vibrations will be further separated. Thus by each prism, the two components will be separated more and more. If a large number of such prisms are employed, the R-motion and L-motion will be completely separated.

Fresnel examined each of the components emerging from the parallelopied by a Nicol and quarter wave-plate and found that each of them are circularly polarised and are oppositely directed.

7.24. Rotatory dispersion.

According to Biot, the rotation (θ) of the plane of polarisation by an active substance will approximately follow the relation, $\theta = A + B/\lambda^2$, which resembles Cauchy's formula for normal dispersion. The relation between θ and λ can be graphically represented by a curve the nature of which is shown in Fig. 7V.

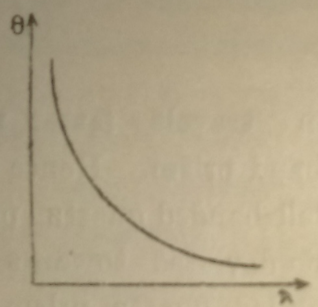


Fig. 7V

Suppose a light of wavelength λ from an illuminated slit S_1 is made parallel by a lens L_1 and is then polarised by a Nicol P whose shorter diagonal is kept vertical (Fig. 7W). Thus the vibration of the light from P will be vertical. This light is then cut off by another Nicol A (analysing Nicol) whose shorter diagonal is therefore horizontal. Thus no light will pass out of the lens L_2 and the screen S_2 will remain dark.

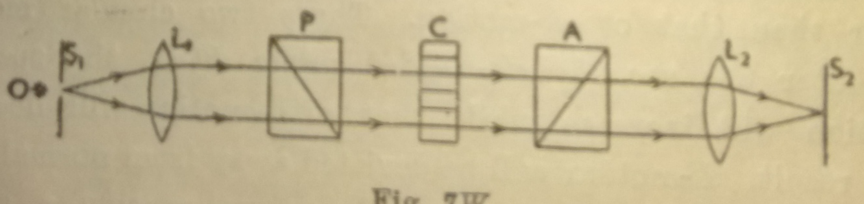


Fig. 7W

If now a quartz crystal C, whose axis is perpendicular to the surface, be interposed between P and A, then the polarised light from P will travel along the optic axis of C. After emergence from C the vibration of the polarised light will rotate by an angle θ and a component OE_1' of this rotated vibration will enter the analyser A and will be converged on the screen S_2 by the lens L_2 [Fig. 7W (a)]. Thus the screen will be illuminated. The emergent light from C can be cut off by rotating the analyser A so that its principal section may be perpendicular to OR.

If the source S emits white light (which contains various wavelengths) the violet light will be rotated more (about 4 times) than red light (Fig. 7W (b)]. Hence greater component OE_2 of the violet light will be transmitted through the analyser (A) than that (OE_1) of red light. As a result, the image formed by L_2 on the screen S_2 will be coloured [Fig. 7W(b)]. This phenomenon is known a **Rotatory dispersion.**

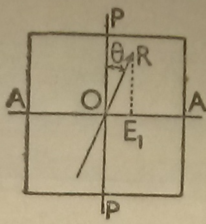


Fig. 7W(a)

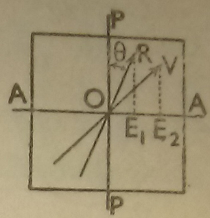


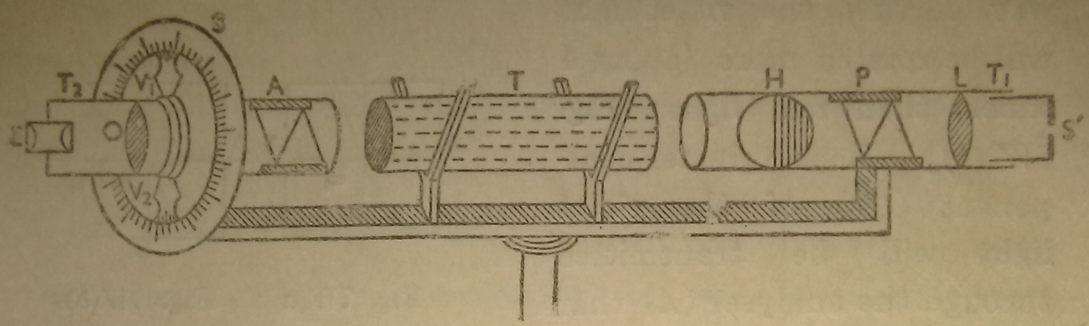
Fig. 7W(b)

If the principal plane of the analyser is kept perpendicular to the vibration of greenish-yellow rays (which are effective in producing illumination) then they will be cut off. The illumination of the field would then be minimum due to the absence of intense part of the visible spectrum. The colour of the emergent beam from analyser would be greyish-violet due to the combination of less intense red and violet parts of the visible spectrum. This greyish-violet colour is called **tint of passage.** For when the analyser is rotated to one side from this position, the field would be red due to the transmission of greater component of red light through the analyser while the rotation of the analyser to the other side will allow a greater component of blue light to pass through it and the field would be blue. This transition from red to blue is very rapid and consequently it is employed to construct a sensitive polarimeter known as Bi-quartz photometer.

7.25. Polarimeters.

(a) Laurent's Polarimeter or Saccharimeter :

If the light polarised by a Nicol be passed through a known length of an active substance and analysed by a second Nicol, then the field of the analyser when made dark will remain so, not at a definite position of the analyser but within a certain range. Thus the measurement of the rotation of the plane of polarisation will be inaccurate. This was overcome by Laurent by using a half-shade plate.



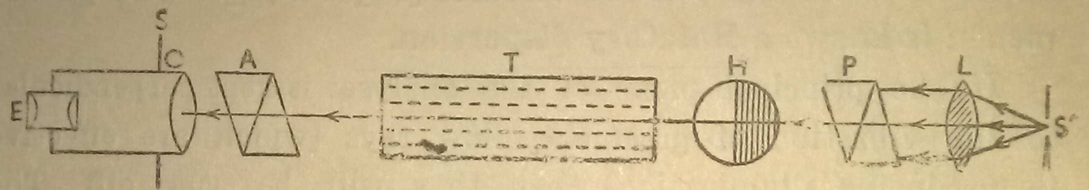


Fig. 7X

Construction.—It consists of tubes T_1 and T_2 kept in one horizontal line. The tube T containing water or the active solution can be kept, when necessary, between T_1 and T_2 and in one line with them [Figs. 7X).

At one end of T_1, there is a slit S' kept at the focal plane of the convex lens L so that the rays emerging from L will be parallel. The polarising Nicol P polarises this parallel light. This polarised light then falls on the half-shade plate H. The slit S' should be illuminated by light suitable for this half-shade plate. One half of this circular plate H is made of glass while the other half is made of quartz whose axis is on the surface and parallel to the line of junction of glass and quartz. The thicknesses of both glass and quartz halves are equal.

The tube T_2 contains another Nicol A, known as the analyser and a telescope consisting of an objective O and an achromatic eye-piece E. This tube T_2 can be rotated about a horizontal axis and this angle of rotation can be recorded by two verniers V_1 and V_2 fixed to the tube T_2 and rotating with the tube T_2 over a fixed circular scale S graduated in degrees.

Working of the apparatus :—The slit S' is illuminated by light suitable for half-shade plate. Light from S' will be rendered parallel by the lens L and after being polarised by the Nicol P, will pass out of the half-shade plate H. This light from H passes through the water taken in the tube T and is then received by the analyser A and the telescope. The tube T_2 is rotated until the two halves of the half-shade plate are equally bright. The readings R_1 of the verniers (V_1 & V_2) attached to the tube T_2 are noted from the scale S.

The water in the tube T is now replaced by the active solution when the two halves of the plate H will be unequally bright due to the rotation of the plane of polarisation by the solution. The tube T_2 is again rotated either towards right or towards left until the two halves of H again become equally bright. The readings R_2 of the verniers (V_1 & V_2) are again noted. Then $\theta=(R_2 \sim R_1)$ will be the angle of rotation of the plane of polarisation by the solution.

Determination of the strength of solutlon.—The length 'l' of the solution is measured and expressed in decimeter. If the specific rotation s of the substance is known, we can find the mass m of the active substance per c.c. of the solution from the relation $\theta=slm$. If m is known, we can find s, the specific rotation of the substance and the molecular rotation can be obtained by multiplying s with the molecular weight of the active substance.

Action of Half-shade Plate—Let the directions of vibration of the polarised rays of light on the half-shade plate be parallel to RS [Fig. 7X (a)]. If θ be the angle which the direction of vibration OS of a ray of light on quartz Q, makes with OX (a line perpendicular to the axis of the quartz which is parallel to YY'), then the vibration of this ray of light on the quartz half will be resolved into two vibrations. One parallel to the axis of the quartz known as extraordinary ray and another perpendicular to the axis known as ordinary ray. These two rays travel within the quartz with unequal speed and hence a path difference will be created. The thickness of the quartz is such that a path difference of $\lambda/2$ or a phase difference of π will be introduced between the emergent ordinary and extraordinary rays and they will combine to form a linear vibration whose direction will be parallel to OT and inclined with OX by the same and θ, but on the other side of OX. The directions of vibration of the rays of light, incident on the glass half (G), will remain unchanged on emergence, *i.e.* the vibrations of the rays of light from the glass half will remain parallel to OR. If now the principal section of the analyser be kept in the position N_1 so that it bisects the $\angle ROT$, then the amplitudes of light received by the analyser at N_1, from both the glass half and the quartz half will be equal and both halves will appear equally bright.

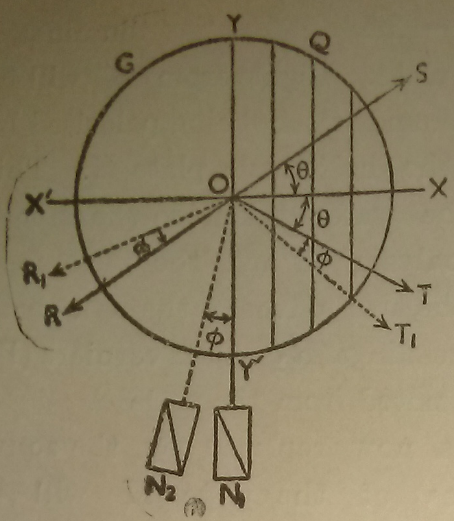


Fig. 7X(a)

If now the tube T containing the active solution be placed between T_1 and T_2, the vibrations parallel to OR and OT from glass half and quartz half respectively will be equally rotated in the same direction by the same angle ϕ and the resolved parts of their amplitudes in a direction parallel to the principal section of the analyser at N_1 will be unequal and hence the two halves G & Q will appear unequally bright. When the tube T_2 is rotated by an angle ϕ to bring the analysing Nicol at N_2 so that its principal section may bisect the angle between the new directions of OR_1 and OT_1, the two halves G and Q will again become equally bright.

(b) **Bi-quartz Polarimeter :**

Construction :—Its construction is the same as that of Laurent's polarimeter, the only modification is that bi-quartz

[Fig. $7X(b)$]. is substituted in place of half shade plate in Fig. $7X$.

Working of the apparatus.—White light from the slit S' is rendered parallel by the lens L and is then plane-polarised by the Nicol P [Fig. $7X$]. The emergent light from P passes out of the bi-quartz placed in the position of H. This light from the bi-quartz passes through the water taken in the tube T and is then received by the analyser A and the telescope. The tube T_2 is then rotated until the tint of passage is obtained when the field becomes greyish-violet colour. The readings (R_1) of the verniers (V_1 and V_2) attached to the tube T_2 are noted from the scale S over which the verniers move.

The water in the tube T is now replaced by the active solution when the field of the telescope becomes either red or blue due to the rotation of the plane of polarisation by the solution. The tube T_2 is again rotated, either towards right or towards left, until the tint of passage, *viz.*, greyish-violet colour, reappears. The readings (R_2) of the verniers (V_1 and V_2) are again noted from the scale S. The angle of rotation of the plane of polarisation by the active substance is given by the mean value of $\theta=(R_2 \sim R_1)$ obtained by the two verniers V_1 and V_2.

Determination of the strength of the Solution.—[Same as in item (a)]

Action of Bi-quartz :—Bi-quartz consists of two semi-circular plates of quartz of equal thicknesses cut perpendicular to the axis [Fig. $7X_1$]. One semi-circular plate L is left-handed quartz while the other semi-circular plate R is right-handed quartz. When plane-polarised white light passes through them, rotatory dispersion will be produced by each. The thickness of each plate is such that greenish-yellow part of the spectrum is rotated by each by 90°. If the principal section of the analyser (A) is kept parallel to that of the

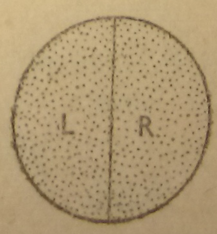


Fig. $7X_1$

polariser (P) then the greenish-yellow part of the spectrum will be cut off from both the plates and both the plates will appear greyish-violet which is the tint of passage. When the incident light is passing through the active substance, its vibration will be rotated during this passage and consequently one half of quartz will appear red while another half will appear blue. The transition from red to blue is very rapid and hence by rotating the tube T_2, containing the analyser A, by a certain along θ, the colours of the two halves of bi-quartz can be brought back to greyish-violet.

Advantages :—This apparatus is more sensitive than Laurent's polarimeter ; besides it can be worked with white light, while Laurent's polarimeter can be worked with a light of particular wavelength suitable for half-shade plate.

(c) Soleil's Polarimeter :

Construction :—Soleil's polarimeter is shown in Fig. $7X_2$. The arrangement consists of a slit (S), a collimating lens (L), a polarising Nicol (P), a bi-quartz plate (B) [the action of bi-quartz has been explained in item (b)], a glass tube (T_1) with plane and parallel ends, a right-handed quartz plate (R), Soleil's compensator (C), analysing Nicol (A) and an observing telescope (T) consisting of the objective (O) and eye-piece (E). Soleil's compensator consists of two equal-angled slender wedge-shaped left-handed quartz prisms (l and l') having their optic axes perpendi-

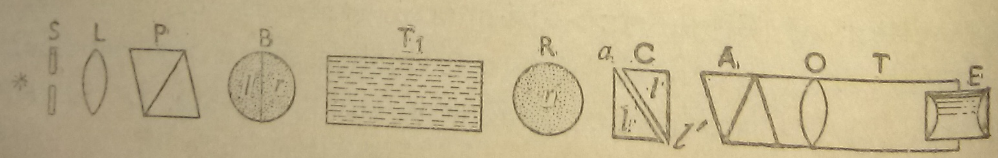


Fig. $7X_2$

cular to the refracting faces of the prisms. One of the wedges (say l) can be made to slide over the other (say l') and this shift of the wedge (l) can be obtained from a micrometer screw attached to the wedge (l) [not shown in Fig. $7X_2$]. When the wedges remain in their normal positions, they constitute a rectangular