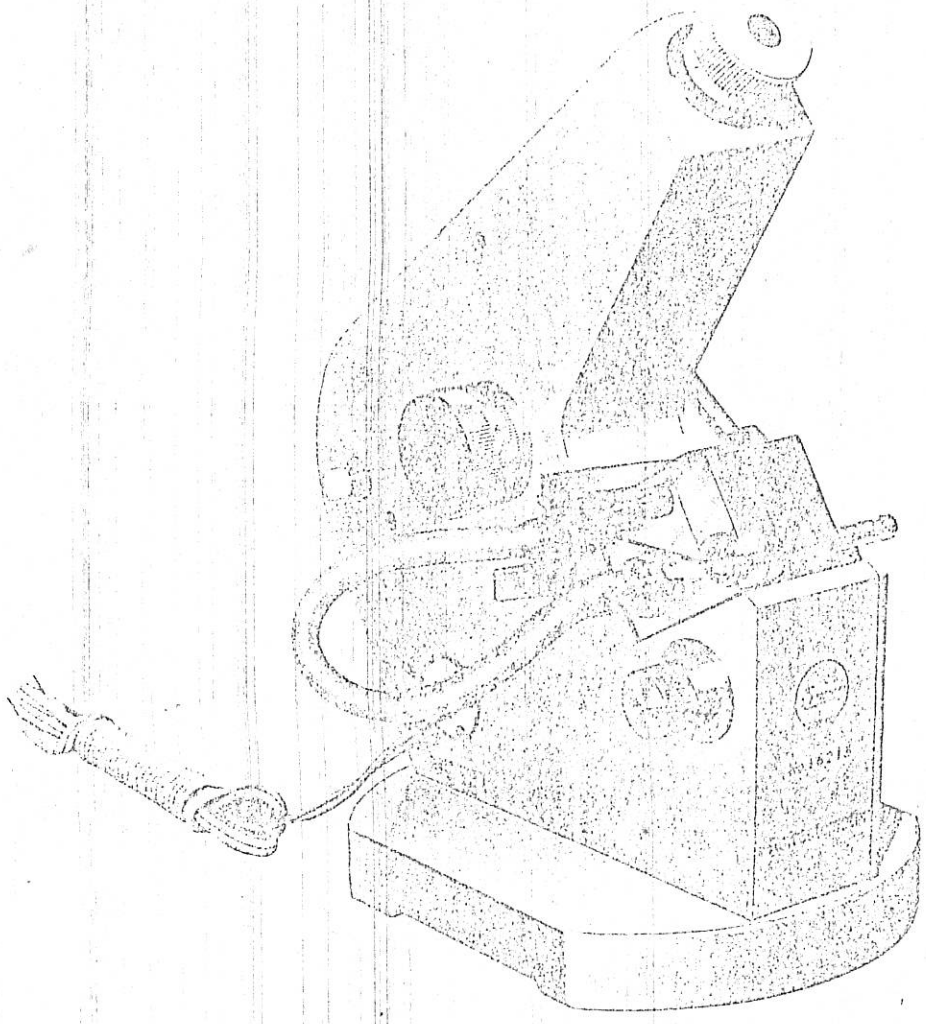
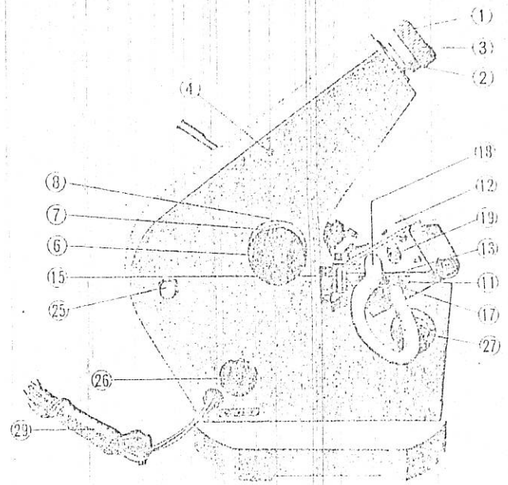
ERMA
NEW ABBE
REFRACTOMETER



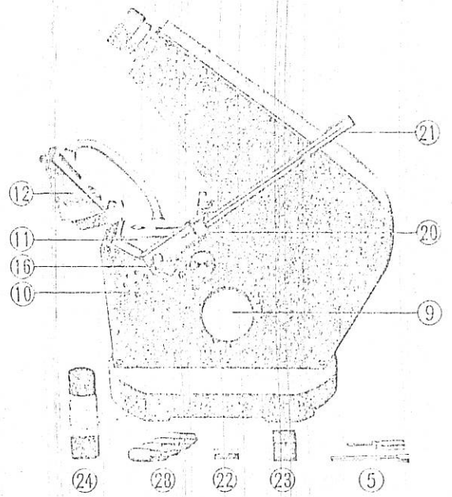
ERMA OPTICAL WORKS, LTD.

TOKYO JAPAN

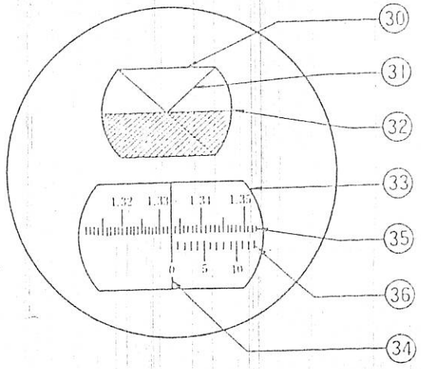
1. Individual Parts and Function



1. Eyepiece
2. Dioptric scale (sliding scale of 1 opt/mm to ± 0 ~ 1)
3. Dioptric adjuster (adjuster for eyepiece)
4. Control screw for scale correction
6. Dispersion knob (for rotating Amici prism)
7. Dispersion scale
8. Dispersion scale indicator
11. Standard measuring Prism A in housing.
12. Cover measuring Prism B in housing
13. Setting nut for Prism A
15. Stopper for Prism B
17. Prism A outlet
18. Prism B inlet
19. Prism B outlet
25. Switch
26. Socket for scale illumination lamp
27. Socket for measuring lamp
29. Electric cord



5. Screw driver for control
9. Measuring knob (for removing boundary line)
10. Radiator for measuring lamp
11. Standard measuring prism A in housing
14. Rod screw driver
16. Prism A inlet (For temperature controlling by Water Circulation)
20. Tfermometer socket
21. Thermometer
22. Test piece for control
23. Reflection prism for test piece light
24. Monobrome naphthalene
28. 4 spare bulbs 6 V, 0.2 A



30. Visual field of measurement
31. Cross reticle
32. Boundary line
33. Reading field
34. Scale reading indicator
35. nD scale (minimum reading 1)
36. Sugar % scale (minimum reading 1)

2. Structure

Fig. 3 shows the principal parts of the instrument. The instrument is divided into two, the internal and external sections.

External section – Prism chamber A and B
Internal section – I Input, switch, transformer and illumination lamp chamber
– II Incident light chamber for A and B
– III Main and Optical parts

A and B of the external section are, as already mentioned, the most important parts of the refractometer. When liquid sample is injected between Prisms A and B, a thin layer of about 0.1 mm is formed. a and b (fig. 3) are empty chambers used for circulation of cold or warm water to maintain the temperature of the sample at a fixed degree. Stainless steel is used for the metal parts of Prisms A and B that corrosion and rust created from the samples are kept at a minimum. Moreover, Prism A with frame can be easily detached for repair or replacement in case it is damaged, or corroded, etc.

The internal section is partitioned 3 parts.

Light source is connected to L_1 L_2 from 1A. of transformer.

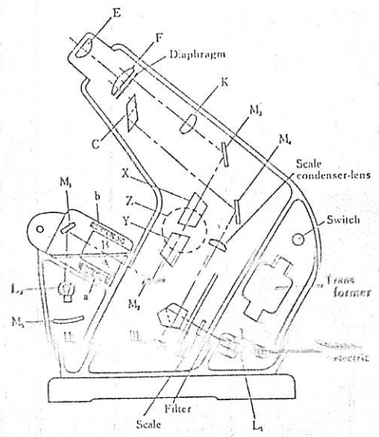
I L_1 illuminates scale through a green filter.

II L_2 reflects on M_2 and enters into B.

III The dark and bright boundary line that emerges from A is reflected on M_2 and enters into the upper sides of X, Y (Amici Prism) M_2 is designed for changing the reflective angles together with scale, by rack and pinion up-down motion.

A ..... Main measuring prism A
B ..... Dispersion prism B
a ..... Temperature regulating chamber
b ..... ditto
C ..... Polarizing prism for scale reading
D ..... Scale reflection Prism
F ..... Eye lens
F ..... Cross line Telescope
K ..... Objective lens
L_1 ..... Scale illuminating lamp

M_1 ..... Surface reflection mirror
M_2 ..... ditto
M_3 ..... ditto
M_4 ..... ditto
M_5 ..... ditto
X ..... Amici prism
Y ..... ditto
Z ..... Rotating knob for Amici prism and dispersion scale



The light from L_1 L_2 enters the telescope through the route is illustrated. Optical view of telescope is shown in Fig. 4.

In case a white light is used as an incident light, dispersion resulting from the changing critical angles due to different refractive indexes of the wavelengths, causes the bright-dark boundary line to color thus making it unclear. To correct and attain a clear boundary line, two Amici Prism X and Y are installed.

X and Y Amici prisms are combination of each 3 prisms suitable for refractive indexes. It permits light to pass the D-line without changing its direction, but when light of other wavelengths passes, it changes direction and causes dispersion. Set Prisms X and Y which have totally the same dispersion index as in illustration, and if only Y is to be made to rotate around the optical axis, dispersion will be reciprocally negated as per position at Fig. 5, but in case Prism Y is made to rotate half way from this position, dispersion will be doubled. Hence, by appropriately rotating Prism Y, the same amount of dispersion created by the sample and Prism A shall be made to disperse in the opposite direction. This will prevent the boundary line from coloring.

The nD of white light source can be obtained by rotating the Amici Prism. Z is for reading the rotating angle of Y and used to calculate the average dispersion of the sample.

3. Usage (Refer to Figs. 1 & 2)

a. Connect electric cord to power source.

b. Push on the switch and see through eyepiece. The scale field alone can be seen clearly. Turn knob (9) to check movement of scale. The switch is used for both the measuring light and scale illumination light that when the switch is pushed on, there will be no light unless sample is inserted.

c. Use available sample, such as distilled water, etc, for trial measurement. Remove stopper (15) of Prism B and open Prism B housing.
Clean the surface of Prism A and put a few drops of distilled water. Close Prism B housing quietly and secure it with stopper.
When Prism B housing is closed, 0.05 mm liquid layer will be formed between Prisms A and B, therefore, only a few drops of liquid sample is required. But in case vaporable (or fluid) samples, double volume are required. Such as samples, may caused of air bubbles, which prevents clear boundary line. Remove the bubbles by opening and closing Prism B, two or three times.

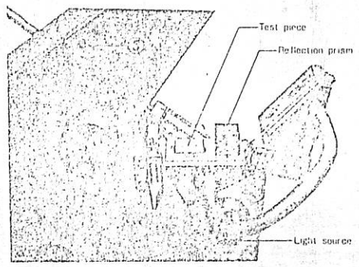
d. Look into eyepiece, turn knob (9) to obtain reading of about 1.333 on the scale. When dark and bright portions appear on the measuring field, adjust diopter (3) to get a light and clear image of the crossline.

e. Again, by turning knob (9), return the boundary line in the upper visual field to the center, turn dispersion control knob (6) on the left-hand side and rotate the Amici prism. This will get rid of the color in the boundary line and given a clear line, which will meet at the crossing point of the cross line. The reading on the scale at this point shall be the refractive index of the distilled water used as sample.
The temperature is adjusted at 20°C, therefore, measurement will be conducted under a uniformed condition as far as possible because the refractive index varies according to room temperature where experiment is to be conducted, the temperature of sample used, the temperature of the instrument itself, etc.

f. Minimum reading of scale will indicate down to 4 places of decimal of nD. accuracy, depending on the personal equation of eye measurement, is 0.0002 but the difference caused by temperature is generally higher.

g. Immediately after the measurement, the auxiliary prism housing should be opened and sample wiped off. (Cleaning method to be explained later.)

4. Calibration of Reading (Refer Fig. 5)



How to use test piece

To check whether the refractometer is indicating the accurate value or not, a test piece made of glass with known refractive index is attached each instrument. This is marked n_D^{20}. test piece (22) should be plastered to measuring Prism A using monobrome-napthalene as shown in Fig. 5 and the measuring light (27) is reflected by reflective prism (23) into the test piece. To plaster test piece, the polished of the prism is the binding side and the other the lighting side.

Be sure that no monobrome-naphthalene should be oozed out on the light pass through the surface of test piece and Prims A.

A small amount of monobrome-naphthalene used will prevent it from oozing out, but in case it does, wiped off carefully so that it will not stick on the surface of the test piece.

After plastering is finished, look into eyepiece and tally the refractive index of test piece with the reading of the scale. If boundary line coinsides the crossline at crossing point it shows that an accurate reading has been obtained. If not obtained, the following steps should be taken to get an accurate reading.

a. Use attached screw driver for adjustment (5) of Fig. 2. While looking inside the telescope, turne the screw for moves boundary line up and down.

b. Besides the above, recheck the reading by standard sample, it is desirable if the standard sample value of nD is similar to the measuring sample.

c. Instead of using a standard sample, distilled water can be used. The nD of distilled water under various temperatures will be shown later.

5. Correction of temperature (Refer Figs. 1 & 2)

Refractive index changes according to temperature. As difference of 1°C will have an effect on the nD down to fourth decimal place, it will be sufficient to maintain the sample temperature within ± 0.5°C. difference. How to obtain n_D^{20}.

a. Use conversion table

b. When conversion table is unavailable, use cold or warm water for temperature control

A. (Refer to Fig. 2) Sample temperature will be read on a thermometer (21) affixed to Prism A. Calculate n_D^{20} by use of conversion table and measured at room temperature.

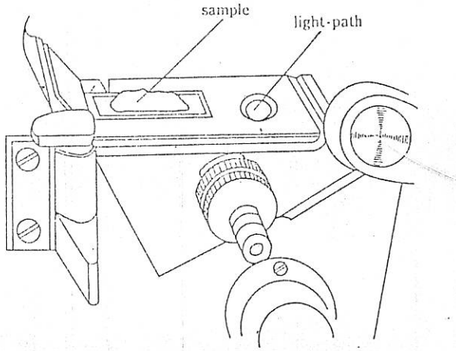
B. (Refer to Figs. 2 & 1) n_D^{20} can also be obtained without using conversion table measured at t°C room temperature. First, measure at t°C the known value of n_D^{20} which is similar to the n_D^{20} of the sample tobe measured. Look at the scale field and turn the knob (9) round twice. Obtain the known n_D^{20} on the scale and keep this position fixed. Next, control screw (4) is turned with the attached screwdriver and adjust the boundary line of the visual field to meet at the crossing point of the cross-line. Now, as the reading of the instrument is so adjusted to obtain n_D^{20} at room temperature even in a limited adjusted scope, the unknown sample can be measured after cleaning Prisms A and B. Remark that the temperature of the instrument should not affect the temperature of the sample when measurement is conducted at room temperature. Thus, attention must be paid to the room temperature where the measurement is conducted and storage place of the instrument.

C. To obtain n_D^{20} when conversion table is unavailable, there is a way to regulate cold or warm water in chambers of Prisms A and B

6. How to measure sample (Refer to Figs. 1 & 2)

A. For liquid sample

As previously mentioned in Page 4, 3-C, measurement for liquid sample should be carried out in the same way as for distilled water. Turn knob (9) according to the refractive index of liquid sample, adjust scale to get bright and dark view in the measuring field. Next, turn knob (6) to get a clear boundary line, then, turn knob (9) again to make the boundry line meet with crossing point of bross lines. Thus, the desired refractive index will be given in reading of scale.



B. For solid sample

Amorphous material-Amorphous material-solid or semi-solid which can not be placed between Prisms A and B should be plastered on Prism A by use of adhesive as shown in Fig. 6 Do not use auxiliary Prism B. The critical angles of such samples will be measured by use of the total reflection. Moreover, the face of adhesion of the sample must be optically plane, and the refractive index of the adhesive should be larger than the refractive index of the sample and smaller than that of the standard prism. The monobrome naphthalene (C_{10} H_7 Br) attached to this instrument in n_D^{20} = 1.6582 and small refractive sample should be used above value. And for large refractive sample, methylene iodid n_D^{20} = 1.7417 is suitable. But the prism be wiped clean immediately after used to prevent it from being affected. Solids wite rectangular faces: In case of glass material, any transparent material having rectangular, no need to polished on both faces. Only the adhesive surface should be ground to an optical plane. Measurement is thus carried out by total reflection as per. mentiond. Another method would be to polish two face and measure the same way as the testpiece method.

C. For powder sample

By changing in divers ways, like mixing ratio changes for two kinds of different refractive liquid, can be obtained the varying value of n between na & nb.

But liquid must be well mixable properties Thus, when the sample power is inserted into such mixed liquid, through eye the reflection of light will dirappear from the surface of the powder in case n of mixed fluid and powder is equal.

When the mixed liquid is measured in a similar way as paragraph A, the refractive index of the powder sample can be obtained. Any solution to be used for mixing if it does not dissolve or act upon the mixing. But, volatile solution may changes n during measurement.

The general used material's refrective indexes are showing on the Table factor.

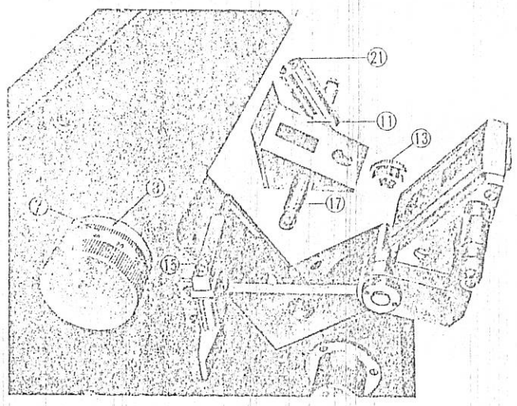
---

7. Remarks

In order to protect any loss inoperating performance, special attention is required against humidity, dust, corrosive chemicals, oil and others.

Therefore, after used, especially on the prims surface has to be wipped off gently with Alcohol-soaked gauze at onece.

Then, the Alcohol must be removed by a dry clean gauze.



1. Remove the thermometer (21), stopper (7) and open the Prism B.
2. Take off the nut of prism chamber (14) by using the attached screwdriver.
3. Prims A housing can be detached.
4. To fix the spare prism, hold prism housing down while securing it to instrument and fix the nut with screwdriver. When spare prism is replaced, the position of Prism A must liable to shift slightly. Proper adjustment should be made in accordance with the aforementioned method See, (How to use test piece.)

Refractive Index (nD) of Sucrose Solution at 20°C

Reading (%)	(n_D)	Reading (%)	(n_D)	Reading (%)	(n_D)	Reading (%)	(n_D)	Reading (%)	(n_D)
0	1.33298	20	1.36382	40	1.39982	60	1.44187	80	1.49069
1	1.33422	21	1.36549	41	1.40177	61	1.44414	81	1.49332
2	1.33586	22	1.36717	42	1.40374	62	1.44643	82	1.49597
3	1.33732	23	1.36887	43	1.40572	63	1.44874	83	1.49863
4	1.33878	24	1.37058	44	1.40772	64	1.45107	84	1.50132
5	1.34026	25	1.37230	45	1.40973	65	1.45341	85	1.50402
6	1.34175	26	1.37403	46	1.41176	66	1.45577		
7	1.34325	27	1.37578	47	1.41381	67	1.45815		
8	1.34476	28	1.37755	48	1.41587	68	1.46055		
9	1.34628	29	1.37932	49	1.41795	69	1.46296		
10	1.34782	30	1.38111	50	1.42004	70	1.46539		
11	1.34936	31	1.38292	51	1.42215	71	1.46784		
12	1.35092	32	1.38474	52	1.42427	72	1.47031		
13	1.35249	33	1.38657	53	1.42641	73	1.47279		
14	1.35407	34	1.38842	54	1.42857	74	1.47529		
15	1.35566	35	1.39028	55	1.43075	75	1.47782		
16	1.35727	36	1.39216	56	1.43294	76	1.48035		
17	1.35889	37	1.39405	57	1.43514	77	1.48291		
18	1.36052	38	1.39596	58	1.43737	78	1.48548		
19	1.36216	39	1.39788	59	1.43961	79	1.48808		

Refractive index and percentage of sucross solids in air at 20°C from ICUMSA (1966) Table III

Temperature Correction Table (Unit nD 0.00001)

Temperature °C			Sugar Percent														
			0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
	10	Deduct from reading	0.50	0.54	0.58	0.61	0.64	0.66	0.68	0.70	0.72	0.73	0.74	0.75	0.76	0.78	0.79
	11		0.46	0.46	0.53	0.55	0.58	0.60	0.62	0.64	0.65	0.66	0.67	0.68	0.64	0.70	0.71
	12		0.42	0.45	0.48	0.50	0.52	0.54	0.56	0.57	0.58	0.59	0.60	0.61	0.61	0.63	0.63
	13		0.37	0.40	0.42	0.44	0.46	0.48	0.49	0.50	0.51	0.52	0.53	0.54	0.54	0.55	0.55
	14		0.33	0.35	0.37	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.45	0.46	0.46	0.47	0.48
	15		0.27	0.29	0.31	0.33	0.34	0.34	0.35	0.36	0.37	0.37	0.38	0.39	0.39	0.40	0.40
	16		0.22	0.24	0.25	0.26	0.27	0.28	0.28	0.29	0.30	0.30	0.30	0.31	0.31	0.32	0.32
	17		0.17	0.18	0.19	0.20	0.21	0.22	0.21	0.22	0.22	0.23	0.23	0.23	0.23	0.24	0.24
	18		0.12	0.13	0.13	0.14	0.14	0.14	0.11	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16
	19		0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	20		0	0	0	0	0		0	0	0	0	0	0	0	0	0
	21	Add to reading	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	22		0.13	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16
	23		0.19	0.20	0.21	0.22	0.22	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24
	24		0.26	0.27	0.28	0.29	0.30	0.30	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.32
	25		0.33	0.35	0.36	0.37	0.38	0.38	0.39	0.39	0.40	0.40	0.40	0.40	0.40	0.40	0.40
	26		0.40	0.42	0.43	0.44	0.45	0.46	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	27		0.48	0.50	0.52	0.53	0.54	0.55	0.55	0.55	0.56	0.56	0.56	0.56	0.56	0.56	0.56
	28		0.56	0.57	0.60	0.61	0.62	0.63	0.63	0.63	0.64	0.64	0.64	0.64	0.64	0.64	0.64
	29		0.64	0.66	0.68	0.69	0.72	0.72	0.72	0.72	0.74	0.73	0.73	0.73	0.73	0.73	0.73
	30		0.72	0.74	0.77	0.78	0.79	0.80	0.80	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81

This table was prepared under the authorization of International Sugar Analysis Control Committee (1949).

Refractive index (nD) of distilled water After Landolt-Börnstein

t°C	nD		
2	1.3342	18	1.3332
6	1.3339	19	1.3331
10	1.3338	20	1.3330
15	1.3334	21	1.3329
16	1.3333	22	1.3328
17	1.3332	25	1.3325
		30	1.3319