MODEL J-710/720

SPECTROPOLARIMETER

INSTRUCTION MANUAL

JAPAN SPECTROSCOPIC CO., LTD.

2967-5, ISHIKAWA-CHO, HACHIOJI CITY

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2. SPECIFICATIONS AND PRINCIPLES OF OPERATION

2-1 Specifications

o Light source

150W xenon lamp, air cooling system (J-710)

450W xenon lamp, water cooling system (J-720)

o Monochromator

Measuring wavelength range	: 175 to 700 nm (J-710) 170 to 800 nm (J-720) 700 to 1000 nm (Option)
Wavelength scanning range	: 168 to 1050 nm
Wavelength accuracy	: ±0.2 nm at 170 to 180 nm ±0.1 nm at 180 to 250 nm ±0.3 nm at 250 to 500 nm ±0.8 nm at 500 to 800 nm ±2 nm at 800 to 1000 nm
Wavelength stability with temperature	: Less than 0.02 nm/°C at 300 nm Less than 0.1 nm/°C at 600 nm
Spectral bandwidth	: Constant half-spectral bandwidth in four steps of 0.2, 0.5, 1 and 2 nm
Slit	: Manual control (can be set at will within 0.01 to 2 nm)
Scanning speed	: 1, 2, 5, 20, 50, 100, 200, 500, 1000, 2000, 5000 nm/min

Substitution with nitrogen gas	: Atmosphere in monochromator and sample compartment are substituted with dry gas.

o Sample compartment

Dimensions	: 140mm wide x 280mm deep x 130mm high (J-710) 310mm wide x 420mm deep x 210mm high (J-720)
Sample stage	: Removable to accept a large attachment, such as electromagnet or other.
Circulating water inlet and outlet ports	: Used for temperature control of thermostatic cell holder, cooling water for electromagnet, and others.

* The optional cell holder for suspension sample can be mounted (suspension, tablet, translucent film sample, etc.)

o CD performance

Modulator	: Piezo elastic modulator (50 kHz)
Detector	: Photomultiplier tube
CD scale	: ±10, 20, 50, 100, 200, 500, 1000 m°/full scale

RMS noise	: (J-710)	(J-720)	
	0.25 m°	0.05 m°	at 185 nm
	0.15 m°	0.04 m°	at 200 nm
	0.06 m°	0.035 m°	at 500 nm

* Operating conditions

Response : 16 sec (equivalent to TC 4 sec)

Spectral band-width : 1 nm

Sample : Measurement is made with no sample in the light path.

Baseline stability : 0.2 m°/hour (after 30 min warm-up)

Response : 0.5, 1, 2, 4, 8, 16, 32, 64 msec

0.125, 0.25, 0.5, 1, 2, 4, 8, 16 sec

o UV specifications

Photometric system : Conversion of PMT voltage to absorbance

Photometric range : 0 to 5 ABS

Accuracy of photometry : ±0.02 ABS

o Utility requirements

Power requirements : 100 V, 50/60 Hz, 2 kW

(Line voltage variation should

be within ±10%. If it is greater than this value, the optional line voltage stabilizer is required.)

Cooling water requirements : Flow rate; 2 ℓ/min (light source cooling water), water pressure; more than 0.5 kg/cm^2 (At a lower pressure than this value, the protector operates and the lamp does not light up.) Water pressure; less than 5 kg/cm^2

Nitrogen gas : 2 to 5 ℓ/min (higher than 200 nm)
10 to 15 ℓ/min (180 to 200 nm)
50 to 70 ℓ/min (lower than 180 nm)

Temperature : 20°C ±5°C

Humidity : Less than 70%

Dimensions: Main unit : 1080mm wide x 580mm deep x 400mm high (J-710)
1230mm wide x 690mm deep x 400mm high (J-720)

Power supply; 300mm wide x 380mm deep x 150mm high (J-710)

460mm wide x 450mm deep x 240mm high (J-720)

Weight : Main unit ;	Approx. 90 kg (J-710)	
	Approx. 100 kg (J-720)	
Power supply;	Approx. 7 kg (J-710)	
	Approx. 35 kg (J-720)	

o Standard components

- Model J-710 (720) Main Unit .... 1 set
- Personal Computer .... 1 set
- Light Source Power Supply Unit .... 1 set
- System Disk .... 1 set
- Cylindrical Quartz Cell, 10 mm .... 1 pc
- Cylindrical Quartz Cell, 1 mm .... 1 pc
- Cylindrical Cell Holder .... 1 pc
- Vinyl Pipe for Cooling Water .... 10 m
- Rubber Pipe for Nitrogen Gas .... 3 m
- Standard tool kit .... 1 set
- Standard sample .... 1 set
- Plastic cover .... 1 pc
- Instruction manual .... 1 copy

2-2 Components and Principles of Operation

2-2-1 Principles of operation

When linearly polarized light passes through an optically active substance, its two circularly polarized components (right and left circularly polarized beams of light) travel at different speeds and are absorbed in differing degrees. Thus the light passing through the substance is elliptically polarized. The substance is said to have "Circular Dichroism (CD)." The magnitude of circular dichroism is usually expressed by molecular ellipticity [θ], which is given by the following formula:

$$[\theta] = \frac{4500}{\pi}(\varepsilon_L - \varepsilon_R)\log_e 10 \qquad (1)$$

where ε_R and ε_L are the molecular extinction coefficients for the right and left circularly polarized beams of light. Since the difference between ε_L and ε_R is given by the following formula:

$$\Delta\varepsilon = \varepsilon_L - \varepsilon_R = \frac{1}{L \cdot C}\log_{10}\left(\frac{I_R}{I_L}\right) \qquad (2)$$

Eq. (1) can be rearranged as follows.

$$[\theta] = \frac{4500}{\pi \cdot L \cdot C} \cdot \log_e 10 \cdot \log_{10}\left(\frac{I_R}{I_L}\right) \qquad (3)$$

In Eq. 2 and Eq. 3, L is the thickness (cm) of the absorbing layer and C is the molecular concentration. I_L and I_R denote the intensities of the right and left circularly polarized beams of light after the light has passed through the substance. Theoretically, it is possible to determine the molecular ellipticity by using Eq. (3), but in practice it is very difficult to determine [θ] with high accuracy by using Eq. (3) because the value of I_R/I_L is nearly one. To overcome this difficulty, we use the following quantities:

$$I_A = \frac{1}{2}(I_R + I_L) \quad (4)$$

and

$$S = I_R - I_L \quad (5)$$

Since $\frac{S}{2I_A}$ << is smaller than 1, Eq. (3) can be rearranged as follows from Eq. (4) and Eq. (5).

$$[\theta] = \frac{4500}{\pi \cdot L \cdot C} \cdot \log_e 10 \cdot \log_{10} \frac{1 + \frac{S}{2I_A}}{1 - \frac{S}{2I_A}} \quad (6)$$

$$= \frac{4500}{\pi \cdot L \cdot C} \cdot \log_e 10 (\frac{S}{I_A} \log_{10} e)$$

Thus the ratio between I_A and S can be approximated with a sufficiently high accuracy for practical application. Given that E_A and E_S are the output voltages of the photomultiplier tubes corresponding to light intensities I and S respectively, $S/I_A = E_S/E_A$. Eq. (6) can be expressed as follows using E_A and E_S.

$$[\theta] = \frac{4500}{\pi \cdot L \cdot C} \cdot \log_e 10 \left(\frac{E_S}{E_A} \log_{10} e\right) \quad (7)$$

Here, if E_S alone can be amplified independently of E_A, Eq (7) can be expressed as follows.

$$[\theta] = \left(\frac{4500}{\pi \cdot L \cdot C} \cdot \log_e 10\right) \left(\frac{E_S \cdot G}{E_A}\right) \left(\frac{\log_{10} e}{G}\right) \quad (8)$$

where G is the amplification factor for E_S. Since the value $E_S \cdot G$ can be made nearly equal to the value E_A by choosing a proper value of G, $[\theta]$ can be determined with high accuracy.

2-2-2 Schematic arrangement of optical system

Fig. 2-1 shows the optical system of the J-720 spectropolarimeter.

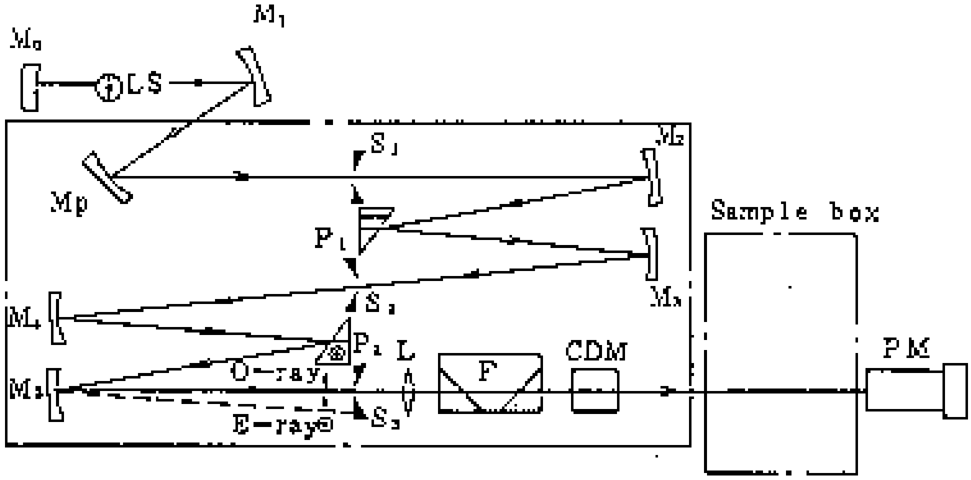

Fig. 2-1 Optical system.

M_0, M_1, M_p, M_2, M_4, M_5	: Mirror
LS	: Light source
S_1, S_2, S_3	: Slit
P_1	: First prism (horizontal optical axis)
P_2	: Second prism (vertical optical axis)
O-ray	: Ordinary ray
E-ray	: Extraordinary ray
L	: Lens
F	: Filter

CDM : CD modulator

PM : Photomultiplier tube

The xenon lamp is used as the light source. The light from the light source is focused by the mirror M_1 onto the entrance slit S_1. The optical system between S_1 and the intermediate slit S_2 is called the first monochromator and that between the intermediate slit S_2 and the exit slit S_3 is called the second monochromator. Such an optical system comprising two monochromators is called a double monochromator. Because of its capability of reducing stray light, the double monochromator is indispensable in the CD measurement.

The J-720 uses crystal prisms P_1 and P_2 having differing axial directions, so that the light passing through the monochromator is not only monochromated but also linearly polarized, oscillating in the horizontal direction.

This linearly polarized light is modulated by the CD modulator to the right and left circularly polarized beams of light. The CD modulator is an element that subjects quartz to mechanical stress to produce circular polarization in the crystal, based on the principle of the piezo effect.

When a sample is placed in the beam, the intensity (I) of the transmission light change as shown in Fig. 2-2 if the sample has circular dichroism.

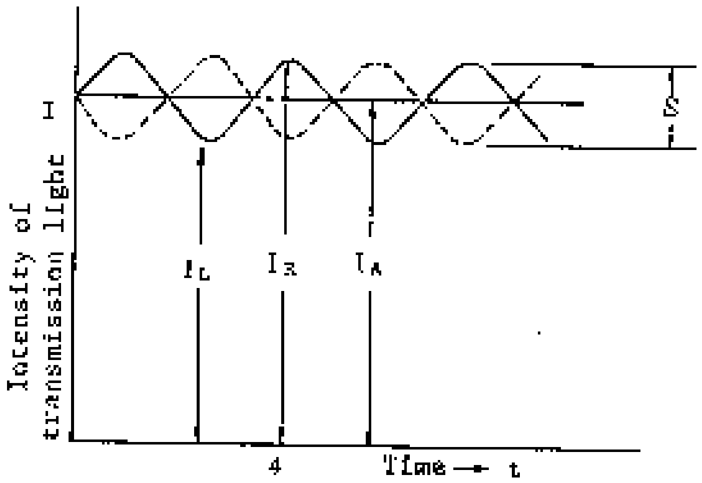

Fig. 2-2 Relationship between intensity of transmission light and CD signal.

Whether the minimum or maximum intensity corresponds to the right or left circularly polarized light depends on which value is larger, ε_R or ε_L. In Fig. 2-2, the solid line represents the case when ε_R is greater than ε_L and the dotted line represents the cae when ε_R is smaller than ε_L. For the definition of I_A and S, refer to the principle of spectropolarimetry under 2-2-1.

When light of which intensity changes as shown in Fig. 2-2 is incident upon the photomultiplier tube, the output signal contains DC components equivalent to I_A and AC components equivalent to S.

2-2-3 Configuration of the electrical system

The output signal from the detector (photomultiplier tube, PM) consists of an AC component electrically modulated by the modulator and a DC component which represents the average intensity of the transmission light, as shown in Fig. 2-2. The CD value can be known by determining the ratio between the DC component E_A and AC component E_S.

This instrument is so designed that the DC component is always kept constant by varying the PM voltage, and utilizes the AC component for the CD signal.

Therefore, the correct CD value can be known simply by calibrating the AC signal using a standard sample.

Fig. 2-3 shows the block diagram of the electrical system. Since the AC component and DC component can be discussed independently, description is given separately referring to Fig. 2-3.

The DC component is obtained between the preamplifier and the main amplifier and is compared with the reference voltage in the PM voltage control amplifier so as to control the voltage of the PM voltage power supply. This voltage is applied to the detector PM and changes the PM sensitivity. That is, if the preamplifier voltage at the output (D point) is lower than the preset reference voltage (-0.3 VDC), the PM voltage control amplifier detects it and sends a command signal to the HT power supply to increase the PM sensitivity until the voltage at point D becomes equal to the preset voltage.

The AC component is synchronized and rectified after being amplified by the preamplifier and the main amplifier and is further amplified to be applied to the interface.

The CD sensitivity is changed over by changing the gain of the main amplifier and DC amplifier.

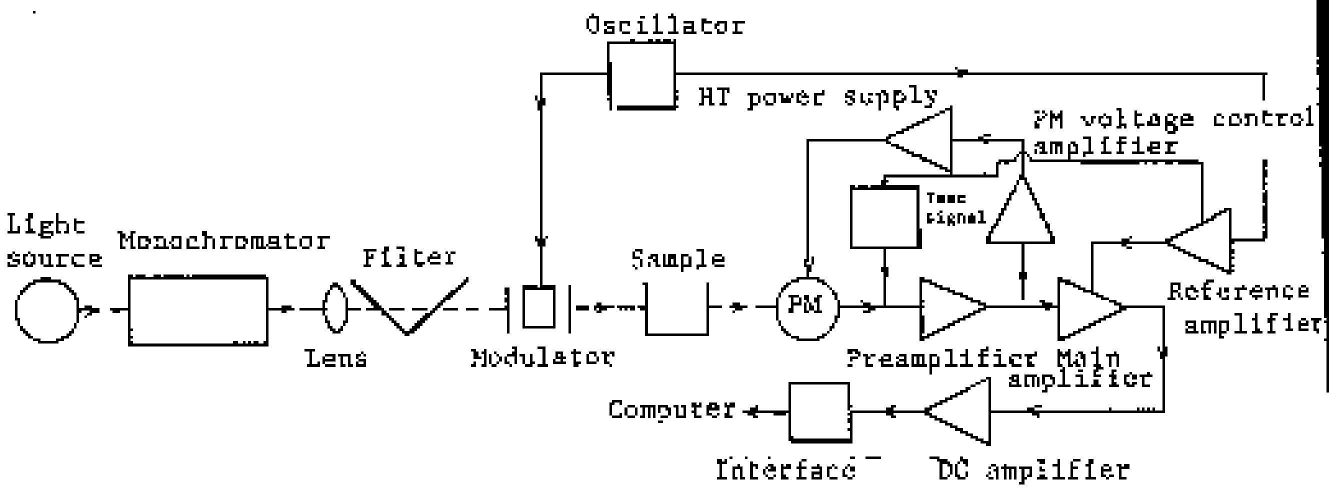

Fig. 2-3 Block diagram of CD electrical system.

2-2-4 Configuration of the computer system

Fig. 2-4 shows the block diagram of the electrical system

including the computer system. The J-710/720 and the personal computer are interfaced through the RS-232C interface. Settings of parameters in the main unit are all done on the personal computer. After being A-D converted and applied to the buffer memory, the CD signal and the PM voltage are transferred to the personal computer (called "PC" in this manual) for data processing through the RS-232C interface, and the results are plotted on the XY plotter or saved onto the floppy disk.
Parameters that can be set from the PC include sensitivity, time constant, scan speed, wavelength range, and spectral bandwidth.
The capacity of the data memory permits measurement of eight CD spectra in the standard measurement.

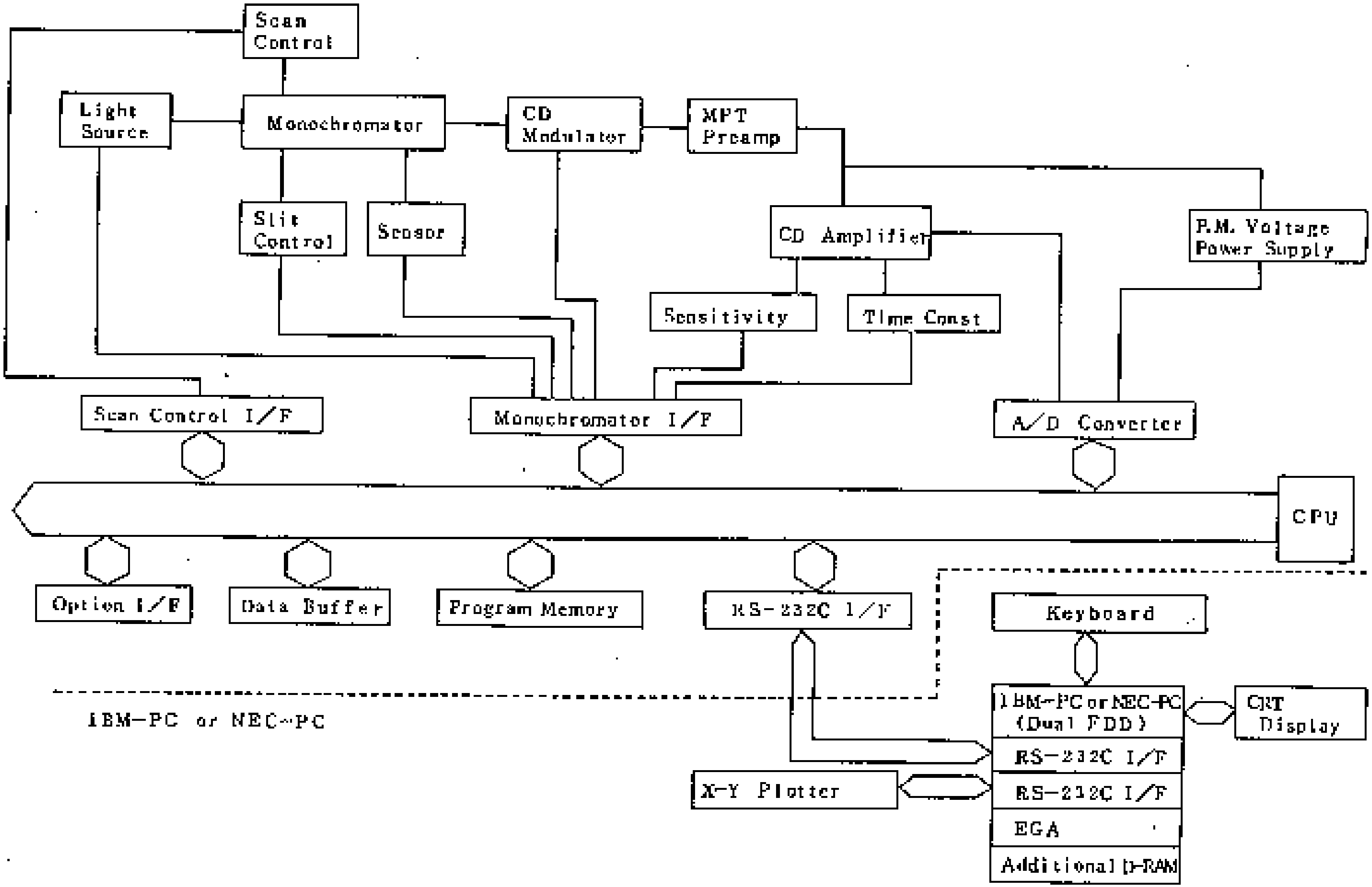

Fig. 2-4 Block diagram of computer system.

3. COMPONENTS & FUNCTIONS

3-1 Overall View

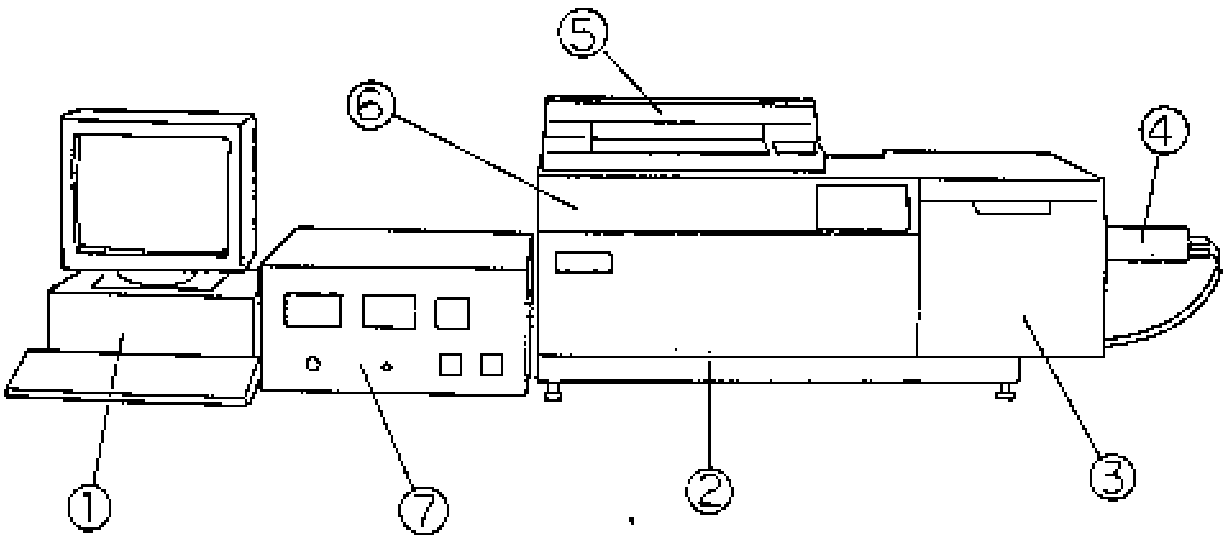

Fig. 3-1

Component	Function
(1) Personal computer	Controls the main unit and performs data processing.
(2) Monochromator unit	A monochromator and polarizer are housed.
(3) Sample compartment	The sample is mounted here.
(4) Detector unit	A photomultiplier tube and

Component	Function
	preamplifier are housed.
(5) XY plotter	Data is plotted here.
(6) Amplifier unit	An amplifier and computer interface are housed.
(7) Power supply unit	Power supply for Xe lamp is housed.