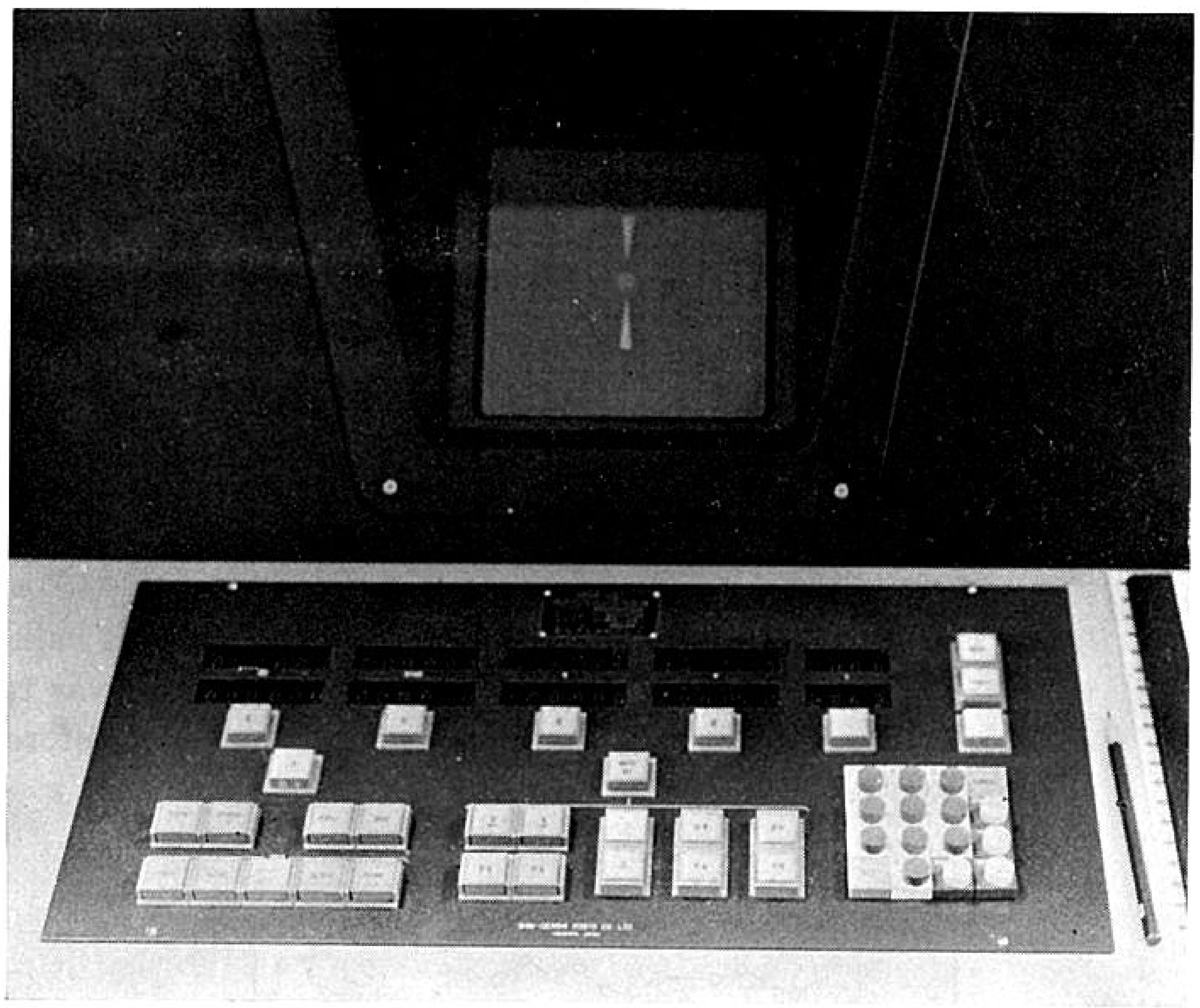

Fig. B-4. The control panel (front) and the viewing screen. Black rectangles seen along the upper side of the control panel are display windows. Square buttons are operation keys while round ones at lower rigrt are ten-keys.

personal error in the centering and is also useful for eliminating the mechanical backlash in the iris diaphragm if there is any.

(2) Automatic drive and speed control of the carriage

"AUTOXY" is a key button used to drive the plate carriage automatically in X and Y axes until coincidence is obtained between the preset and actual values. The accuracy of this automatic setting is estimated to be better than 100 μm. The actual values are read out by encoders. The preset values are given by manual operation of the ten-key on the control panel or by the prepared paper tape fed in the reader.

The plate carriage is driven in the "Quick" mode while the difference between actual and preset values of X or Y position is large, but the speed is changed automatically to "Slow" mode when the difference becomes small. While the carriage is in motion, "AUTOXY" button continues to flicker.

There is a special key button "LOGIC" which is used to perform some sequential operation automatically.

(3) Displays

There are five pairs of display windows on the control panel, each pair showing the preset and actual values (see Figure B-4). The leftmost indicates the serial number of measurement which is increased by one whenever "PUNCH" button is pushed. The next shows the proper number of individual stars which can be put in with the ten-key or using the paper tape. The rest of them are for X, Y, and the iris values.

3. Test of Performance

Figure B-5 shows examples of the variation of iris values as a function of time elapsed since the power was turned on. It is seen from the figure that 24 hours are needed for the instrument to become stable.

Switching on or off of the high voltage power supply gives no detectable effect on iris values.

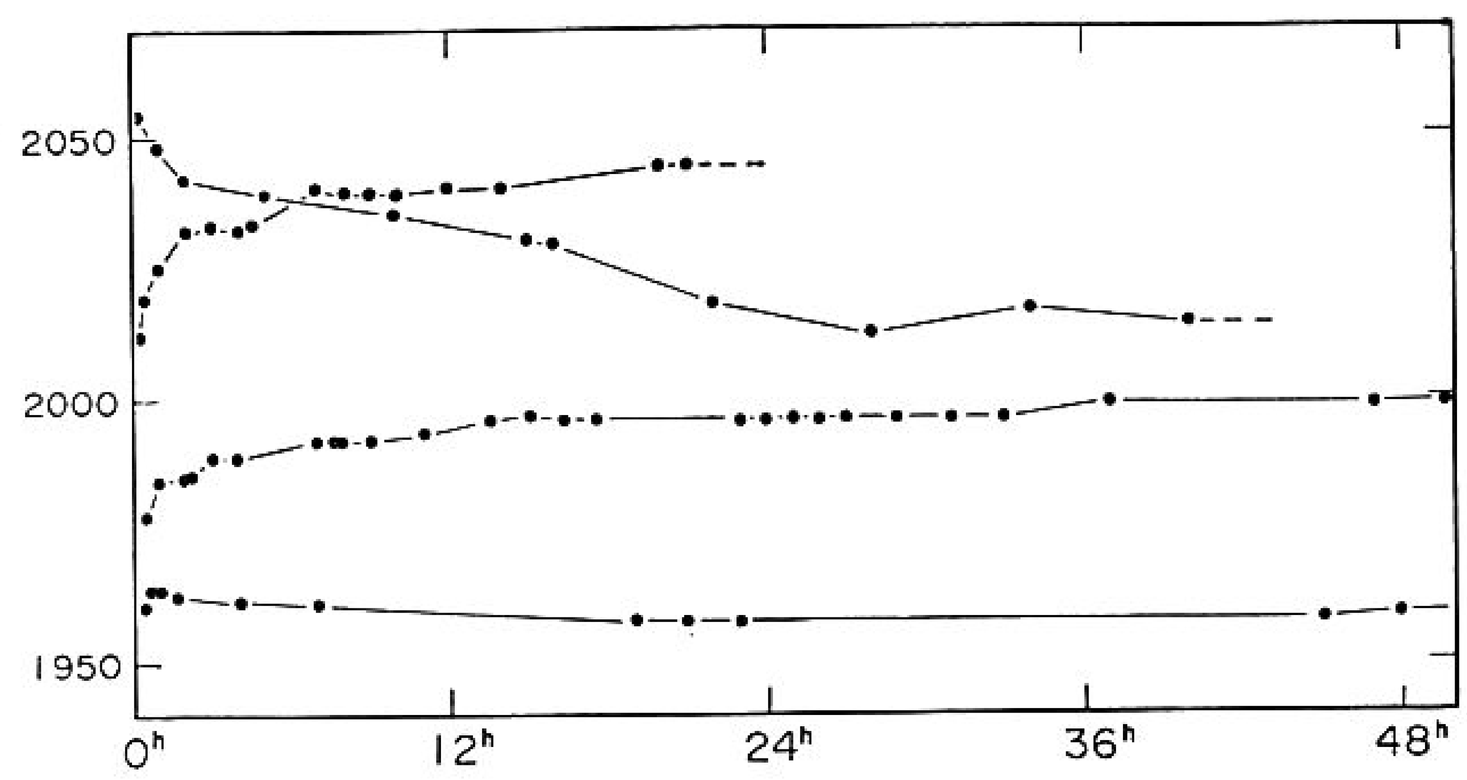

Fig. B-5. Time variations of iris value. The ordinate is the iris value and the abscissa is time elapsed since the electric power was turned on. It is seen that about 24 hours are needed before the instrument becomes stable.

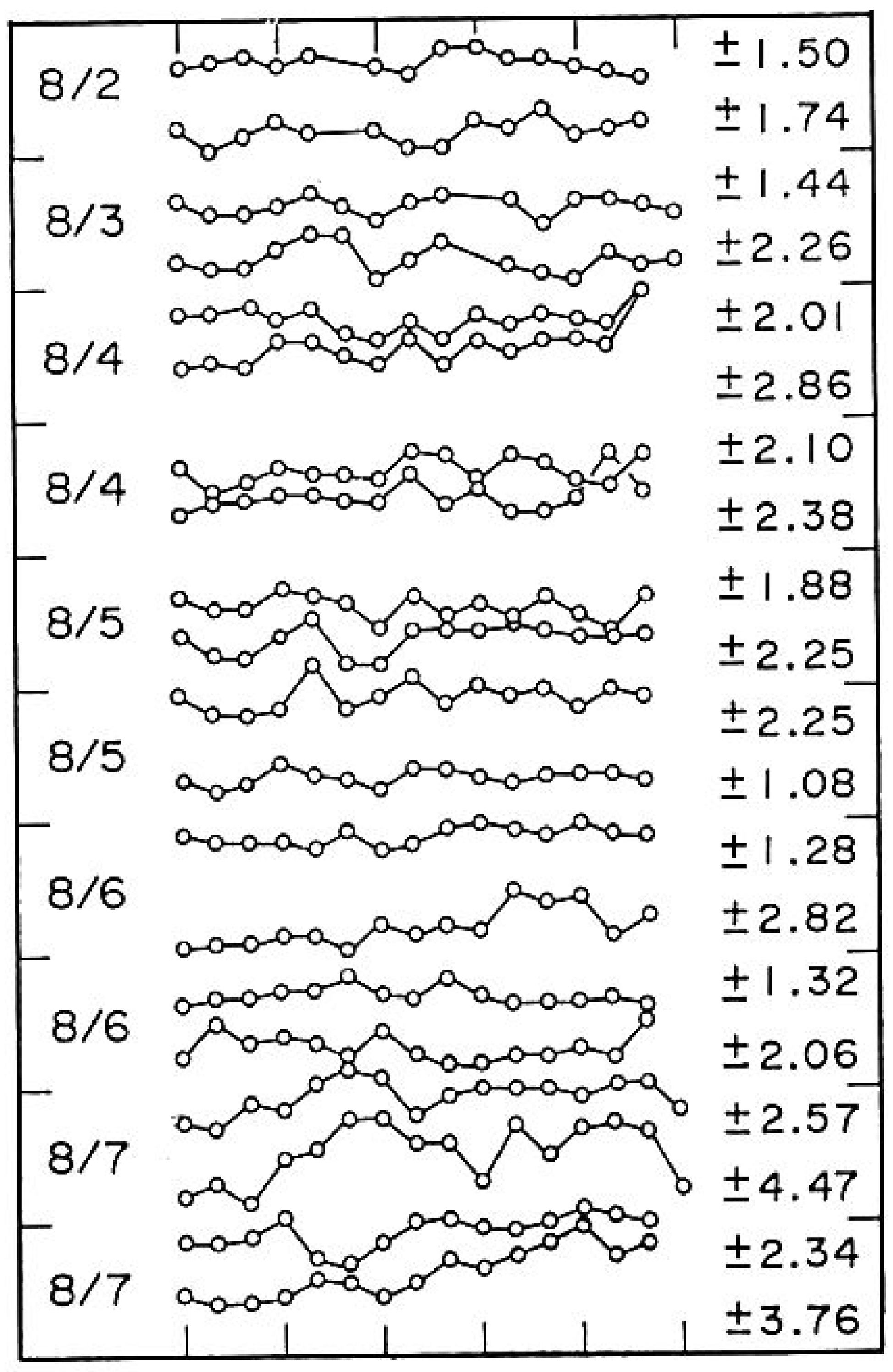

Fig. B-6. A stability test of the irisphotometer continued for six days. The measurement of two pilot stars on each of ten plates was repeated every 20 minutes for 5 hours. The standard deviations of the iris values of these stars are given at the right hand side. One division of the ordinate corresponds to 20 iris values while that of the abscissa to one hour. The electric power supply was turned on well in advance.

The iris value remains almost constant for several days once it has been stabilized. For example the maximum change of the iris value was only 3 units in five days when a star image was kept at the center of the iris diaphragm.

Figure B-6 shows a result of a test measurement of estimating accuracy of the magnitude determination. Iris photometry of two particular stars on each of ten plates was repeated every 20 minutes for 5 hours. It is seen that the standard deviations of the iris values of these two pilot stars lie in the range between 1.1 and 4.5 units. The mean value, 2.2 units, corresponds to about 0.01 mag.

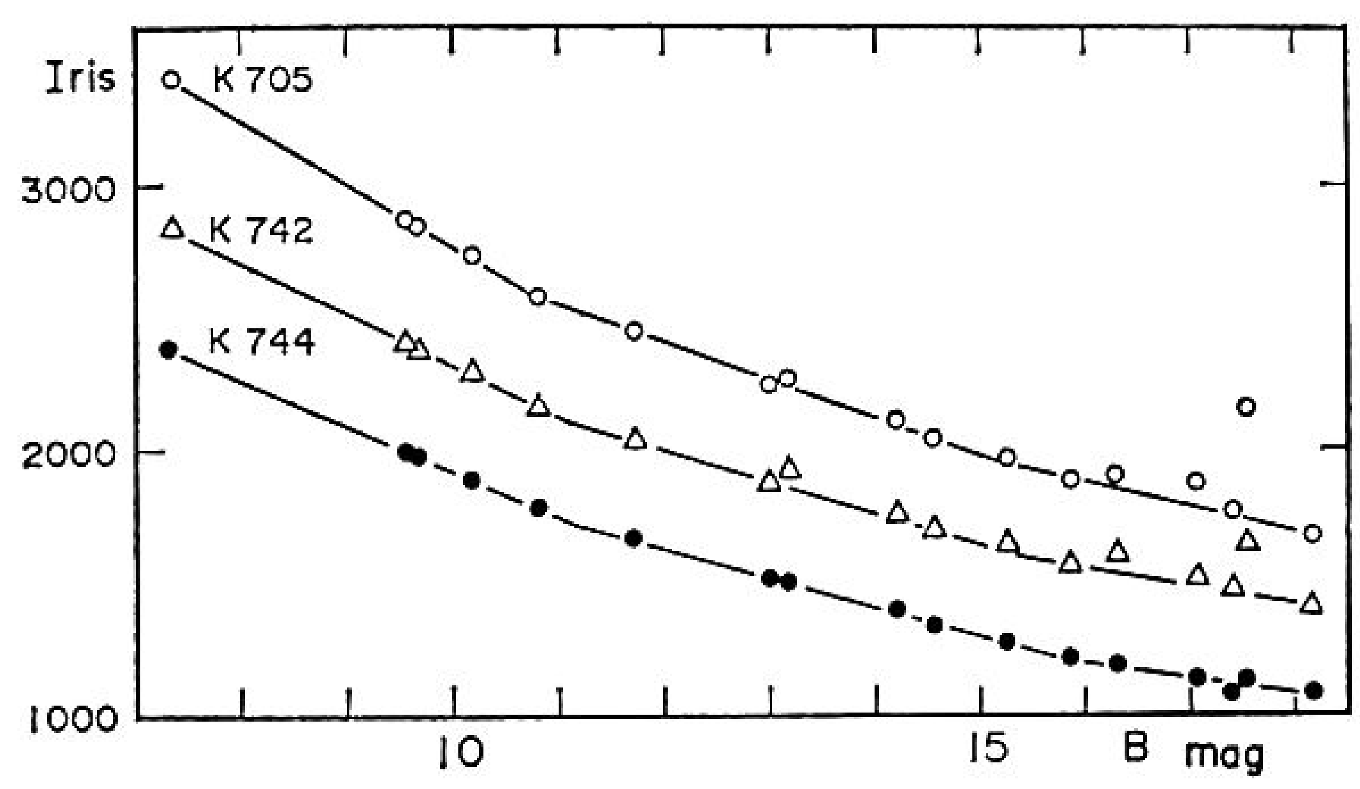

Fig. B-7. Examples of the characteristic curves which show the relation between iris values and B magnitudes of stars on the plates taken with the Kiso 105 cm Schmidt telescope. Their exposure times are 60 min, 10 min, and 2 min for plates K705, K742 and K744, respectively. All of these plates include the field around NGC 2264. Some of the faint stars which are imbedded in the nebulosity deviate upwards from the curves of longer exposure plates.

The effective speed of the measurement is about one star per minute, thougn it depends on the person and the plate field.

4. Characteristic Curve

The characteristic curve which gives the relation between iris value and stellar magnitude was obtained for 30 plates taken with the Kiso Schmidt telescope. In most cases the curve decomposes approximately into two straight lines which meet at about 11th magnitude as is illustrated in Figure B-7. In a few cases, the relation is better expressed by a smooth curve.

The shape and the gradient of the characteristic curve vary depending on the density profile of stellar images on the plate, and the density level adopted to measure the image size. The standard gradient usually ranges from one to two units of iris value per 0.01 mag.

C. THE BLINK COMPARATOR

1. Main Characteristics

The main body of the blink comparator is similar to but still larger than that of the iris-photometer, for it has to carry two plates to be blinked (Figure C-1 (a) and C-1 (b)). Any of three speeds, 10 mm sec^{-1} (Quick), 1 mm sec^{-1} (Slow), or $\sim 80\ \mu m\ sec^{-1}$ (Fine) may be selected for the plate motion in both X and Y directions. The position of the right plate can be adjusted by as much as ± 5 mm in X and Y directions and the left plate can be rotated by up to $\pm 2°$ so that both plates

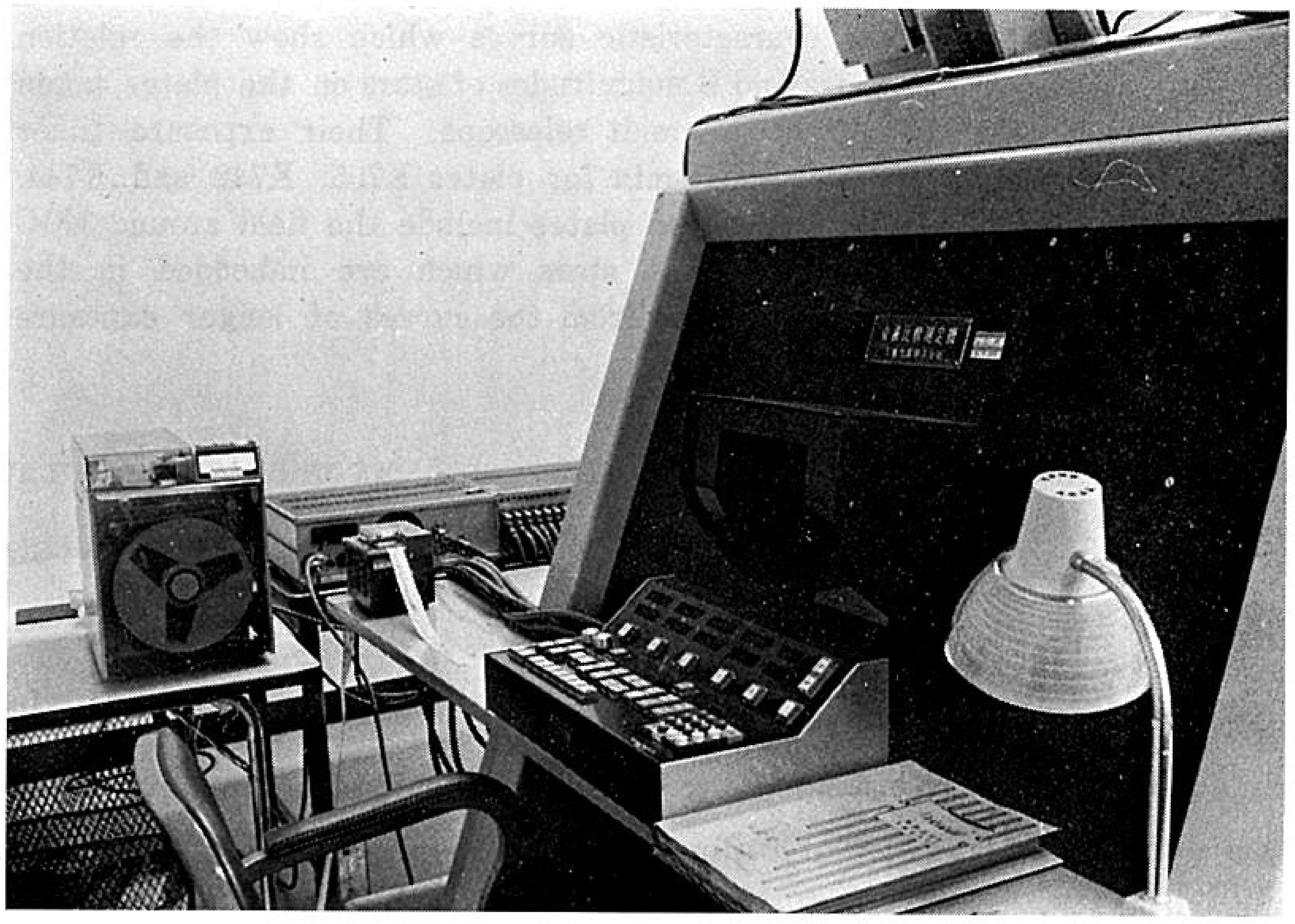

Fig. C-1 (a)

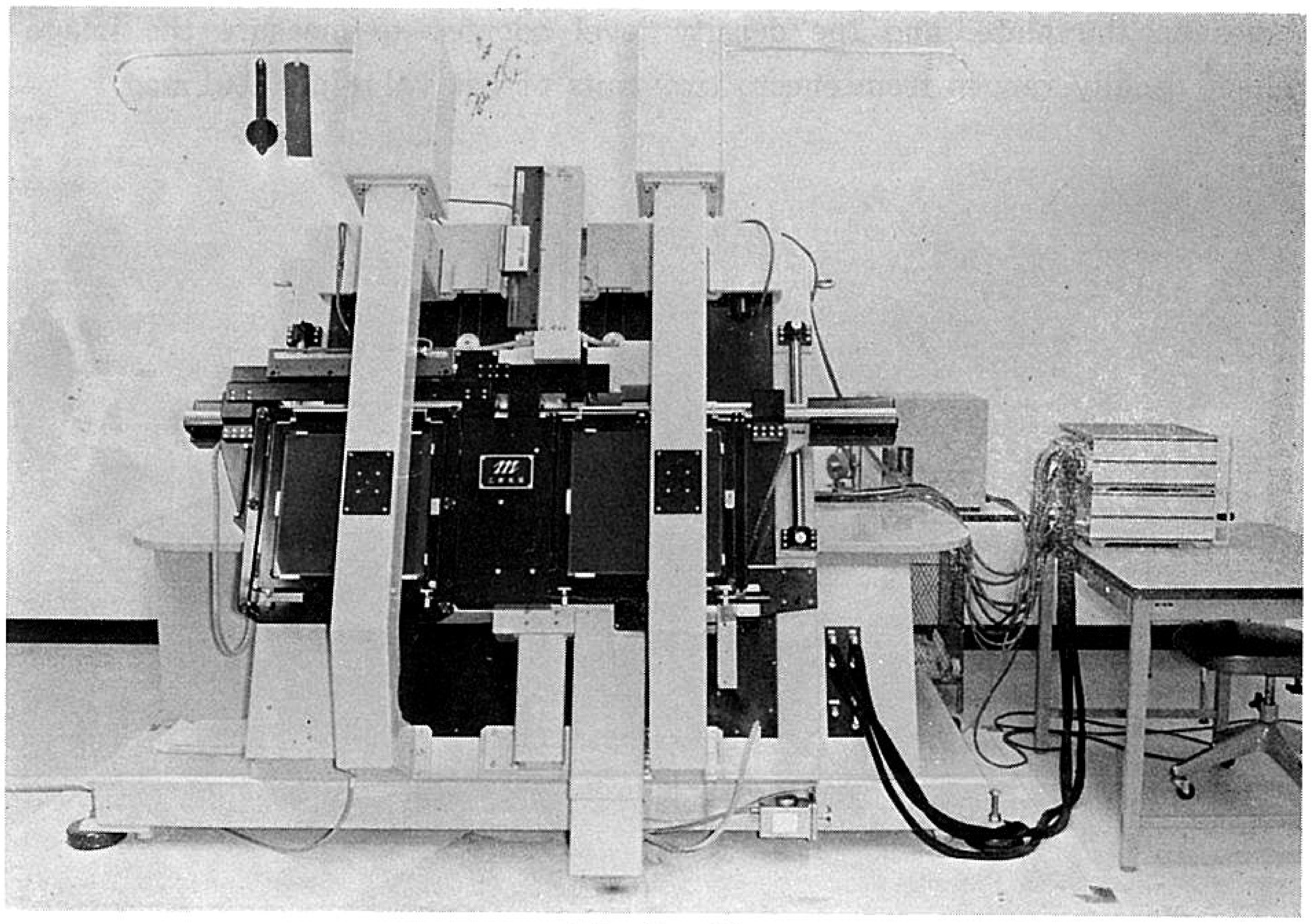

Fig. C-1 (b)

Fig. C-1. The blink comparator. (a) Control panel (right) and paper-tape reader and puncher (left). (b) Backside view: two plates to be blinked are seen hanging on the carriage.

are projected identically on a viewing screen.

Two plates are projected alternatively on the screen of 15 cm square, with any of 1, 2, 5 or 10 Hz blinking frequencies. Projection of a single plate is also possible. We can select either 7 (Low) or 35 (High) magnifications, the former gives a viewing field of about 20 mm square and the latter a 4 mm square area of the plate. At the high magnification the focus is adjustable. A diagram of the light-path is given in Figure C-2. The blinking is generated by rotating a chopper inserted immediately before the point where right and left beams meet together.

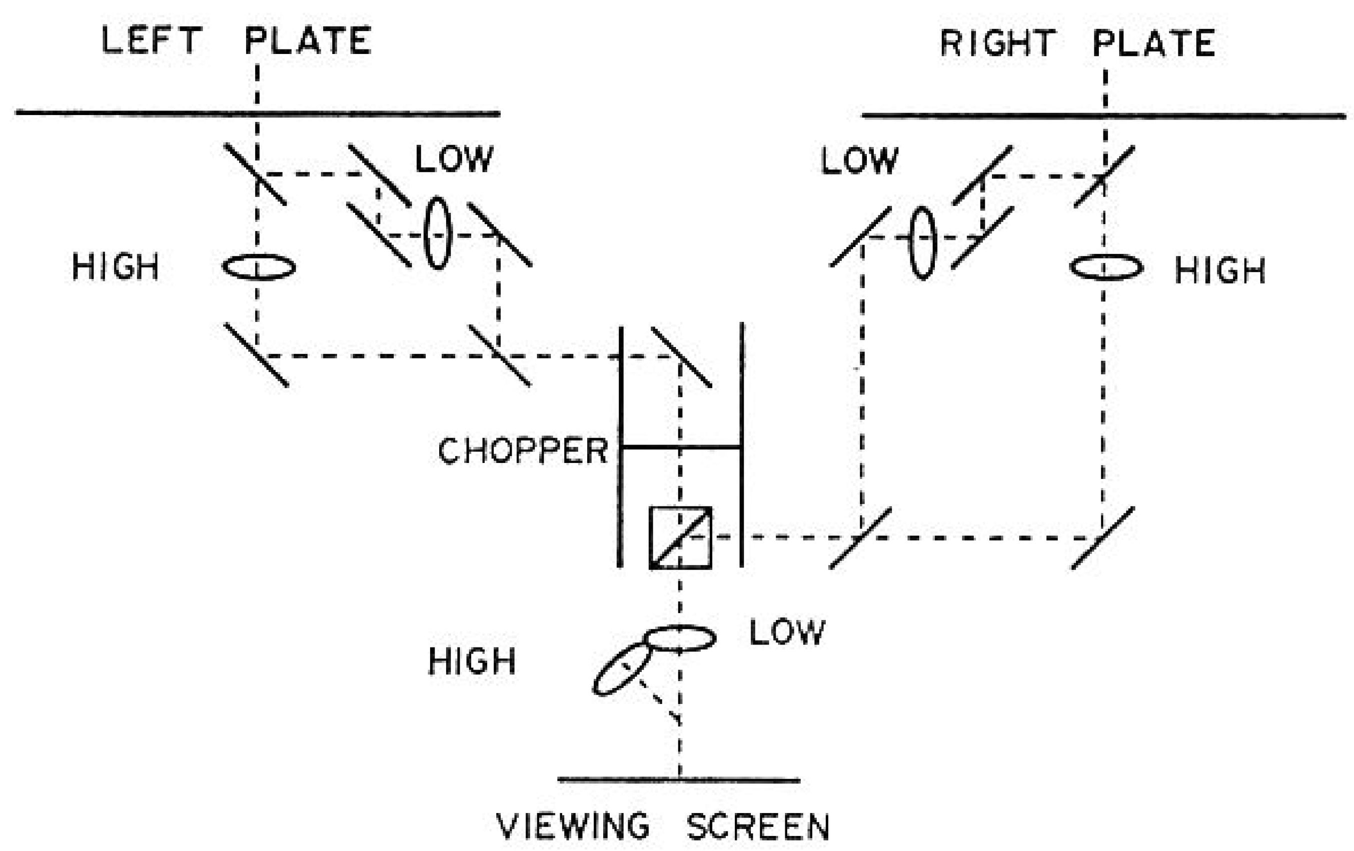

Fig. C-2. A diagram of the light path.

The control pannel with display windows and ten-key buttons is analogous to that of the irisphotometer. It has no "PEAK" and "LOGIC" button but has "AUTOXY" key whose function is the same as that of the irisphotometer. The X and Y coordinates of object stars are recorded on a paper tape. It is designed so that the format of punching tape is common and compatible with that produced by the irisphotometer.

2. Research Examples

The blink comparator has been widely used to search for minor planets, comets, red giants, infrared sources and variable stars. A plate combination of visual with near-infrared colors is useful for the identification of infrared sources. Sometimes the blinking is made between an objective-prism plate and a direct plate for the identification of stars with characteristic spectra such as the red giants now being surveyed. The blinking frequency of 2 Hz is adequate for ordinary purposes.

3. Performance as an X and Y Coodinate Measuring Machine

The blink comparator has been more frequently utilized for the purpose of the astrometry rather than of blinking. Its high-accuracy encoder reading of 1 μm pitch is useful for determining the star positions and for a study of proper motions. In the following the performance as an X and Y coordinate measuring machine is described.

(1) Measuring speed

For astrometry the "AUTOXY" mode is very efficient for repeated measurements of a number of stars. The speed of the measurement reaches about 40 seconds per star including the processes of automatic presetting and manual bisection of a stellar image, the latter of which is performed on the high magnification screen with the fine speed driving. In order to apply the "AUTOXY" mode we should prepare the preset tape. In practice we first make identification marks on a transparent film attached to an original plate, and carry out a quick and a coarse measurement of

X and Y coordinates of stars on the low magnification screen. The output tape thus obtained can be used as a preset tape for the next precise measurement. When the programmed stars are already catalogued, the preset tape can be punched through a computer.

(2) Stability

Figure C-3 (a) shows the variation of the X (open circle) and Y (closed circle) values with time elapsed since the lighting of the equipment. In Figure C-3 (b) is given the position of a small circular speck of dust adhering on the plate measured at every one hour. A trend similar to Figure C-3 (a) is seen. These two figures suggest that the stability of the machine is attained after a

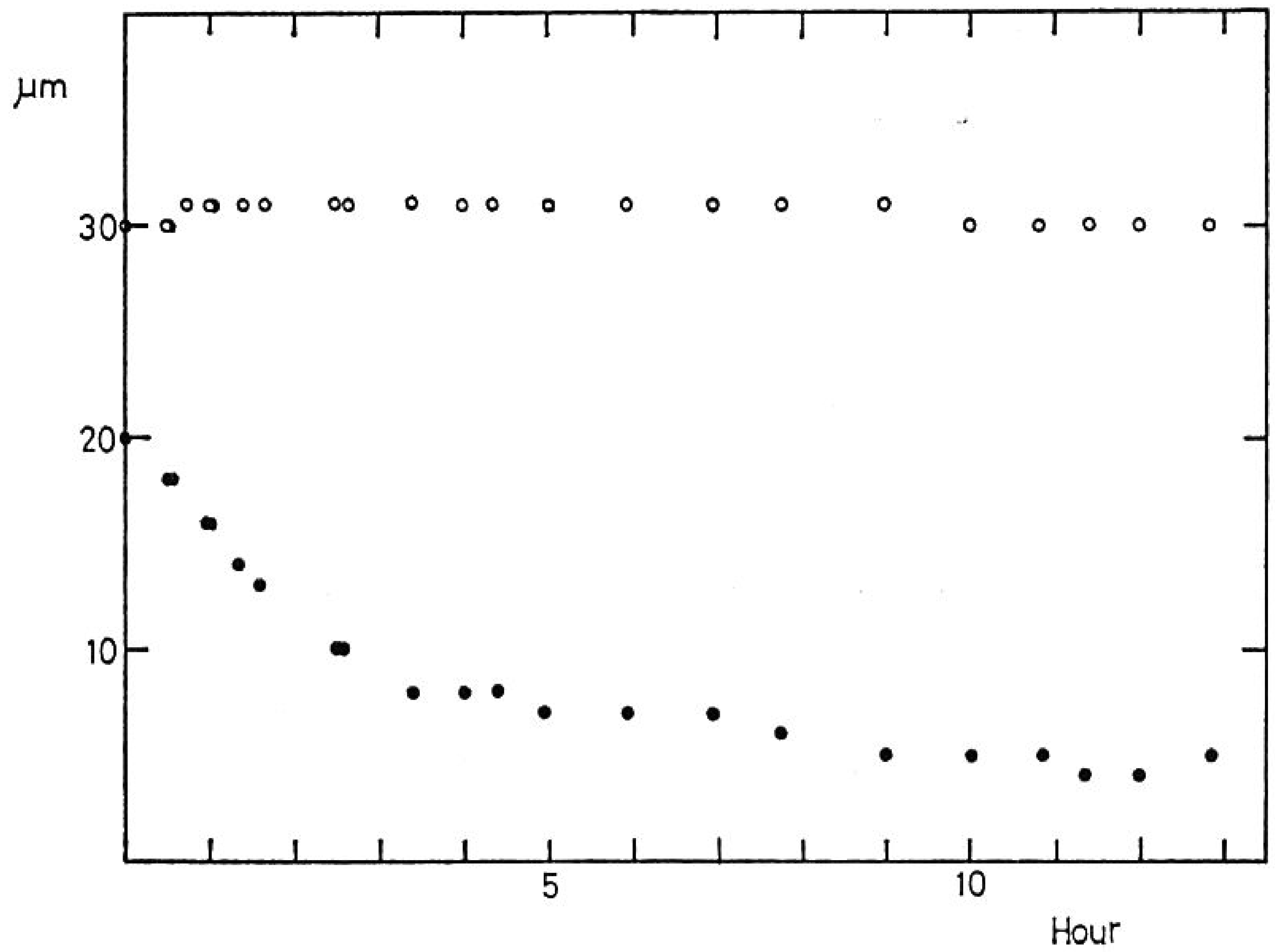

Fig. C-3 (a)

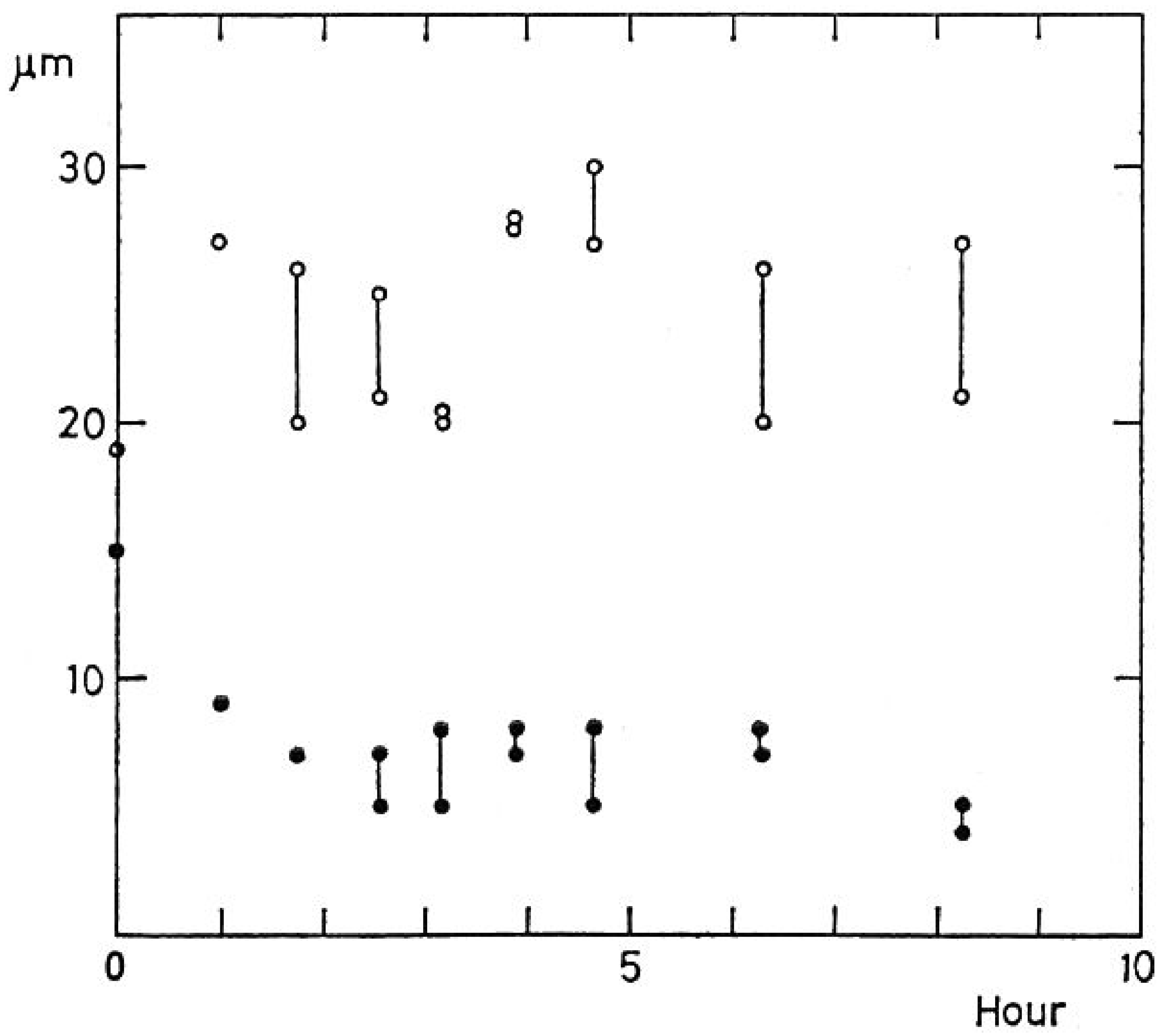

Fig. C-3 (b)

Fig. C-3. Time variation of X (open circle) and Y (filled circle) values with time since the lighting of the blink comparator. The origin of the ordinate is taken arbitrarily. (a) The case where no operation is made. (b) The case where readjustment to the same point on a plate is applied.

warming-up time of about three hours. However, a drift of the X and Y values is sometimes observed even after one day. It reaches 3 μm per hour and the cause is not yet fully understood. So for the most accurate astrometry a drift check is necessary, that is to measure reference stars every one or two hours.

(3) Accuracy

The standard deviation of repeated measurements of a single star is ~1 μm in each of X and Y coordinates. A somewhat larger value of ~3 μm arises when we measure the whole area of the plate (35.6 cm square). However this corresponds to only 0.2 arc seconds on the Kiso Schmidt plate, and so the repeatability is considered satisfactory. This test was carried out using small circular specks of dust adhering to a plate which have a size slightly larger than the width of the bisection thread. The accuracy of the position determination for ordinary stellar images is dependent on their size and quality. Selecting a plate (K3614) which was taken under good seeing conditions with an exposure time of 40 minutes, we measured the position of stars of different sizes repeating the bisection five times for each star. The resultant standard deviation is plotted against the image diameter in Figure C-4. Open circles indicate data for X coordinates and closed ones for Y coordinates. The standard deviation gradually increases with the image size, but it becomes better again for image size above 300 μm. This may be due to the fact that the cross image of the spider is helpful for the bisecton of such bright stars.

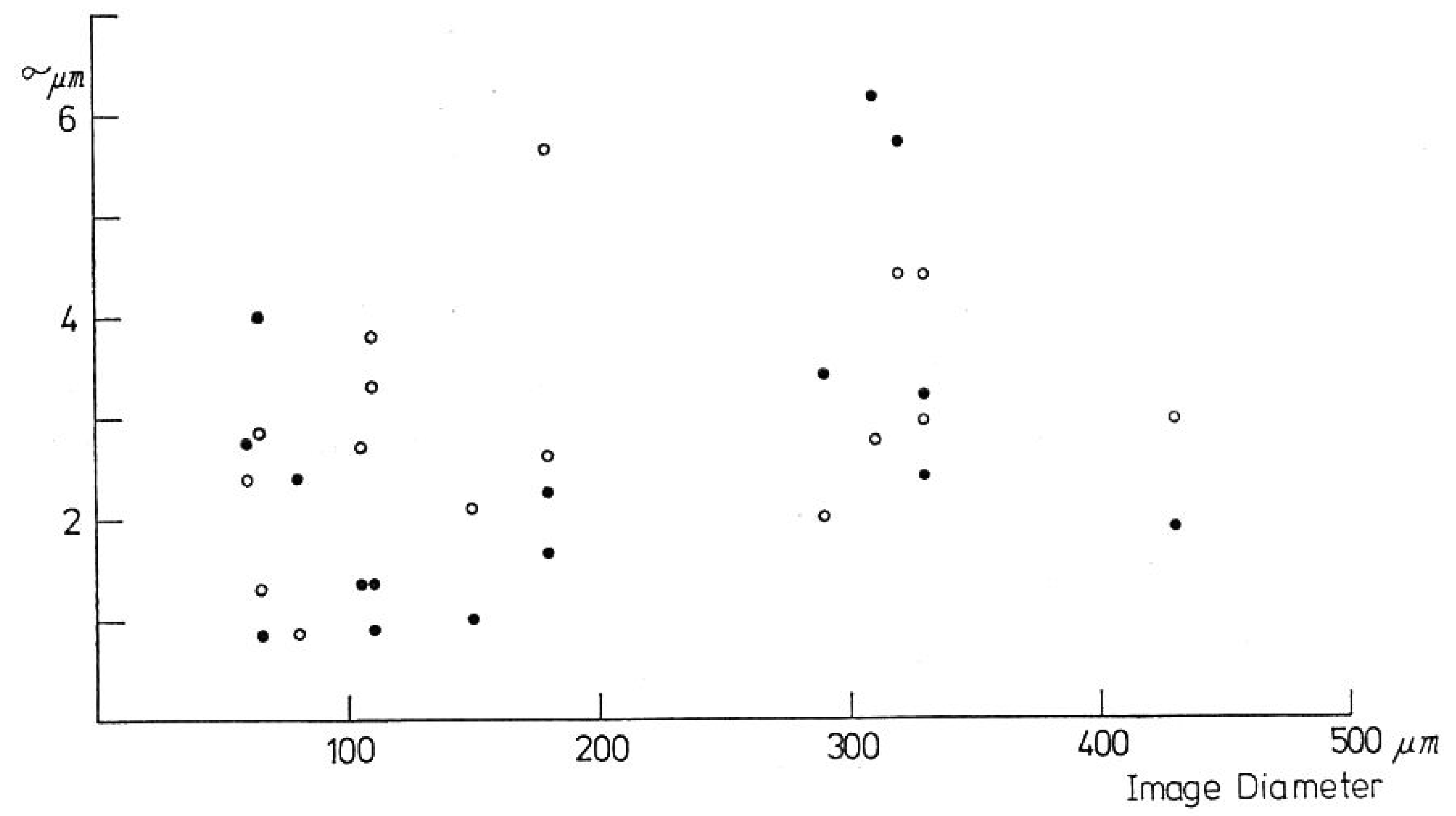

Fig. C-4. Standard deviation (open circle for σ (X), filled circle for σ (Y)) of the position measurement as a function of the stellar image size. The plate K3614 is used and the repetition of the bisection is made five times for each star.

In practice the accuracy can be better evaluated through the method of established astrometric reduction. We prepared two kinds of computer programs, one of which is based on the standard coordinate method and the other on the Stephenson's method (1974). A comparison of these two methods shows the former is superior to the latter except for a special case, where the number of reference stars is small and some stars have a large catalogue error (Mikami 1979). Therefore the result obtained by the standard coordinate method will be described in the following. A plate taken with an exposure time of 1 minute (K2261) has been investigated using 146 reference stars selected from the AGK3 catalogue, which are distributed uniformly over the whole plate. The equatorial coordinates of each reference star are calculated after the plate constants are determined. The

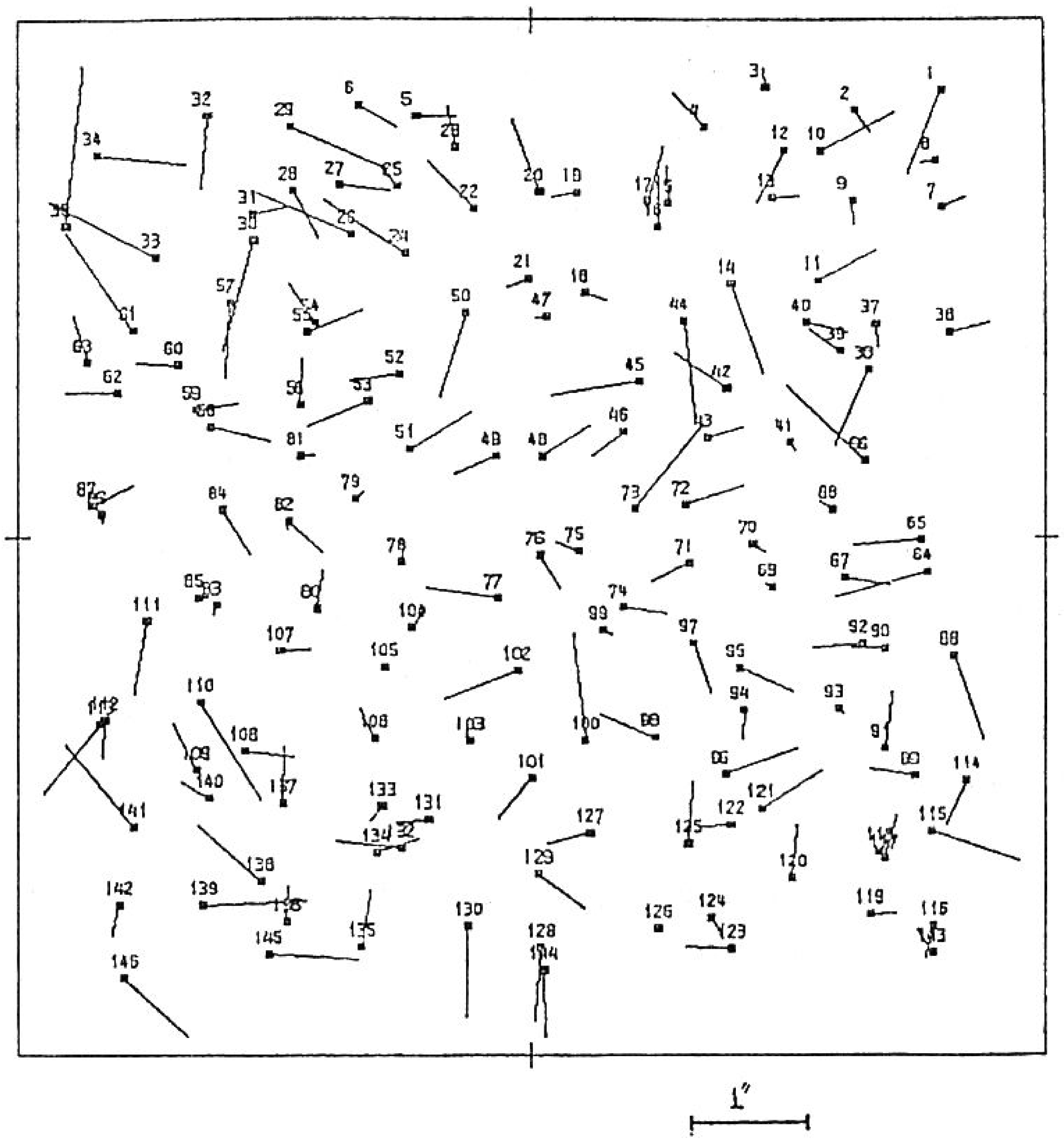

Fig. C-5. A plot of the residual vectors ($\Delta\alpha$, $\Delta\delta$) after applying the astrometric reduction to the plate K2261.

residuals of these from the catalogued values are displayed in Figure C-5 using the vector representation. The errors in right ascension and declination are 0".39 and 0".37, respectively. These values seem reasonable when we consider the bisection error and the catalogue error, the latter of which is estimated nominally to be 0".25 for AGK3. We have also checked the accuracy making use of 25 plates taken for the survey of ultraviolet-excess objects, with longer exposure times ranging from 25 to 100 minutes. For about 25 reference stars selected on individual plates, the average accuracy has been found to be 0".45–0".5 in each coordinate, which is a little worse than the above value obtained for the short-exposure plate. This may be ascribed to the effect of the differential refraction arising in long exposure plates and also to the difference in the number of reference stars.

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Stephenson, C.B. 1974, Astron. J., **79**, 1317.

D. THE ISOPHOTOMETER

1. Introduction

The design of an isophotometer was undertaken in 1972, together with an irisphotometer and a blink comparator. Although the fundamental function of the isophotometer is to draw isophotometric maps of extended objects such as galaxies and nebulae from the photographic plates, data processing including noise cleaning, correction of background non-uniformity, and cancellation of stellar images, ordinarily accompany the isophote mapping. Furthermore, high-speed measurement and data reduction is indispensable, because a huge amount of data has to be treated for two-dimensionally extended objects. In consequence, it was decided to construct a high-speed measuring machine yielding digital outputs.

The main characteristics of the Kiso isophotometer are as follows; a minicomputer controls the machine and also processes plate data. A solid-state sensor is employed as a detector instead of a conventional photomultiplier. The previous detector, a CCD101, was a 500 element linear array manufactured by Fairchild Cooperation. In 1978, it was replaced by the new detector, a CCD121H composed of 1728 elements with 13 μm pitch. This replacement gave a fair improvement in the dynamic range.

Several articles concerning this machine have been issued. The general description and the result of a performance test of the previous detector was given in Maehara and Ishida (1978). A superposition of photographic plates was discussed by Isobe and Maehara (1978). The results of a performance test of the present detector were reported by Maehara and Watanabe (1980), and a report on the software capable of automatic image detection was given by Maehara (1981).

2. Mechanical and Optical Components

The fundamental mechanical structure is similar to that of the irisphotometer, as shown in Figure D-1. The main frame is of a wedge shape. The plate carriage moves horizontally for the

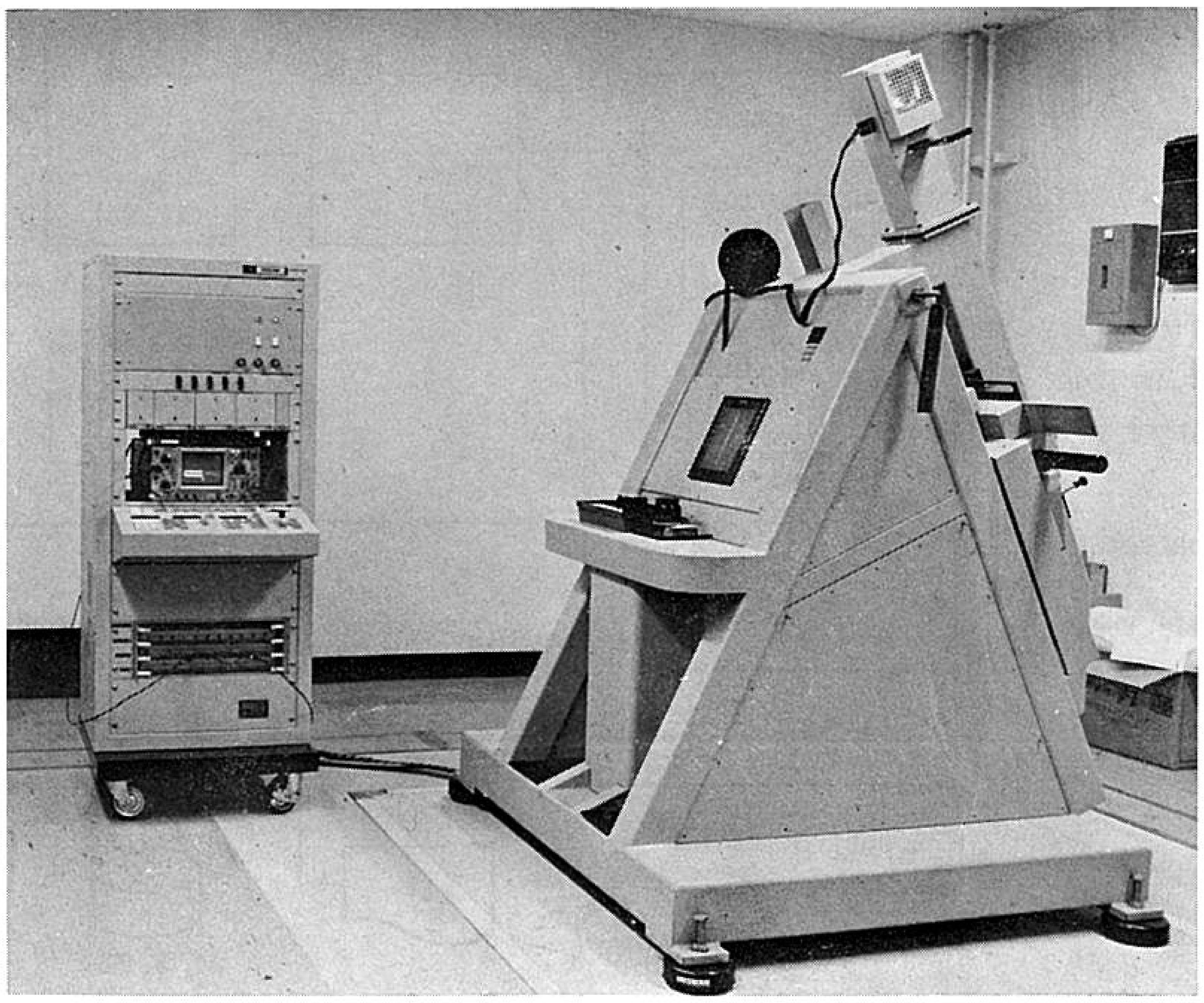

Fig. D-1. The Kiso Isophotometer with its mainbody (right) and controller (left).

X direction, and also along the Y direction which is orthogonal to X and parallel to the plane of the inclined surface of the frame. The X and Y positions are read and displayed in units of 2 μm with optical linear encoders. The driving speed of both axes is about 600 mm min^{-1} (Quick) or from 50 to 100 mm min^{-1} (Slow). For the measuring speed any of 4, 8, 16 or 32 mm min^{-1} can be selected for the X axis motion.

The light source is an electric bulb of 650 VA, which is automatically adjusted by means of a servo-mechanism to keep the brightness constant. The lamp house is located at the uppermost portion of the machine for ease of thermal release. The plate area of 50 mm square is illuminated uniformly. The beam is projected on the monitor screen at a magnification of 3, while it goes to the camera directly during the measurement.

A knife-edge slit of 0.3 mm width can be inserted in front of the plate which greatly diminishes the scattered light. The image is focused on the CCD121H detector through the camera lens at a magnification of unity. The detector is oriented along the Y axis of the plate. The performance of this detector will be mentioned in a later section.

3. Electric and Data-Processing Units

The electric controller is seen at the left-hand side of Figure D-1. It consists of the units for power supply, machine control and data acquisition from the detector. The operation panel and the CCD monitor are also installed in this controller rack. Measurement parameters and conditions are displayed, and push-buttons are arranged on the panel. The monitor is an oscilloscope which exhibits analog values of individual elements.

The interrelation among various hardware components is illustrated in Figure D-2. An OKITAC-4300C minicomputer (12 K words) controls the mechanical and optical parts of the machine through

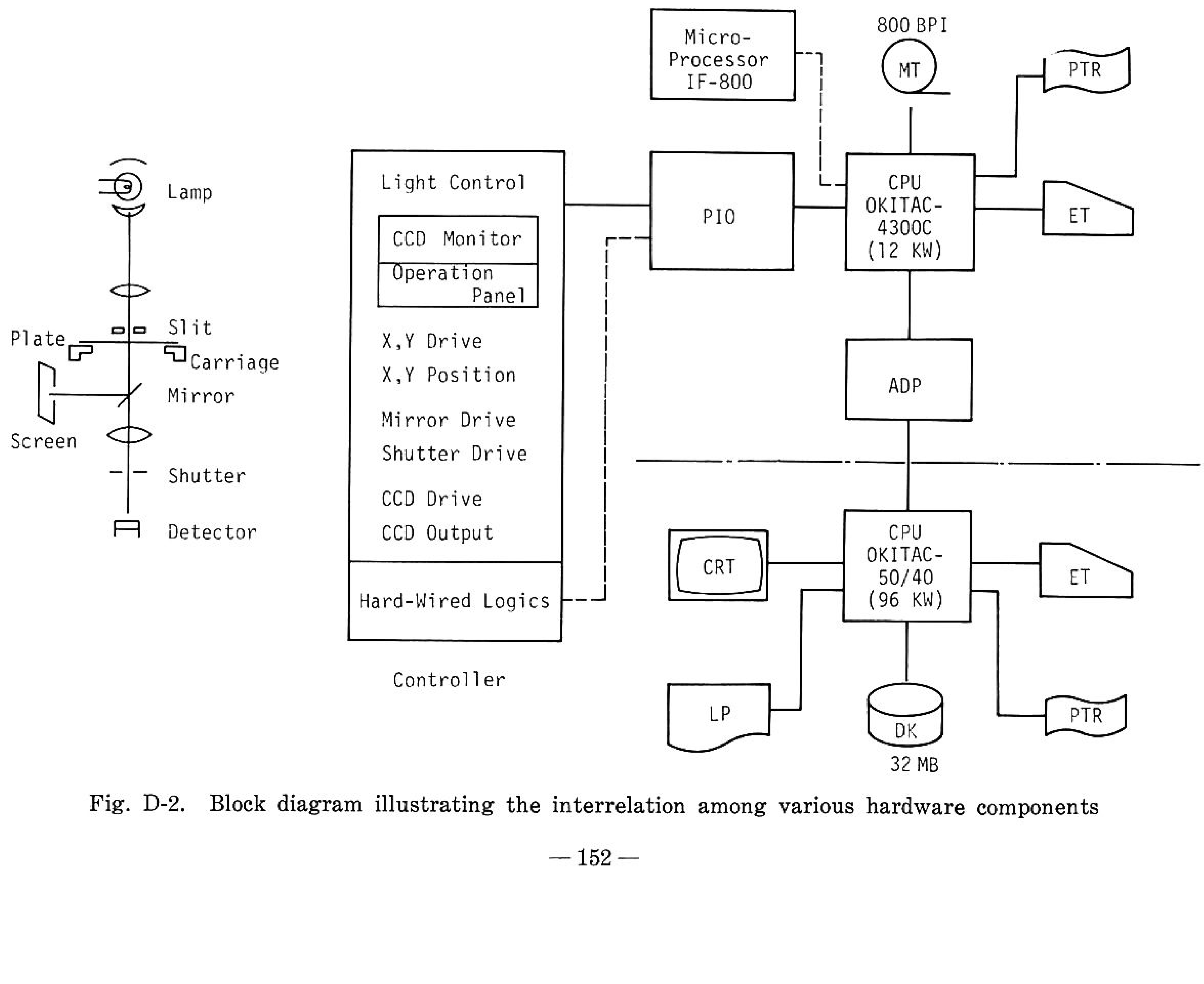

Fig. D-2. Block diagram illustrating the interrelation among various hardware components the interface (PIO). It reads and processes output signals from the detector. During the measurement, data are directly written onto a 9-track magnetic tape (MT). The software consists of assembly language programs. The electric typewriter (ET) and the paper-tape reader (PTR) are mainly used for development and editing of the program.

The other minicomputer, an OKITAC-50/40, is an upper-grade unit for the data processing. The measured data are transferred from the former computer through the adapter (ADP), and written into the magnetic disk (DK) of 32 MB. The line printer (LP) works not only as an ordinary printer, but also as a plotter. Processing programs can be written in either FORTRAN or assembly languages. There is a plan to install a console with a cathode-ray tube in order to make the operation easier.

4. Performance of the Detector

The characteristics of the Fairchild CCD121H are as follows; the device is a 1728 element linear array packaged in a 24-lead Dual In-Line package with a glass window. The spectral response ranges from 4,500 Å to 10,500 Å. The saturation exposure is 0.5 $\mu J\, cm^{-2}$, and dynamic range is typically 170:1. The two sets of two-phase clocks are built into the package in order to transfer the charge packets.

The output signals from individual elements are consecutively digitized into 8-bit or 10-bit binary values. The performance tests concerning linearity, uniformity, stability, and spatial resolution have been reported in Maehara and Watanabe (1980). As a whole, the linearity of the output to incident light is as good as the least significant bit (LSB) for each element. Thus the output data are well corrected by means of the linear equation, though the maximum non-uniformity surpasses 10% of data levels.

The reproducibility of data is as good as the LSB, while the long-term instability originates from the variation in brightness of the light source. The spatial resolution is mainly limited due to the scattered light from surrounding regions. A slit of 0.3 mm width is now utilized, instead of previously used wider slits. A narrower one is more useful, since the scattered light is largely suppressed by the slit. The accurate transmittance of a pixel must be corrected using the point-spread function.

5. Measurement and Data Reduction

A standard measurement program written in the assembly language, of 2,000 lines, is recorded on a magnetic tape, and easily loaded into the OKITAC-4300C. There exist two kinds of measuring modes in which data are recorded with or without the movement of the plate carriage, respectively. The transmittance is written on a magnetic tape in 8-bit or 10-bit binary values together with the X and Y positions. The beginning and end positions and steps in both axes must be entered before the measurement.

Data can be transferred between the magnetic tape unit and the disk unit. It is easier to program the CPU OKITAC-50/40 than the OKITAC-4300C. On the other hand, a magnetic tape has better compatibility than a magnetic disk when data are reduced elsewhere. Therefore, the transfers of data are frequently requested.

The present machine has been working as an input device to draw isophotometric maps (e.g., Watanabe et al 1981, and Mizuno et al 1981). Data processing is usually carried out using outside computers with a powerful array of peripheral equipment for this purpose. However, this system alone is capable of detecting images on photographic plates. Such a program was developed by

Maehara (1981), and is called as the Kiso Image Detection System (KIDS).

It consists of a set of processing programs loaded in both computers. Its performance is as follows; the faintest detectable images reach nearly the same level as the limiting magnitude of the original plate. The brightness and the position of images can be determined to within an accuracy of about 0.13 magnitude (s.d.) and $0''.5$ (s.d.) on Schmidt plates. These values correspond to a coarse measurement of plates, since the applied logics of processing are simple and straightforward. Using the KIDS, a computer blinking can be carried out in order to pick out moving objects, variables, and objects of peculiar color.

Yamagata et al. (1981) have also developed a similar program applicable to large computer. The on-site processing will be fully automatic after the introduction of hard-wired logic and extended programs. As a first step, a microprocessor and hard-wired logic capable of pre-processing will soon be added in order to process data easily at higher speed.

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