6 – 3 REPORT ON WATER CONSUMPTION (O.S. 1981, M.S. 1981/1982)

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A Report on Water Consumption for Rice Cultivation for Off-Season 1981 and Main-Season 1981, 82, At Demonstration Farm

I. Introduction

An area of about four hectares of Demonstration Farm (D/F) consists of 12 lots, and these lots are partitioned with roads or borders.

Each lot has offtakes and outlets independently, therefore, water can be controlled freely and independently. Lot No. 12 is subdivided into six small lots.

Accordingly, irrigation within lot No. 12 is practiced by lot to lot irrigation.

Rice cultivations for the above two seasons were carried out with the purpose of finding out some basic techniques of rice cultivation with emphasis on water management techniques.

On water management, the methods of "NAKABOSHI" for Off-Season (O/S) and intermittent irrigation for Main-Season (M/S) were adopted.

In this paper, a summarized result of investigation pertaining to the water consumption, which was carried out with the above mentioned methods are discussed.

The figures shown in this paper may not be accurate, because the data used for analysis were measured manually moreover, the staffs engaged in this investigation were not proficient for the investigation in this matter. However, the result of this investigation may be useful for future investigation on this matter.

II. The Condition of D/F

1. Location of each lot and area

The location of each lot is shown in Fig. - 1.

The area of each lot, and devices for irrigation and drainage are shown in Table - 1.

2. Soil texture

The clay soil type of D/F is mainly Kaolinite. The soil texture, 30 cm layer of soil surface is shown as follows.

Clay	:	57 to 49 (%)
Silt	:	45 to 40 (")
Fine Sand	:	5 to 3 (")
Coarse Sand	:	2 to 0 (")

3. The difference of elevation

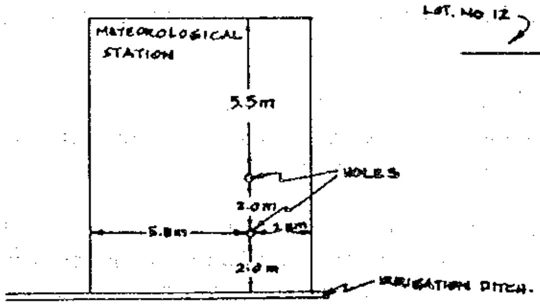
   i) Difference of elevation between neighbouring lot: Maximum 7 cm.

   ii) Difference of elevation in lot : $\pm$ 5 cm.

4. Underground water table

Observation of underground water table was carried out with two holes at Meteorological Station, which is set at center of D/F. The outline of measured holes is shown below.

Place



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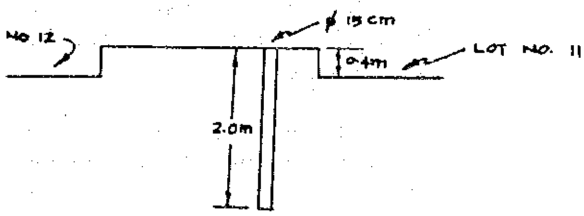


The depth of underground water table is below 1.5m from soil surface before presaturation, and after presaturation it rises to 0.1 m to 0.15 m below soil surface.

5. Soil moisutre ratio

A representative figure of soil moisture ratio at D/F at the condition of before and after presaturation during O/S is shown in Appendix - 2.

6. Meteorological data

The devices for the meteorological observation are shown as follows.

Devices	Type
Pluviograph recording rain-gauge.	Tumbling bucket type. Rainfall catching cylinder diameter is 20 cm.
Evaporimeter.	1.2 m diameter white PAN.
Thermometer.	
Hygrometer.	

III. Method of Investigation

This investigation was carried out for the purpose of obtaining the amount of water consumed for rice cultivation at D/F.

The amount of water consumption on field is the total of

i) Supplied water plus ii) Effective rainfall.

1. Supplied Water

The amount of supplied water was measured with Weir set on offtake, and its discharge was controlled with valve. The outlet was closed during irrigation. The time of discharge was recorded and calculation of volume was carried out daily.

Measurement and management were carried out manually.

2. Rainfall

Rainfall was observed at meteorological station.

The effective rainfall was estimated as 0 to 70 mm, continuous rainfall exceeding 70 mm was eliminated from effective rainfall, because, the crest height of outlet was maintained about 70 mm above soil surface.

IV. Results of Investigation

1. Planting Schedules.

Excuted schedules paddy cultivation are shown in Table - 2 and 3.

2. Amount of water consumption for O/S in 1981

(1) Presaturation period.

Generally, amount of water consumption for presaturation is calculated as follows.

$$q1 = T(P+Eu) + S + H \quad ..... \quad (1)$$

$$q2 = \frac{T}{2}(P+Eu+Es) + S + H \quad ..... \quad (2)$$

Where,

q1 : The amount of water requirement during presaturation period for independent paddy field.

q2 : The amount of water requirement during presaturation period for lot to lot irrigation.

This formula is used for lot No. 12

T : Presaturation period. (days)

P : Percolation loss. (mm/day)

Eu : Evaporation loss from Unsaturated soil. (mm)

Es : Evaporation loss from saturated soil. (mm)

H : Flooding water depth at the end of presaturation. (mm)

S : The required amount of water in order to soak unsaturated soil. (mm)

Actual consumed water for each lot is shown in Table-4-1. It varies from each lot.

We may analyse the reason for variation as shown in Table-4, using formula (1) or (2).

Supposing P, Eu, Es and H for each lot is constant S of each lot is calculated from, q, shown in Table-4-1. Using formula (1) or (2)

i) With reference to P, Eu, Es and H

a) P : We may estimate P as 1 mm/day, the reason is mentioned in Appendix 1.

b) Eu and Es : According to D.I.D. report, Eu equals 0.7 Ep,

Where Ep is the figure observed with Black PAN evaporimeter

Mr. Yashima (T.A.R.C, MUDA) derives a correlation between Ep, Eu, and underground water table.

But, we like to use the figure measured with PAN evaporimeter, because we don't have profitable method estimating Eu yet, moreover the big factors influencing q and T and S.

We therefore used 4 mm/day for Eu and Es which were observed with PAN for this period.

c) H : H is maintained of 20 mm or 25 mm, because of easy working for transplanter.

ii) Calculation of S

Using decided figure above, we estimate S. The result of calculation are shown in Table-4-2.

Average figure of S is equal to 94 mm/day

We eliminated the figure of lots No. 2 and 3 from this calculation, because both of these lots had just completed underground drainage works in April, 1981. Accordingly, the void ratio of soil of these lots were larger than other lots.

This shows that the amount of water consumption for these lots which have completed underground drainage work is two or three times that of non-underground drainage work for presaturation period.

As to the reason of smaller figures of No. 4 and No. 7, we may suppose that the start of presaturation for No. 4 and No. 7 were delayed, accordingly, previously supplied water to neighbouring lots of No. 4 and No.7 leaked into the soil of No. 4 and No. 7, then soil moisture content of these two lots had increased before presaturation for No. 4 and No. 7.

(2) Normal Period

The amount of water consumption during normal period were calculated with two periods respectively.

One is from the day after transplanting to the day before beginning of "NAKABOSHI", which is period A.

Other is from the day after end of "NAKABOSHI" to the day before drainage for harvesting, which is period B.

The results of calculation are shown in Table-5-1 and 5-2. Average water consumption per day is shown as follows.

	Period A	Period B
Average figure (mm/day)	5.6 100%	7.6 100%
Items		
Supplied Water (")	3.2 57%	4.6 60%
Rainfall (")	2.4 43%	3.0 40%

3. Amount of water consumption for M/S

Generally, there are a lot of precipitation for M/S, if we plant paddy to fit the rainfall pattern, we can save water supply.

But, in order to implement double cropping, it is very difficult to shift planting schedule to fit rainfall effectively, water management is required more seriously than O/S.

(1) Presaturation period

The amount of water consumption of each lot is shown in Table-6-1.

Supposing P = 1.0 mm, Eu = Es = 3.3 mm/day, average S may be calculated as 20 mm, the process for calculation of S is shown in Table-6-2.

Supposing underground water table measured before presaturation is 14 cm under soil surface, the figure of 20 mm is optimum.

(2) Normal Period

The amount of water consumption of each lot is shown in Table-7.

Average figure	(mm/day)	8.4	100%
Items			
Supplied Water	(")	5.2	62%
Rainfall	(")	3.2	38%

V. With Reference Above

As previously mentioned, we adopted the method of "NAKABOSHI" irrigation and intermittent irrigation.

"NAKABOSHI" means that, we make drain field about one week in the midst of paddy cultivation.

Actually, we drained for one week from the date of one month after transplant.

Intermittent irrigation had been carried out for lots No. 1, 2, 3 and 8, 9, 10.

A circulating irrigation of three days flood, two days drainage was carried out for lots No. 1, 2 and 3, and for lots No. 8, 9 and 10, it was of three days flood and one day drainage.

Actually, the interval of cycle were not the same, because, it was influenced by heavy rainfall sometimes.

1. Comparison of amount of water consumption between different irrigation methods.

Water consumption between different irrigation methods are summarized as follows.

Lot No.	O/S		M/S		Note
	P.A	P.B			
	(mm/day)	(mm/day)	(mm/day)		
1	6.4	8.0	7.9	Intermittent irrigation 3 days flood 2 day drainage	P.A: Period A P.B: Period B
2	6.3	9.7	8.7		
3	6.2	9.5	7.0		
4	-	-	5.9		
5	6.6	7.0	9.1		
6	5.9	7.6	6.6		
7	9.2	9.3	8.7		
8	5.9	7.5	10.8	Intermittent irrigation 3 days flood 1 day drainage	
9	6.9	6.5	10.9		
10	6.4	6.1	11.1		
11	7.1	5.3	5.2		
12	-	5.9	8.3		

It is clear that, water consumption increases after "NAKABOSHI", and the lots which were carried out with intermittent irrigation for M/S consumes more water than other lots. This tendency of increasing of water consumption is very important study for future planning of irrigation system.

2. Comparison of water duty between D.I.D. Report and the results of this investigation.

In order to check the figures investigated in our D/F, we prepared a table here under.

Item	Unit	O/S			M/S	
		P.P	N.A	N.B	P.P	N.P
D.I.D	mm/day	381	254	254	330	229
	l/sec	1.5	1.3	1.3	1.3	0.9
D/F	mm/day	259	168	225	159	222
	l/sec	1.0	0.7	0.9	0.6	0.9

Note:

D.I.D	:	The figures recommended by D.I.D.
P.P	:	Presaturation period.
N.A	:	Normal period A.
N.B	:	Normal period B.
N.P	:	Normal period.

The figures of P.P of D/F are smaller than that of D.I.D, these reasons are assumed that, i) the standing water layer of 20 or 25 mm for D/F are much smaller than that of D.I.D, ii) the figures of D.I.D are included such losses as conveyance loss.

VI. Conclusion

The investigation for these seasons were merely carried out to grasp the tendency of water consumption at D/F, but it requires more accurate figures regarding water consumption, to clarify the relationship between water management and water consumption and rice yield.

Appendix - I

Percolation loss

Pertaining to the typical movement of percolation water, we may explain that, some of stored water in field penetrated into soil and reaches underground water table, the water, reached there will contribute to increase of potential energy of underground water.

The underground water with potential energy will be discharged to the drain. Percolation loss, so called usually, is the loss which is lost by the process above.

Percolation loss is influenced by permeability coefficient and potential energy of water.

1. Permeability Coefficient

Permeability coefficient was observed with auger hole method at D/F, It is 10^{-6}m/sec

Actually, we treated permeability coefficient as that, Horizontal value is similar as Vertical one.

2. Calculation of Percolation Loss

i) From underground water table to the drain

There are a lot of formulas regarding calculation of the amount of discharge, but, we would like to adopt a formula mentioned under, in this case.

$$Q = k.\frac{H}{l} \times A \ (m^3/s) \qquad ..... \quad (i)$$

Where:

Q : The amount of discharge from underground water table to the drain. m^3/s.

k : Permeability of coefficient. m/s.

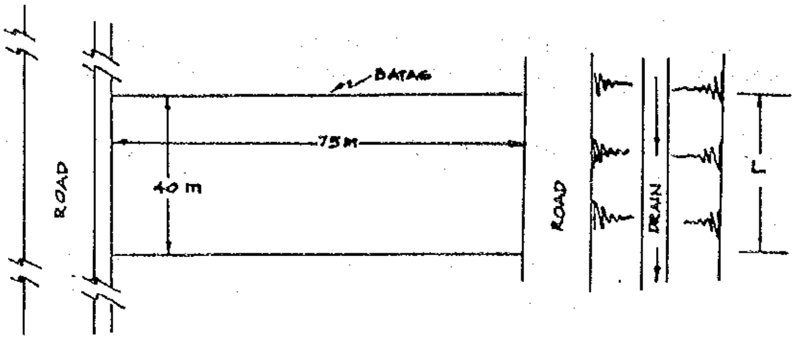
L : Length of percolation path. m.

H : Difference of potential energy between underground water table and drain water level.

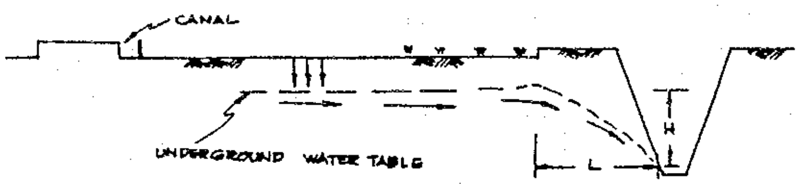
A : Cross-section area of flow.
A = H x L

L : Length of drain faced field.

Standard Plane



Standard Section



Supposing, $k=10^{-6}$m/s, H=1.5 m, l=5.0 m, A=1.5x40=60 m^2

$$Q = 10^{-6} \times \frac{1.5}{5} \times 60 = 1.8 \times 10^{-5} (m^3/s)$$

Convert Q to Qd (m^3/day)

$$Qd = 1.8 \times 10^{-5} \times \frac{86400 \text{ sec.}}{\text{day}} = 1.56 \ m^3/\text{day}$$

Convert Qd to q (mm/day)

Qd equal to the discharge volume which is discharged from one lot, we may convert 1.56 m/day to percolation loss; q (mm/day).

$$q \text{ (mm/day)} = 1.58 \ m^3/\text{day} \div (40m \times 75 \ m) \times \frac{1000 \text{ mm}}{1 \text{ m}} = \underline{0.4}$$

Actually, there are a lot of assumption in this calculation, we may decide it as 1.0 mm/day.

ii) From field to underground water table

The vertical percolation velocity at a section from field to underground water table may be calculated as follows.

$$\bar{V} = k.\frac{h}{l} \times 86400 \times 1000 \qquad ..... \quad (ii)$$

Where:

$\bar{V}$: Percolation velocity. (mm/day)

k : Vertical permeability coefficient. (m/s)

h : Distance from flood water level in field to underground water table. (m).

l : The path of percolation. (m)

Supposing $k=10^{-6}$ m/sec $h/l=1.0$

$$\bar{V} = 10^{-6} \times 1.0 \times 864000 \times 1000 = \underline{86.4 \text{ (mm/day)}}$$

3. Conclusion

Actually, the underground water table was below 1.5 m under field before presaturation, and after presaturation it rises 0.1 m or 0.15 m from field surface.

It is supposed that, some of supplied water in field penetrated with a velocity of 8.64 mm/day, but the amount of discharged from underground water table to the drain was less than 1 mm/day. Accordingly, the ground water table rises gradually, and finally, it reaches near field surface.

From above mentioned idea, we estimated the percolation loss as 1.0 mm/day.

Appendix - 2

Soil Moisture Ratio

Soil moisture ratio between before presaturation and after are quite different especially for O/S.

Typical figure of soil moisture ratio for O/S shows under

Soil Moisture Ratio

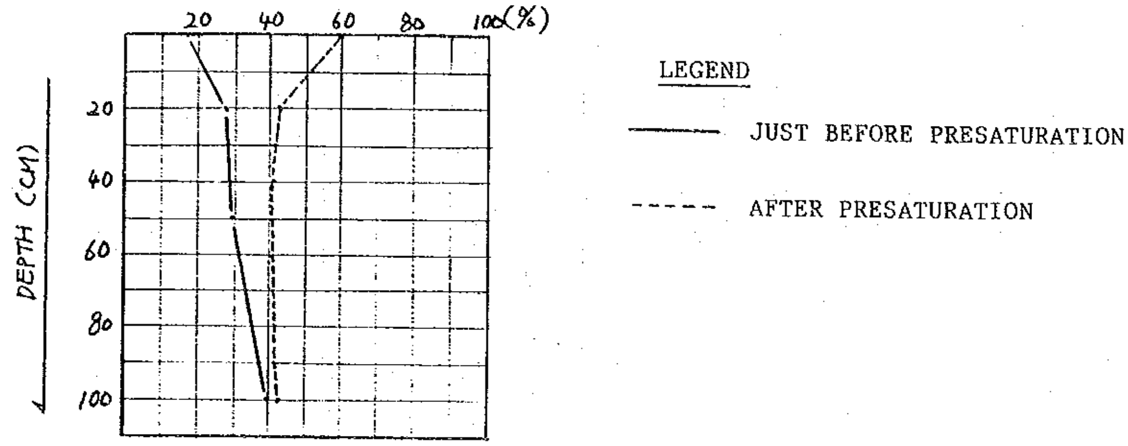
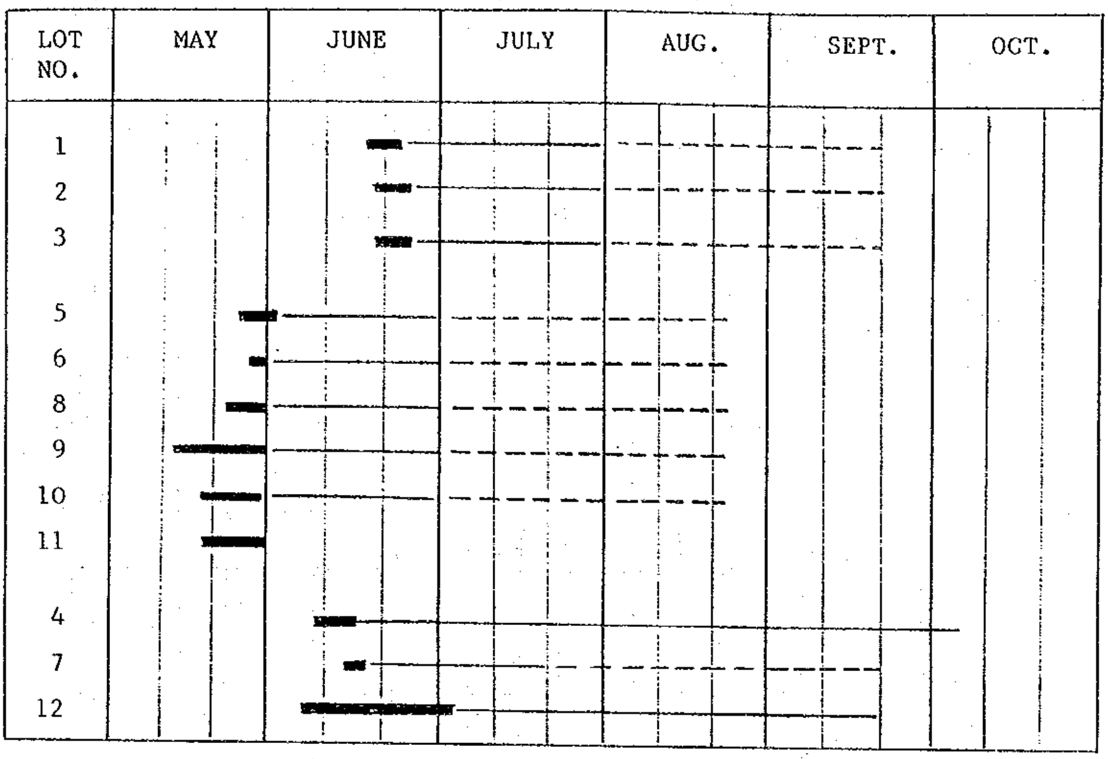


TABLE I: THE AREA OF EACH LOT AND DIVICES FOR IRRIGATION AND DRAINAGE

LOT NO.	AREA	OFFTAKE		OUTLET		NOTE
		NO.	SIZE	NO.	SIZE	
	m^2		cm cm		cm cm	
1	3,000	2	R.20x20	2	35 x 35	R: RECTANGULAR WEIR
2	3,000	2	R. "	2	"	T: TRAINGULAR WEIR
3	3,000	2	R. "	2	"	
4	3,000	2	R. "	2	"	
5	3,000	2	R. "	2	"	
6	3,000	2	R. "	2	"	
7	1,778	2	R. "	2	"	
8	1,538	1	R. "	2	"	
9	3,000	2	R. "	2	"	
10	3,000	2	R. "	2	"	
11	3,000	2	R.20x20 T.30x60	2	"	
12	7,249	7	R.20x20	4	"	
	37,565					

TABLE 2: <u>EXECUTED CULTIVATION SCHEDULE</u>

(Off-season in 1981)



NOTE:

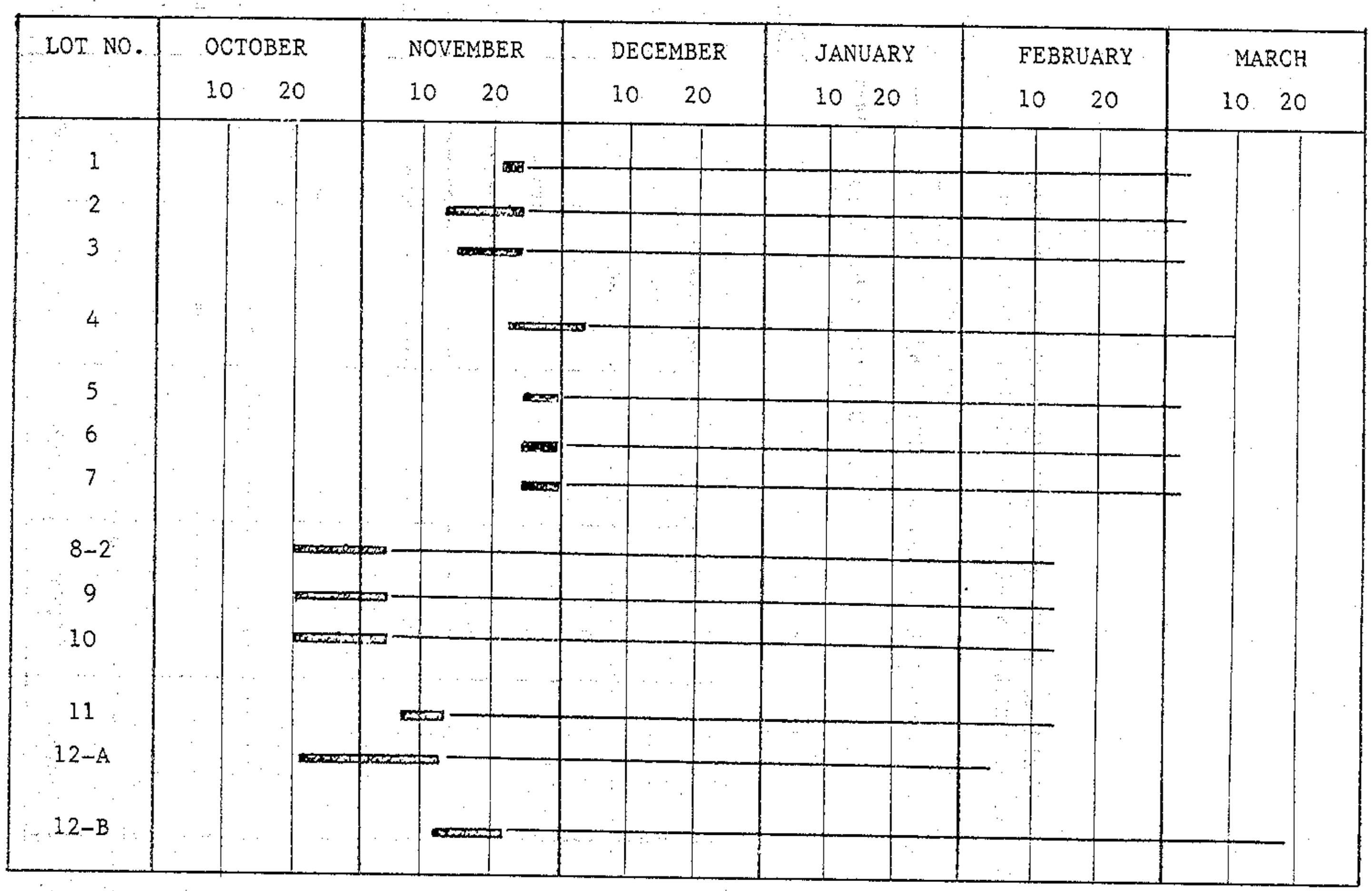
▬ PRESATURATION PERIOD

—— THE PERIOD FROM THE DAY AFTER TRANSPLANT TO THE DAY BEFORE NAKABOSHI

- - - THE PERIOD FROM THE DAY AFTER NAKABOSHI TO THE DAY BEFORE DISCHARGE OF RESIDUAL WATER OF FIELD

TABLE 3: EXECUTED CULTIVATION SCHEDULE

(Main-season in 1981 - 82)



NOTE:

PRESATURATION PERIOD

NORMAL PERIOD

TABLE 4-1: PRESATURATION PERIOD (O/F in 1981)

LOT NO.	AREA	PERIOD			CALCULATION				q (1) + (2)
		D.S.	D.T.	PERIOD (days)	S.W (1)	SWxAREA	ER (2)	ERxAREA	
	m^2				(mm)	m^3	m^3		
1	3,000	14 JUNE	23 JUNE	10	148	444	18	54	166
2	3,000	16 "	27 "	12	345	1035	80	240	425
3	3,000	15 "	27 "	13	250	750	80	240	330
4	3,000	9 JULY	16 JULY	8	75	225	28	84	103
5	3,000	25 MAY	2 JUNE	9	162	486	25	75	187
6	3,000	27 "	31 MAY	5	117	351	15	45	132
7	1,778	14 JUNE	17 JUNE	4	88	156	2	4	90
8-2	1,538	23 MAY	31 MAY	9	174	268	27	42	201
9	3,000	12 "	30 "	19	154	462	70	210	224
12	7,249	7 JUNE	1 JULY	25	175	1269	95	689	270
	31,565			114		5446		1683	

NOTE:

D.S. : DATE OF START OF PRESATURATION

D.T. : DATE OF TRANSPLANT

S.W. : SUPPLIED WATER

E.R. : EFFECTIVE RAINFALL

TABLE 4-2: THE AMOUNT OF WATER SOAKING UNSATURATED SOIL

LOT NO.	q	T	Tx(p+Eu)	H	S	SxAREA	NOTE
	(mm)	(days)	(mm)	mm	mm	m^3	
1	166	10	50	25	91	273	
2	425	12	60	25	340		
3	330	13	65	25	240		
4	103	8	40	20	43	129	
5	187	9	45	25	117	351	
6	132	5	25	20	87	261	
7	90	4	20	20	50	89	
8	201	9	45	25	131	201	
9	224	19	95	20	109	327	
12	270	25	113	50	107	776	
						2407	

NOTE:

AVERAGE S $= 2407^{m^3} \div (3000\times5+1778+1538+7249)m^2 \times 1000$

$= 2407 \div 25562\times1000 = 94.1^{mm}$

TAB 5-1: NORMAL PERIOD: A (O/S in 1981)

LOT NO.	PERIOD: A			A.S.W. (1)	E.R (2)	T.W.C. (3)=(1)+(2)	W.D/DAY (3)/PERIOD	NOTE
	D.B.	D.E.	PERIOD					
			(days)	(mm)	mm	(mm)	(mm/day)	
1	24 JUNE	1 AUG.	39	97	152	249	6.4	
2	28 JUNE	1 AUG.	35	145	75	220	6.3	
3	28 JUNE	1 AUG.	35	141	75	216	6.2	
5	3 JUNE	29 JUNE	27	99	80	179	6.6	
6	1 JUNE	29 JUNE	29	92	80	172	5.9	
7	18 JUNE	19 JUNE	32	161	134	295	9.2	
8-2	1 JUNE	29 JUNE	29	90	80	170	5.9	
9	31 MAY	29 JUNE	30	112	80	192	6.4	
10	31 MAY	29 JUNE	30	113	80	193	6.4	
11	1 JUNE	29 JUNE	29	134	80	214	7.4	
			315	1184	916	2100		

NOTE:

D.B: DATE OF BEGINNING OF PERIOD A
D.E: DATE OF ENDING OF PERIOD B
A.S.W: AMOUNT OF SUPPLIED WATER DURING PERIOD A
E.R: EFFECTIVE RAINFALL
T.W.C: TOTAL WATER CONSUMPTION

Average Water Consumption: 2100/315 = 6.7 (mm/day)
Supplied Water: 1184/315 = 3.8 (")
Effective Rainfall: 916/315 = 2.9 (")

TABLE 5-2: NORMAL PERIOD: B (O/S in 1981)

LOT NO.	PERIOD: B			A.S.W.	E.R.	T.W.C.	(3)/PERIOD	NOTE
	D.B.	D.E.	PERIOD (days)	(1)	(2)	(3)=(1)+(2)		
				(mm)	(mm)	(mm)	(mm)	
1	6 AUG.	18 SEPT.	45	170	188	358	8.0	
2	"	"	45	249	188	437	9.7	
3			45	241	188	429	9.5	
5	5 JULY	22 AUG.	48	234	101	335	7.0	
6	"	"	48	266	101	367	7.6	
7	24 JULY	18 SEPT.	56	331	191	522	9.3	
8	6 JULY	22 AUG.	47	251	101	352	7.5	
9	"	"	47	205	101	306	6.5	
10	"	"	47	205	101	306	6.5	
11	7 JULY		46	143	101	244	5.3	
25	1 JULY	18 SEPT.	80	214	262	476	5.9	
			554	2509	1623	4132		

NOTE:

D.B: DATE OF BEGINNING OF PERIOD, B.
D.E: DATE OF ENDING OF PERIOD, B.
A.S.W: AMOUNT OF SUPPLIED WATER DURING PERIOD, B.

AVERAGE WATER CONSUMPTION: 4132/554 = 7.5 (mm/day)
SUPPLIED WATER: 2509/554 = 4.5 (")
EFFECTIVE RAINFALL: 1623/554 = 3.0 (")

TABLE 6-1: WATER CONSUMPTION FOR PRESATURATION PERIOD (M/S in 1981 - 82)

LOT NO.	AREA	PERIOD			CALCULATION				q (1)+(2)
		D.S.	D.T.	PERIOD	S.W.(1)	SWxAREA	R (2)	R X AREA	
	m^2			(days)	mm	m^3			
1	3,000		25 NOV.	10	0	0	70	210	70
2	3,000	16 NOV	"	10	29.3	87.9	"	210	99.3
3	3,000	"	"	10	11.2	33.6	"	210	81.3
4	3,000	23 NOV	5 DEC.	13	25.9	77.7	"	210	95.9
5	3,000	24 NOV	29 NOV.	6	21.8	65.4	8.5	25.5	30.3
6	3,000	"	"	6	74.6	223.8	"	25.5	100.1
7	1,778	"	"	6	65.2	115.9	"	15.1	80.3
8	1,538	20 OCT.	3 NOV.	15	57.8	88.9	26.2	40.3	84.0
9	3,000	"	"	15	111.0	333.0	"	78.6	189.6
10	3,000	"	"	15	84.9	254.7	"	78.6	111.1
11	3,000	8 NOV.	11 NOV.	4	8.2	24.6	70.0	210	78.2
12	7,249	22 OCT.	21 NOV.	31	43.8	371.5	114.8	832.2	158.6
	37,565			141		1677.0		2145.8	

NOTE:

D.S: DATE OF START OF PRESATURATION

D.T: DATE OF TRANSPLANT

S.W: SUPPLIED WATER

E.R: EFFECTIVE RAINFALL

TABLE 6-2: PRESATURATION PERIOD (M/S in 1981 - 82)

	q	T	Tx(P+EU)	H	S	SxAREA	NOTE
	mm	days	mm	mm		m^3	
1	70	10	43	25	2	6	
2	99	10	43	25	31	93	
3	81	10	43	25	13	39	
4	96	13	56	25	15	45	
5	30	6	26	25	-21	-63	
6	100	6	26	25	49	147	
7	80	6	26	25	29	52	
8	84	15	65	25	- 6	9	
9	190	15	65	25	100	300	
10	111	15	65	25	21	63	
11	78	4	17	25	36	108	
12	159	31	118	50	- 9	-65	
						734	

NOTE:
AVERAGE $S = 734^{m3} \div 37565^{m2} \times 1000 = 19.5^{mm}$

TABLE 7-1: NORMAL PERIOD (M/S in 1981 - 82)

LOT NO.	PERIOD			A.S.W. (1)	E.R. (2)	T.W.C. (3)=(1)+(2)	W.D/DAY (3)/PERIOD	NOTE
	D.S.	D.D.	PERIOD					
			(days)	(mm)	mm	mm	mm/day	
1	26 NOV.	3 MAR.	97	554	204	758	7.9	INTERMITTENT IRRIGATION (lots 1–3)
2	"	"	"	639	204	843	8.7	
3	"	"	"	460	204	664	7.0	
4	6 DEC.	10 MAR.	95	382	182	564	5.9	
5	30 NOV.	3 MAR.	94	659	195	854	9.1	
6	"	"	94	426	195	621	6.6	
7	"	"	94	620	195	815	8.7	
8	4 NOV.	11 FEB.	100	586	497	1083	10.8	INTERMITTENT IRRIGATION (lots 8–10)
9	"	"	"	593	497	1090	10.9	
10	"	"	"	608	497	1105	11.1	
11	12 NOV.	4 FEB.	94	77	407	486	5.2	
12	22 NOV.	17 MAR.	116	559	407	968	8.3	
			1178	6163	3688	9851		

NOTE:

D.S: DATE OF BEGINNING OF NORMAL PERIOD.
D.D: DATE OF DRAINAGE FOR HARVESTING.
A.S.W: AMOUNT OF SUPPLIED WATER.
E.R: EFFECTIVE RAINFALL.

TABLE 7-2: - NORMAL PERIOD (ELIMINATE THE FIGURES OF NO. 1, 2, 3, 8, 9 AND 10)

LOT NO.	PERIOD	A.S.W. (1)	E.R. (2)	T.W.C. (3)=(1)+(2)	NOTE
	(days)	(mm)	(mm)	(mm)	
4	95	382	182	564	AVERAGE WATER CONSUMPTION: 4308/578 = 7.5 (mm/day)
5	94	659	195	854	
6	94	426	195	621	
7	94	620	195	815	
11	94	77	409	486	
12	116	559	409	968	
	587			4308	

7. OPERATION MANUAL OF MEASURING INSTRUMENTS

7 - 1 LEAKAGE CAPACITY TESTER

LEAKAGE CAPACITY TESTER

Todai-550 Type

The percolation measure frame with a cap is pushed into the paddy field. The amount of percolation water in the frame is read on the scale. As the scale of percolation is magnified, you can measure the leakage per day within about 5 minutes. This is convenient in searching for the leakage spot in the paddy field.

* Components and Specifications

(1) Inserting drum: ..... 1 pc.
stainless steel, 144ø x 80 mm

(2) Floating meter: ..... 1 pc.
wooden plate, with scale
range (for 5 min) 0-10(0.02) cm/day
(for 1 min) 0-50(0.1) cm/day

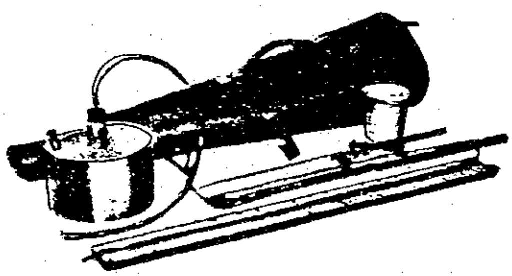
(3) Mariotte meter: ..... 1 pc.
transparent acrylic resin,
range (for 10 min) 0-30(0.1) cm/day

(4) Support for Mariotte meter: ..... 1 unit
holder and rod, 10ø x 400 mm

(5) Connecting parts: ..... 1 unit
polyvinyl tubing, T-shape tube,
pinchcocks and rubber stoppers

(6) Beaker: ..... 1 pc.
polyethlene, 100 ml

Case:	vinyl leather, hand carrying type
Dimensions:	15ø x 60 cm
Weight:	1 kg



* Optional Accessories

Sandglass:
1 min and/or 5 min

(This accessories will be supplied at request.)

* Float Method

1. Drum settlement:

1) Separate the drum from the float. Vertically push the drum into your measuring point of the paddy field. Then, put it into the paddy field by pushing carefully its shoulder with your both hands.

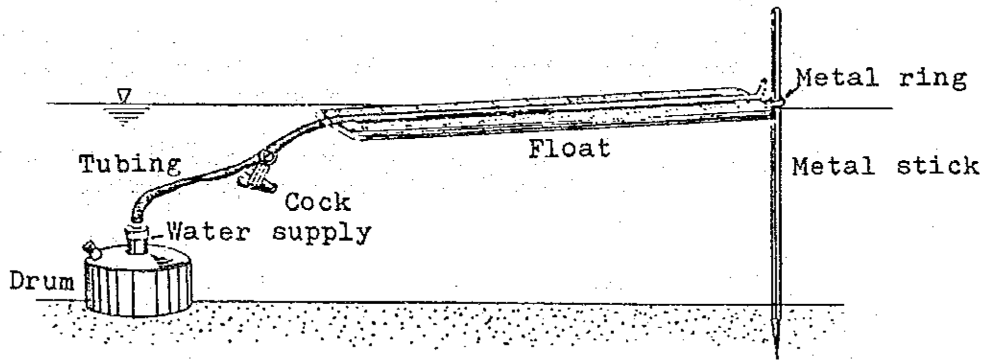
2) It is suitable to immerse its drum as not to move.

3) It is easy to operate when a mouth of water supply is located under water surface.

* Remove the waterplants and straw.

* A good result can not be produced, if the drum was pushed hurriedly.

* Use a small hole at top of drum as ventilator, when measure at the water side of a slope. Stop with a rubber stopper after deflation.



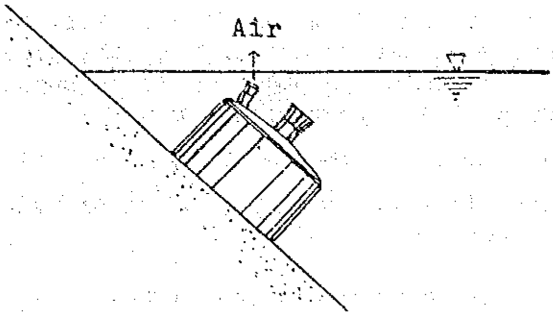
2. How to fill a graduated tube with water:

1) Open the cock. Have an end of vinyl tube (a rubber stopper) in your left hand and a float in your right hand.

2) Immerse the tubber stopper into the water. Then, carefully immerse it little by little, as watching that water get in the vinyl tube. Thus, evenly fill the graduated tube with water.

* Do it slowly so that no bubbles remain in the graduated tube.

3) When they remain in it even if do it carefully, suck softly from an end of the connecting tube after connecting it with an end.



3. Connection of drum and float:

   1) Keep the float plate in the water-surface, and push the rubber stopper in a hole of water supply in the water. (Don't lift up from water.)

      * When put the rubber stopper in the hole of water supply, press it with your finger so that air does not come in.

   2) Get a metal stick through a metal ring, and strike its stick so that the float does not wander.

      * Take care that the vinyl tube does not become loose, when strike its stick.

4. Measurement:

   1) Start the measurement justwhen water in the graduated tube begins moving.

   2) Read moving-length for one minute. This shows leakage value (water depth) per day.

      For example:

Graduation at measurement start:	5.0
Graduation after one minute:	7.8
Balance of above, 7.8 - 5.0:	2.8
Leakage value at this field:	2.8 cm/day

* In case of a little variation per one minute read five minutes-graduation. Its moving length shows leakage value per day.

* Repeat measurement three times or so and can get exact value by making sure no difference.

* When water in graduated tube does not move:

  a) Check whether bubble remains in the tube. If remains, do it over again from above "2".

  b) Check whether drum is sinked correctly in the paddy field. If imperfect, water does not move by connecting with large hole between exterior and interior of drum. Then, check whether water in the tube moves, as sink the drum carefully. If water overflows from the graduated end by moving, it is connected with large hole between exterior and interior of drum. Then pull out the drum, sink it again in the paddy field.

5. Water supplement:

   1) When fill the graduation tube with water for re-measurement, open the cock and sink the float in the water.

* <u>Mariotte Method</u>

1. Drum settlement:

   Same to float method.

2. How to strike the stick:

   1) Stand the stick about 20 - 30 cm from position of drum settlement.

3. How to fill mariotte tube with water:

   1) Attach the holder to the mariotte tube.

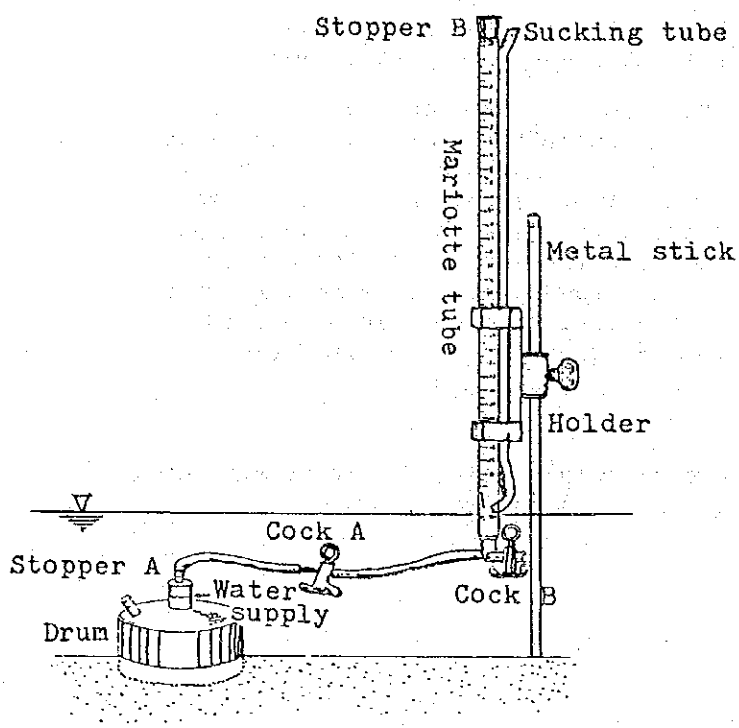
   2) Close the cock-B and remove the rubber stopper-A. Put the water in a suitable beaker, and fill the mariotte tube and vinyl tube with water in the beaker.

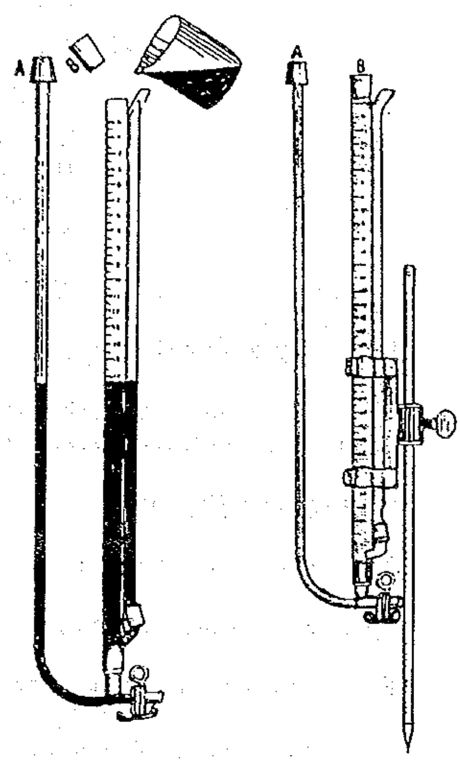
   3) Have the rubber stopper-A with a vinyl tube and the mariotte tube in your left hand, and stop the rubber stopper-B with your right hand.

4. Mariotte settlement:

1) Have the rubber stopper-A and the mariotte tube in your left hand, and set the holder to the metal stick.

2) Adjust the height so that align the upper rim of red color on mariotte tube and water surface of paddy field. And fix the holder.



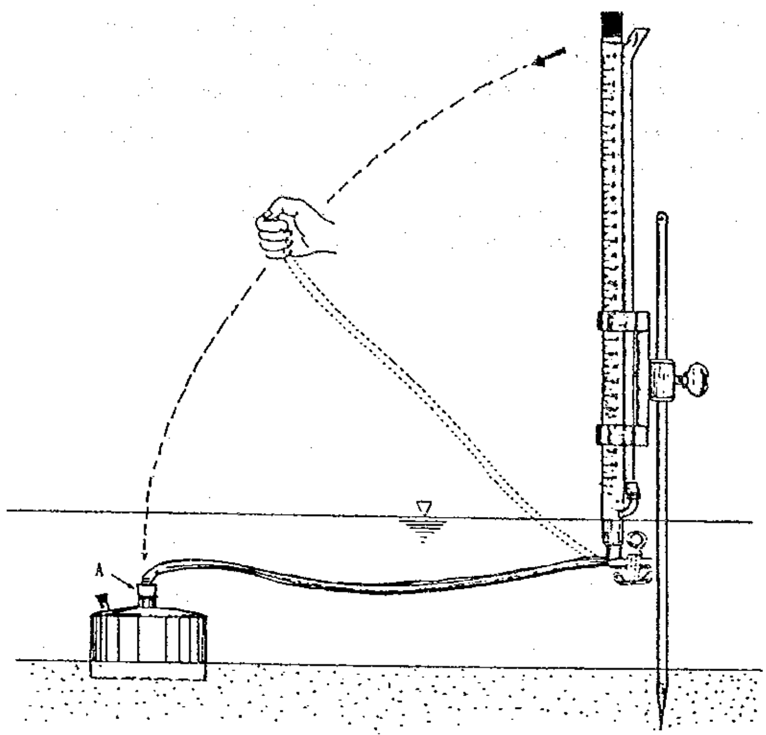


5. Connection between mariotte tube and drum:

1) Put the rubber stopper-A in the hole of water supply, as stopping a mouth of its rubber stopper-A with your finger so that water and air don't go in and out.

* Take care that air does not remain in the vinyl tube.

2) Open the cock until water in air sucking tube comes down at its bottom position. Finish preparation of measurement. Measurement can start by closing the cock.



6. Measurement:

1) Though start measurement by closing the cock, wait the reading record until bubbles in the mariotte tube go up at constant interval.

2) In mariotte method, measurement takes ten minutes. Read the graduation of start time and the graduation after ten minutes.

For example;

Graduation start time: 5.0
Graduation after ten minutes: 8.3
Balance of above, 8.3 - 5.0: 3.3
Leakage value (water depth): 3.3 cm/day

* Repeat measurement three times, and can get exact value by making sure no difference.

* In too much leakage value, measure it for one minute and determine by multiplying its value by 10.

* When measuring value is zero, refer to "4" of float method. When you wish to check whether large hole is connected by exterior and interior of drum, loosen the screw of holder and elevate the mariotte tube. Then, when bubble goes up in the mariotte tube, you should sink the drum over again.

7. Water supplement:

1) When use up water in the mariotte tube, remove the rubber stopper-A and lift up in the left hand. Remove the rubber stopper-B and fill the mariotte tube pouring water from it.

2) Make sure that fill the mariotte tube with water. Close the rubber stopper-A.

3) Lift up the water in the air sucking tube by opening the cock. And close the cock.

7 - 2 FIELD PERMEABILITY MODEL 420

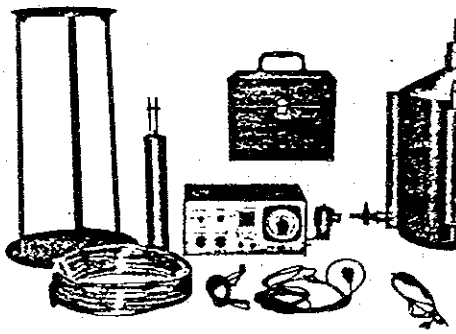
FIELD PERMEABILITY MEASURING INSTRUMENT

Model 420

This is manufactured under the instruction of the Civil Engineering Experiment Station, the Ministry of Agriculture and Forestory. A hole of optional depth is made in the soil on the field, and the constant head casing pipe of 10 cm diameter is set vertically. The reading of water supply with the progress of time is done by the automatic constant head system in which the signal of the constant head and automatic water supply value etc. are operated electrically using batteries and the amount of percolated water in course of time is known by reading the magnetic counter and the fall of water in the water supply tank with scaled tube.

* Consists of

1)	Casing pipe (5ø x 50 cm)	.....	1
2)	Water tank (10 lit.)	.....	1
3)	Switch board	.....	1
4)	Battery (24 V)	.....	1



The field permeability measuring instrument is designed to measure the water percolation in the field.

Make a hole of 10 cm in diameter and optional depth in field. Set a casing pipe vertically in the hole and pour water into the hole. When the water level is down, water is supplied automatically from the Marriotte tank. After the water supply reaches a stationally state (constant head), the coefficient of water permeability is calculated from the relation between the time and the amount of percolated water.

* <u>Specifications</u>

1) Casing pipe 1

50ø x 400 mm, made of polyvinyl chloride

Two water level electrodes are fitted to the casing pipe at any optional height and the water pour port is located at the upper part of it. When the water level in the casing pipe goes down, water is supplied into it at a signal.

2) Marriotte tank with stand..... 1

360ø x 350 mm, made of stainless steel

The Marriotte tank has a gauge pipe to measure the fall in water level and a sliding scale of its side.

3) Switch board 1

300 x 200 x 125 mm, a timer, a magnetic valve, a counter, plug sockets, switches and a DC battery charger are attached.

4) Battery 1

12V x 2 = 24V, packed in a wooden box

5) Accessories 1

includes cords and rubber tubes

* Instructions to use

The assembly and connections of the instrument are shown in Fig. 1.

1) Drill a hole of 100 mm in diameter and optional depth in the field and set the casing pipe vertically in the hole. It will stabilize the casing pipe to stuff sands, gravels and the like around the casing pipe.

2) Take measure of height (H) which is a distance between the lower end of the water level electrodes and the casing pipe in contact with the field.

3) Connect the hoses:

   Connect the hoses respectively to the water pour port of the casing pipe, outlet of the magnetic valve, inlet of the magnetic valve and the drain port of the Marriotte tank.

4) Wiring

   a) Set the switch at "off" position.

   b) Set the counter at "0" position.

   c) Connect the level jack with the level electrode of the casing pipe with using the specified cord.

   d) Connect the power source.

      In case of use at AC _____ V, connect to the AC _____ V plug socket with the specified cord.

      In case of use of DC 24V (battery), connect to the DC 24V plug socket with the specified cord.

      * Care should be taken to (+) and (-) of the battery.

   e) Set the time of the timer.

      Since the amount of percolated water within the time is calculated, set the timer to longer time for soils of poor permeability and to shorter time for soils of good permeability.

   f) Push the reset button in order to set the hand back to zero.

5) Supply water through the water supply port of the Marriotte tank and seal the tank. Adjust "0" of the sliding scale to the water level.

6) Pour the initial water with using a beaker so that water is filled beyond the constant head of the water level electrode in the hole.

7) Turn on the switch at AC or DC according to use power source.

8) When the water level goes down below the constant head due to the percolation of water, water is supplied from the Marriotte tank to keep the constant head.
The number of water supply within the time is displayed by the counter. Read the amount of percolated water within the pre-set time with the sliding scale, and calculate the amount of percolated water per water supply.

9) When the timer goes out of the pre-set time, even if water goes on supplying, the water supply is not counted.

10) Make the counter reset to zero and set the hand of the timer back with pushing the reset button, and the counter begins to operate again.

11) For soils of large initial percolation, more initial water should be supplied to maintain the constant state.

12) The coefficient of water permeability is calculated by the amount of percolated water after the percolation velocity reached the constant state.

13) Charging of the battery.

a) Connect the battery to the DC 24V battery charger with the specified cord.

b) Turn on AC _____ V power source. Then, turn on AC switch.

c) The charging is over in 5 hours. The battery should never be charged beyong 10 hours.

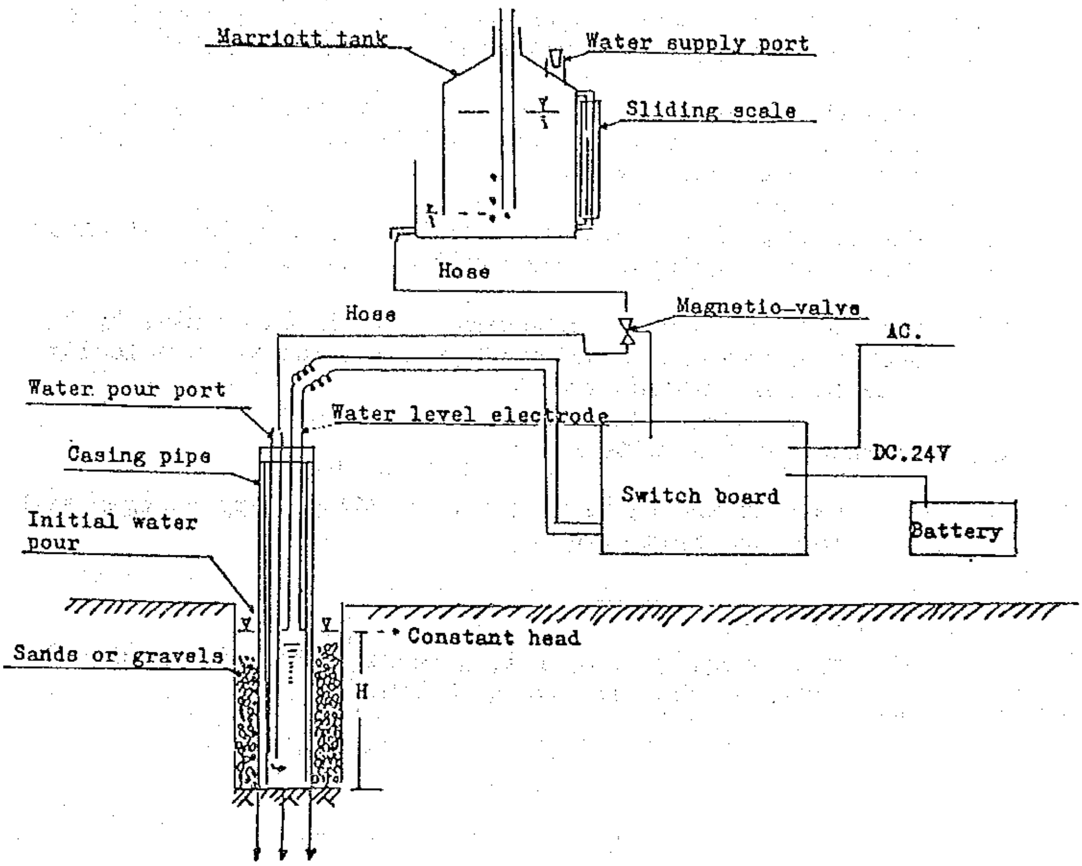


Fig. 1 : Systematic drawing of Field Permeability Measuring Instrument

7 - 3 PARSHALL FLUME

1. Summary:

A dam is popularly adopted for measuring of water flows in various cases such as: water flows at experimental flow-model-set in a laboratory, flows through pumps, at inspection of water-flow meter, water-flow into a water-field, at irrigation etc.

Its popularity is because that a dam has many practical points with it, and through a dam pretty precise and reliable measurement results can be obtained.

That is, when a dam is made and mounted in accordance with specified standards, flow-measuring can be easily made only at the front part of the dam without having any measuremental effect on results by other conditions.

Measuring operations are very simple and easy only to measure flows at the front of the dam, and a higher measurement accuracy can be available if a proper dam facility for a certain flow is prepared and used, and also if the formular for it is adopted.

By operating a water level recorder in combination with the systems, a flow-rate per hour can be measured and recorded automatically.

Parshall Flume is to be mounted in a slow flowing water-way such as water-field, stream, drainage, and make the water-day width narrower and volume of the flow larger enough to prevent soil or sand from accumulating in it, in order to get precise measuring results of water-flows.

In case of water field, there are very possibilities of relative positions between a water way and a water field, and of widths of water control-ditches.

From these possibilities it is not available to design out a unified mounting standards of Parshall Flume, but it is possible to measure flows by applying a experimented formular which is figured under Parshall, only if the mount conditions are strictly kept at each mounting as follows:

Conditions for mounting:

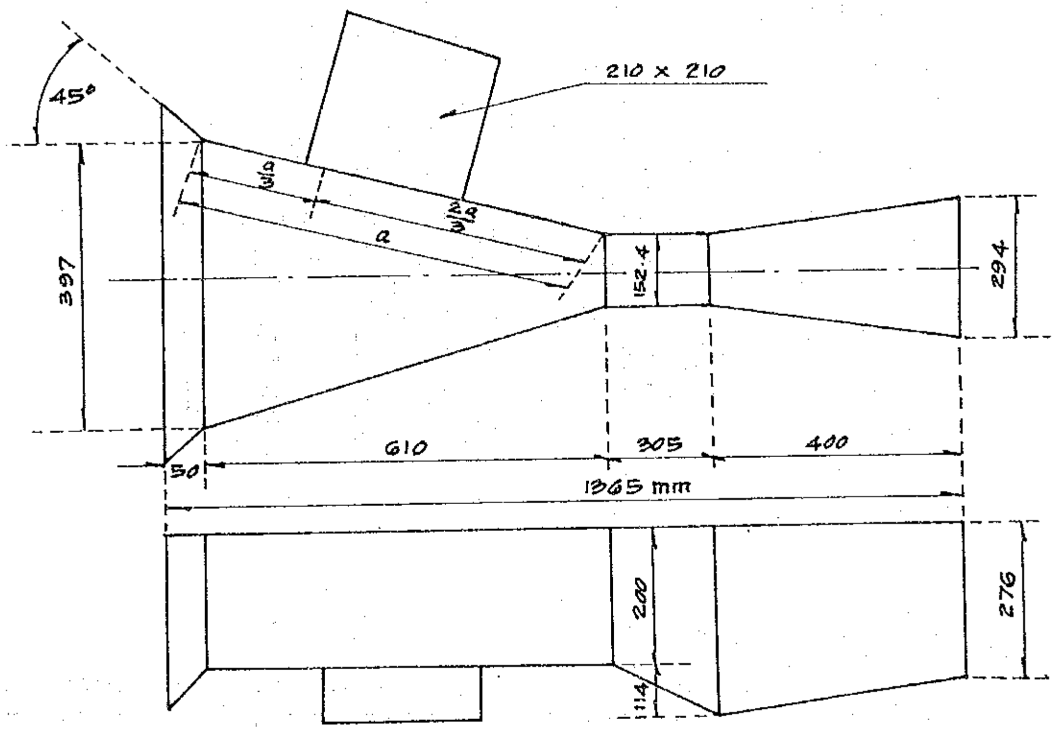
1. Take a very true level position of the level-floor of the Flume.
2. Take water equally into the whole of the Flume.
3. Keep a water level at out-let side not to be above the level of the level-floor of the Flume.

Consisting of:

1. Parshall Flume Water Level
2. Recorder (Clock One day or 7 day)
3. Float and Weight.

2. Composition:

This system is composed of Parshall Flume and recorder.

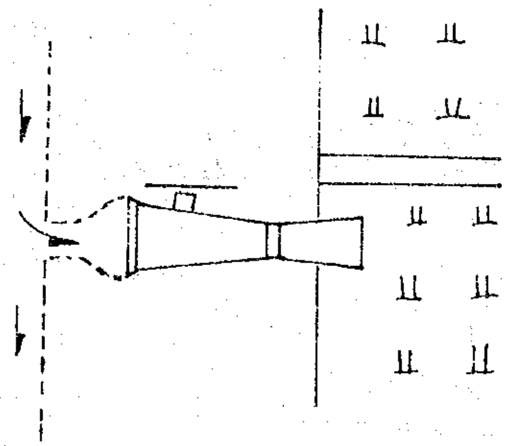


2 inch TYPE

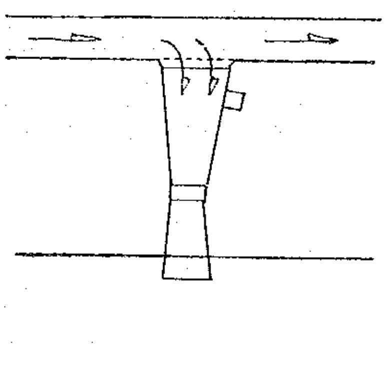
3. Way of mounting

A. Mounting of Parshall Flume

1) In case that the length of the water control ditch is not long enough and its width is not wide enough, make the width wider and set the Flume with its outlet part extended into the water field, as per Fig.



2) In case Parshall Flume takes a right angle with the water control ditch as per Fig.2, it is not preferable position between each other, because water flow always into the Flume with direction against the one-side of it, but, if flow-velocity in the water control ditch is not high, measuring errors caused by this positioning can be scarecely expected.



3) Adjustment of water-flow volume can be made at the front part of the Parshall Flume, and be more preferably, it may be made at the head part of the water control ditch.

4) The following steps for mounting should be done:

   a. Positioning the mounting location and dig up soil into a hole larg enough for the dam.

   b. Put a mark of the highest surface level of the water-field on the rear part of the dam which is the out-let part extended in the water field.

   c. Drive approx. 4.5 cm dia. piles into at the points P & Q as per Fig.1. At first, pile at the point Q so that the floor of the rear part of the dam keep the highest water level of the water field, next, position the dam and drive a pile at the point "P" for the dam to take level.

      Precise level can be obtained only by shifting the dam slightly backward or forward.

      Take level of right and left direction of the dam by piling at the point "g". A water-level must be used for this.

      Put soil around the pile up to the same height of the pile and make them solid status.

   d. Set the dam in the right position and put soil under the dam and make them fixed firmly enough.

   e. In case the out-let part of the dam is to be extended into and in the water field, the dam will be easily to be relax from fixing, so, drive another four piles just beside the both sides of the dam and fix them firmly with the dam by fixing the piles with bars.

B. Mounting of recorder:

Have the float afloat in the water tank and fix tightly the mounting base and set the base board on it, and take and keep true level of it.

If level of the base is inadequate, some unexpected frictions with the float during its moving will be possible.

4. Adjustments of recorder

Adjustments of pen positions:

There are two methods of pen position adjustments. One is to adjust pen positions, having water flow through the Flume. The other is to adjust pen positions, having water in the tank but not flow through the Flume.

Both methods require a point-gauge or a slide caliper for precise adjustment.

In the former method, flow rate must be kept in constant and unchanged for correct adjustment, at first, measure a depth from a optional point on the out-let to the floor of the Flume, and name this depth "a", next, measure a depth down to the water-face level and name the depth "b". After measuring repeatedly these depths, make means (a-b) of the depths measured and this means a-b shows water level during that water is flowing through.

Consequently adjust the pen to take a-b values by moving the pen-holder upperward and downward.

In the latter method, water the tank upto and just above the level of the floor and close the out-let so that water does not flow out, and adjust the pen to take "0" position.

Chart speed

7 days	12 mm/H
One day	4.35 mm/one day

7 - 4 SOIL ACTUAL VOLUMENOMETER

SOIL ACTUAL VOLUMENOMETER

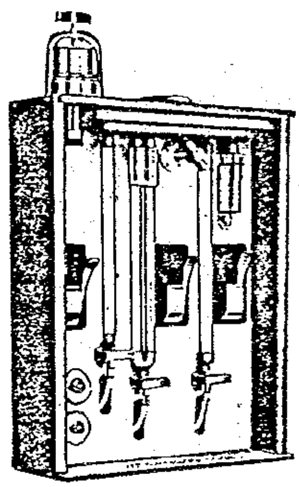
Model 100

(Three Phase Distribution Measuring Instrument)

This instrument measures measures the actual volume (volumetric sum of soild phase and liquid phase) of the soil sample collected or filled up by sampling cylinder with whole volume of 100 ml. Three phase distribution of soils such as moisture ratio, porosity, and solid phase ratio can be derived from the relation between the said value (V) the weight (W) and the specific gravity (d). It is noteworthy that the measurement can be completed within 1 or 2 minutes with high accuracy without any thermal dehydration.

* Specifications

Sample capacity:	100 ml
Measuring range:	25 - 100 ml
Accuracy:	± 0.1 ml
Dimensions:	40 x 17 x 55 cm
Weight:	12 kg
Accessoreis:	Sample cylinders (6 pcs. with case) ..... 1 set



* <u>Principle</u>

1) The soil is a substance having a grained structure, and consists of three phases, i.e., the solid phase, the liquid phase and the air phase, as shown in Fig. 1. The actual volume means the total of the volumes of the solid phase and the liquid phase. This unit is an instrument measuring the actual volume of the soil directly.

2) When the actual volume is known, the fundamental physical properties of the soil can be obtained very simply and systematically one by one, as shown in Fig. 3, such a method is called the actual volume method.

3) The instrument has a structures shown in Fig. 2; measuring tubes and U-shaped tubes are all made of acrylic resin, and the metal parts are of alloy or brass, and they are correlated. The measuring range is from 25 ml to 100 ml, and the accuracy is ±0.1 ml.

4) The sample cylinder can be commonly used for not only the actual volumenometer but a soil pF measuring apparatus and a soil permeability measuring apparatus; it has an inner diameter of 50 mm, a height of 51 mm, and the inner capacity of 100 ml; it is made of metal and has the weight of about 80 g. For collecting the soil in nature, a soil sampler (optional parts) is used. (Refer to Fig. 4).

* <u>Operation</u>

1) Turn the cock K to the left to open.

2) Open the cock K1 to adjust the liquid surface at the center of the measuring tube B, and close K1.

3) Open the cock K3 to adjust the liquid surface at the point of 60 ml in the measuring tube A, and close K3.

4) Open the cock K2 to adjust the liquid surface at the measuring point in the lower part of the U-shaped tube, and close K2.

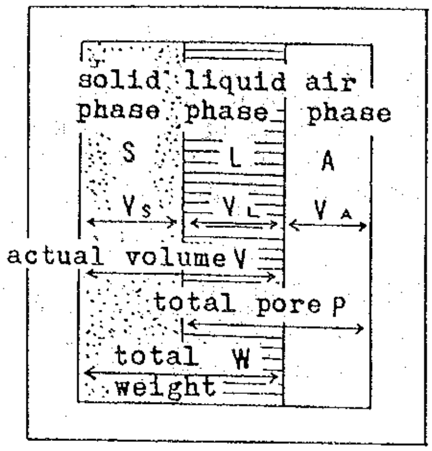


Fig. 1

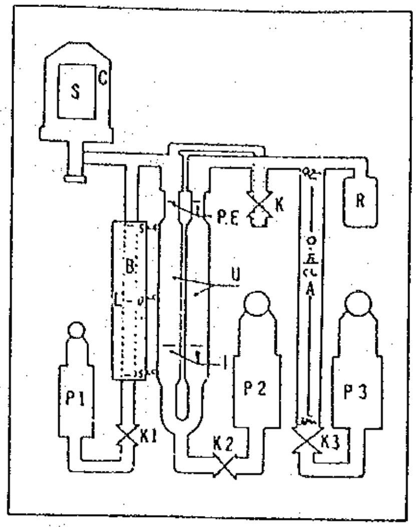


Fig. 2

5) Remove the cover C of the sample chamber, put a basin, a net plate, a sample cylinder, and test pieces of 60 ml (10, 20, 30 ml) of the instrument into, and close the chamber tightly.

6) Turn the cock K to the right to close, open the cock K2 to raise the liquid surface in the U-shaped tube, and when the surface reaches the upper point E, close K2.

7) Adjustment of point 0 is completed when all of the liquid surfaces are at point E.

   a) When the right liquid surface is higher, lower the liquid surface of the micro tube B.

   b) When the left liquid surface is higher, raise the liquid surface of the micro tube B.

   *Note: This operation is performed by opening K2, lowering the liquid surface in the U-shaped tube to the lower observation point 1, and opening K.

8) After adjusting point 0, adjust point 0 of the sliding scale L to the liquid surface of the micro tube B.

9) Open the cock K2, adjust the liquid surface of the U-shaped tube to the lower observation point 1, close K2, and open the cock K.

10) Take the test pieces and the sample cylinder out from the sample chamber and set the collected soil as removing the cover of the cylinder. At this time, confirm whether the rubber packing of the sample chamber is clean or not.

11) Open the cock K3, set the liquid surface of the measuring tube A at the predicted value, and close K3. Close the cock K, open the cock K2, and raise the liquid surface up to the upper point E in the U-shaped tube. When the difference of the liquid surface at the upper point is large, adjust the liquid surface of the measuring A and when it is small, adjust the liquid surface of the tube B.

* Note: When lowering or raising the liquid surface of the measuring tube A or B, be sure to lower the liquid surface of the U-shaped tube, open K and then adjust.

12) When the liquid surface is fit at the upper point E in the U-shaped tube, the value is the actual volume of the soil in the sample chamber.

$$V = A + B \text{ or } V = A - B$$

where: V : actual volume of soil sample

A : measuring tube A

B : measuring tube B

* Note 1 : Don't open the cock K, the sample chamber or cocks of K1 and K3 when keeping the liquid surface of the U-shaped tube raised (the whole system is under a compressed state).

* Note 2 : When measuring, avoid the direct sunshine as much as possible (for keeping the whole system at an equal temperature as much as possible).

* <u>Soil Structure and Term</u>

1)	Total volume	Vt
2)	Total weight	W
3)	Actual volume	V
4)	Weight of solid phase	S = W - M
5)	Volume of solid phase	Vs= (W - V)/(d - 1)

6)	Weight of soil water	$M = Vl$
7)	Volume of soil water	$Vl = V - Vs$
8)	Volume of soil air	$Va = 100 - V$
9)	Porosity	$P = 100 - Vs$
10)	Solid ratio	$Sv = Vs$
11)	Water ratio	$Mv = Vl$
12)	Air ratio	$A = Va$
13)	Water saturation percentage	$H = Mv/P \times 100$
14)	Air percentage	$U = 100 - H$

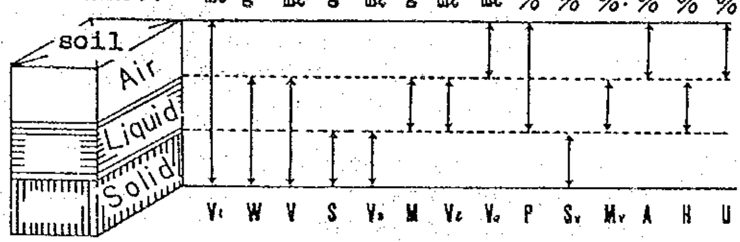


Fig. 3

15)	Water content by wet soil	$Mm = M/W \times 100$
16)	Water content by weight	$Mo = M/S \times 100$
17)	Specific gravity	$d = S/Vs$
18)	Apparent specific gravity or Bulk density	$do = S/100$
19)	Actual specific gravity	$dm = W/V$
20)	Water-solid ratio	$Ls = Vl/Vs$

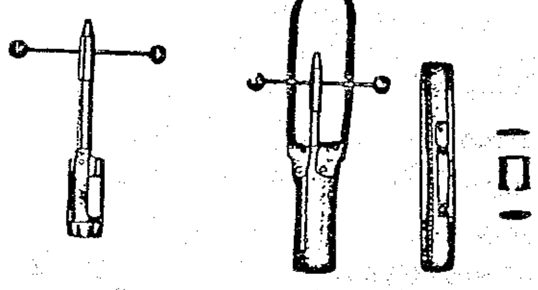


Fig. 4: Soil Sampler & Cylinders

7 - 5 pH METER MODEL HM-7B

C O N T E N T

SPECIFICATIONS

Measuring range	: pH0 - pH14, 0 - ±700mV 0 - ±1,400mV by displacing zero
Minimum graduation	: 0.1pH, 10mV
Accuracy	: pH:±0.03pH, ORP:±10mV
Temperature compensation	: 0 - +100°C automatically
Output	: voltage : 5mV/pH
Power source	: AC 220V, 50, 60 Hz (0.6VA), DC UM-3 (8 pcs.)
Dimensions	: approx. 310 (w) x 110 (h) x 180 (d)mm
Weight	: approx. 2 Kgs.

Accessories

Three-in-one electrode GST-155C	1 pce.
Standard neutral phosphate solution pH-6.86, 500ml	1 bottle
Standard phthalate solution pH-4.01 500ml	1 bottle
Saturated KCL solution 100ml	1 bottle
Thermometer (0 - +100°C)	1 pce.
Electrode holder	1 pce.
Glass beakers, 30ml	3 pce.
Instruction manual	1 copy

CAUTION WHEN MEASURING

(1) When inserting the electrode plug into the terminal, always ensure that it is pushed in completely. If it is not pushed in completely, measurement may not be possible due to poor connections.

(2) Although it is not always necessary to connect the ground wire to the ground terminal, if the indications vary when the instrument is touched, connect one side of the ground wire that is provided, firmly to ground and the other to the ground terminal.

(3) When measuring strong alkaline fluids, take into consideration the fact that it will take longer for the electromotive force in the glass electrode to stabilize that when measuring neutral or acidic fluid. Also, wash the electrode carefully with water after completing measurement as it is necessary that all traces of alkali are removed from the membrane portion of the electrode. In this case, the effectiveness of washing with water can be increased by dipping the electrode into a 1/10 N solution of hydrochloric acid and rinsing with water.

(4) Refrain from using charged items (polyethylene receptacles, chemical fiber clothings, etc.) as the indicator needle will waver if they are moved near the electrode.

(5) As errors will arise if the electrode is not thoroughly washed when changing the fluid to be measured, wash with distilled water at each change being careful not wipe when removing water by applying filter paper.

(6) When the glass electrode is left in the open for several days or more, (when the tips are allowed to dry), there will be cases of extremely slow indication and unstable potentials resulting in increased errors. In these cases, immerse in distilled or pure water for a period of 24 hours prior to use.

(7) The saturated KCl solution in the reference electrode must be always in saturated condition at the temperature of the solution to be measured. It is also necessary that the inner electrode be completely submerged. When KCl solution is low, or when no KCl crystals can be observed, replenish with the KCL solution supplied, according to the instructions enclosed.

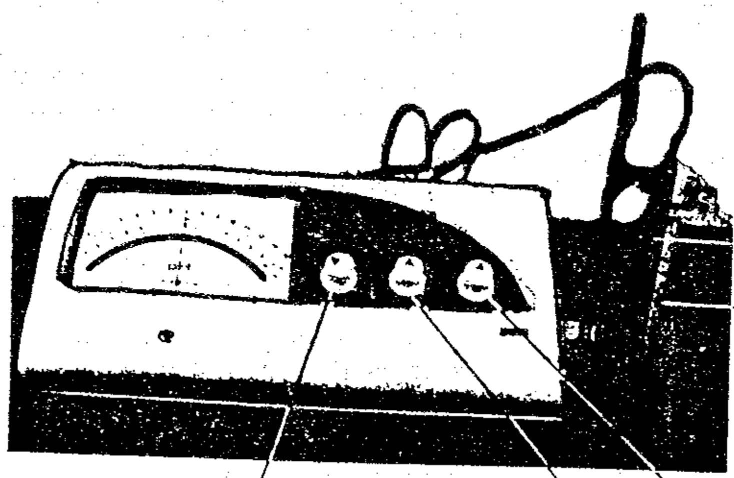
(8) As the reference electrode terminal is automatically connected internally when the plug is removed from the glass electrode terminal, by using this as an mV meter, this method is used in carrying out zero calibration.

(9) When using this as an mV meter, the "SENS ADJ." knob, and A.T.C. electrode circuit are disconnected and will therefore have no effect on the measurement.

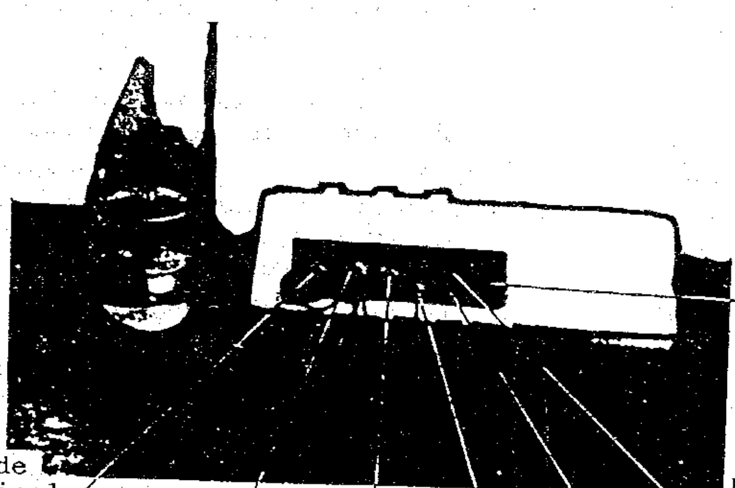
Note:

When cleaning the instrument, use gauge or some other soft material moistened with a dilute soap solution. Never use thinner, toluene or the like.

NAME AND OPERATION OF EACH PART



Front Panel



Rear Panel

Electrode	Three-in-one electrode which is composed of glass electrode, reference electrode and automatic temperature compensation electrode (called A.T.C. electrode)
Glass electrode terminal	Terminal to connect the glass electrode lead to the indicator
Reference electrode terminal	Terminal to connect the reference electrode lead to the indicator
A.T.C. electrode terminal	Terminal to connect the A.T.C. electrode lead to the indicator
"5mV/pH" output terminal	Terminal from which an output voltage of $\pm$35mV can be obtained in relation to the full scale reading.
Electrode holder	Holder to hold the electrode and thermometer in place
Electrode stand	The stand in which the electrode and holder are inserted and held in measuring position.
Terminal	Terminal to ground the indicator case
Range switch-over knob	
"PH"	Range to use as a pH meter
"MV"	Range to use as a mV meter
"BAT"	Range to check the battery condition in case of battery in use. If the indicator points "BAT GOOD" or over, the battery is in good condition. Otherwise, exchange the battery.
"ZERO ADJ." knob	Knob to first adjust and compensate for the unsymmetrical difference in potential (irregular potential difference) or the glass electrode.
"SENS. ADJ." knob	Knob to adjust and compensate for the potential gradient of the glass electrode to enable the indicator to show the true pH value.

HOW TO MEASURE

1. Measuring pH value

   The following sequence to be followed when measuring the pH value.

   (1) After installing the electrode stand with use of the coin or the like, place the electrode and the thermometer in the electrode holder.

   (2) Fasten the electrode holder with the electrode installed to the electrode stand.

   (3) Connect the each of plug of the electrode to their respective terminal. At this time, before the electrode in the solution, remove the rubber cap and the cap from the KCl replenishing inlet.

   (4) When the meter is powered by the AC, put on the AC side of the slide switch on the back panel, and plug the power cord into the receptacle.

(5) When measuring in the field, turn off 4 pcs. of rubber foot, put the 8 pcs of "C" size cell into the cell holder case, and turn the "BAT-AC" switch to the "BAT." position.

(6) Completely immerse the spherical portion of the electrode into the standard neutral phosphate solution (pH-6.86/25°C), and the instrument will be in operating condition after about 1 minute.

(7) The "ZERO ADJ." knob to be adjusted to indicate the true pH value at the temperature of the standard solution. (The pH values at each temperature of the standard solution are noted on each receptacle.)

(8) After completing adjustment, remove the electrode from the solution, wash with distilled or pure water, remove water droplet by lightly applying filter paper (do not rub) and immerse in a standard phthalate solution (pH-4.01/25°C) or standard borate solution (ph-9.18/25°C) of the same temperature. Although the needle may quiver or swing to the extreme right at this time, continue with the measurement as this is not abnormal.

(9) Adjust the "SAN.ADJ." knob so that the indicator will show the correct pH value at the current temperature of the standard solution.

(10) As this operation completes all adjustment wash the electrode throughly and remove the water drops remaining. The pH value of the solution being measured may now be read directly from the indicator.

The proceeding process is called the 2 point adjusting method and is used each time a new electrode is used, when the electrode has not been used for some time, or when a particularly high degree or precision is required.

As the potential difference of the glass electrode will not vary to any extent within a short period after the 2 point adjustment has been carried out, operation (6) and (8) only may be carried out for a while by simply confirming that the position of the "SENS. ADJ." knob is unchanged and, though operation (9) and (10) are omitted, measurement of about 0.1 pH precision may be made.

An even more accurate reading may be obtained at this time by carrying out operations (6) and (8) on a standard solution with the closest pH value to the solution to be measured, in place of the standard neutral phosphate solution. (This is called the 1 point adjusting method.)

After completing the 2 point adjustment, a pH value with a discrepancy of within 0.1 pH can be read directly from the indicator on solution that may be of a different temperature from the standard solution by the operation of the A.T.C. electrode, when the automatic temperature compensator is used.

Excellent results can be obtained particularly in solution with small buffer effects (such as tap water, etc.) if, in addition to washing the electrode thoroughly, its submerged portion is washed with a portion of the solution to be measured. As errors in reading of the pH value will result due to the effects of foreign matter adhering to the electrode, care must be taken when measuring with an electrode that has been incompletely washed.

When measuring values of below pH2 and above pH11, use standard oxalate solution (ph-1.68/25°C) and standard carbonate solution (pH-10.02/25°C) respectively in place of the standard phthalate solution, when carrying out the 2 point adjustment process. However, caution must be taken as standard solution is easily changeable in contact with air.

2. Measuring oxidation reduction potentials.

(1) Placing the platinum and reference electrodes into the electrode holder, attach to the electrode stand and operate the instrument by turning the function knob to "mV" position. Do not insert the plug of the platinum electrode lead into the terminal at this time.

(2) By means of the "ZERO ADJ." knob, adjust the indicator to exactly 0 mV. When it becomes necessary to measure potential differences of over ± 700 mV, up to -1,400 mV can be measured by setting to + 700 mV, and up to + 1,400 mV by setting to - 700 mV.

(3) Connect the reference electrode to the reference electrode terminal and the platinum electrode plug to the glass electrode terminal.

(4) If the electrode is now submerged in the solution to be measured, the potential difference generated may be read directly from the mV graduation. If the platinum electrode used is the type HP-105 platinum electrode which is sold separately, it can be connected directly but, when using other optional electrode, an adaptor must be attached to the glass electrode terminal.

(5) When carrying out "0" adjustment, remove the platinum electrode plug from the glass electrode terminal. If an adaptor is used, this must also be removed. When the plug is removed, the electrode terminals will be automatically connected internally.

(6) To obtain oxidation reduction potential Eh from the measured value, add the potential of the reference electrode to the measured value.

The potential of the reference electrode between 0 to 60°C is as shown in the following table.

Saturated Silver chloride electrode			
Type of electrode HS-205C, HS-205S, PS-115C			
Temp. (°C)	Potential (mV)	Temp. (°C)	Potential (mV)
0	223	30	194
5	218	35	189
10	214	40	184
15	209	45	179
20	204	50	173
25	199	60	162
PS-115C is of combination electrode			

Also if before measuring the reference electrode potential, its zero setting is shifted by means of "ZERO ADJ." knob in relation to the temperature at which measured, the trouble of adding values later will be avoided.

3. Disposition after completion of measurement

After completing measurement, turn off the power by turning the function knob to "OFF" position and carry out the following step.

(1) Rinse the electrode.

(2) Store the electrode in a saturated potassium chloride solution.

(3) Care must be taken to leave the "SENS ADJ." knob in its present position and not to turn it at random as this would necessitate readjustments later.

(4) When not using for long periods of time, remove the electrode from the stand and cover the instrument with the vinyl cover provided.

4. Uses for the output

The pH value or mV (potential difference) can be recorded in the following manner.

The output voltage of ± 35 mV can be obtained from "5 mV/pH" between terminals full scale reading. Therefore, when measuring with an EPR type recorder, short out the input, adjust "0" setting of the recorder, and set the range to 50 mV. Voltage of 5 mV per 1 pH can be obtained at this time and the same value as that indicated on the meter is recorded.

1. Method and care in use

(1) Immerse the membrane portion of the electrode in water or standard solution prior to use. This is especially necessary when the electrode is left in the open for long periods of time. When the reference electrode is also left in the open for long periods and the tip become dried, immerse in saturated Kcl solution before using.

(2) Rinse well with pure water after use. If the portion that was contaminated by the solution previously measured cannot be removed with water, wash with suitable solution of o.1N hydrochloric acid (approx. 3%), chromate washing solution, soap, organic solvents, etc.. Refrain from rubbing the electrode membrane when washing as this membrane is easily damaged. Also, use this same procedure when the electrode is in soiled condition prior to use.

CARE AND REPLACEMENT OF THE ELECTRODE

Select a suitable electrode from the following table for use with the model HM-7B pH meter according to the purpose for which it is to be used, such as the type of solution to be measured, the temperature, range of measurement, etc.

Reference electrode equivalent of the HM - 7B glass electrode

Type of electrode	Applications	pH range of direct reading	Usable temp. range (C)	Amount of sample required (ml)	Equivalent reference electrode
GST-155C	For normal temperature.	0 - 13	0 - 60	1 ml	
GS-125C	For normal temperature.	0 - 13	0 - 60	1 ml	
GS-135C	For containers such as test tube etc.	0 - 13	0 - 60	1 ml	
GS-195C	For microscopic quantity	0 - 13	0 - 60	0.5 ml	
GS-8C	For microscopic quantity of solution such as blood etc.	0 - 11	0 - 60		
HGS-2005	For normal temperature.	0 - 13	0 - 60	20 ml	HS-205C, HS-205S HS-305D, HS-305DS
HGS-4005	For high alkaline content	0 - 14	0 - 60	20 ml	HS-205C, HS-205S HS-305D, HS-305DS
HGS-6005	For high temperature	0 - 125	0 - 100	20 ml	HS-605C
HGS-9007	For small amount	0 - 125	0 - 60	3 ml	HS-907
HGS-9005	For microscope quantity	0 - 125	0 - 60	0.1 ml	HS-905
HGS-5005	For microscopic quantity of solution such as blood, etc.	0 - 13	0 - 60	0.1 ml	HS-205C, HS-205S HS-907

(3) When the solution in the electrode is dirty or when the internal KCl crystals have disappeared, replace with a new supply of saturated KCl solution, and when the internal supply of solution is low and the internal electrode is exposed, replenish with a new supply of solution.

The saturated KCl solution in the electrode must be full at all times either when in use or in storage.

(4) When in use, keep the inlet hole open at all times as correct reading cannot be expected if closed, and this is especially true when the solution temperature changes during measurement. However, close the inlet hole in the HC-205S and in the electrode when it is being used in the factory attached to a retainer.

(5) As errors in reading will arise if the KCl crystals overflow and adhere to the walls of the supporting tube and to the electrode cap, the reference electrode must be kept clean at all times.

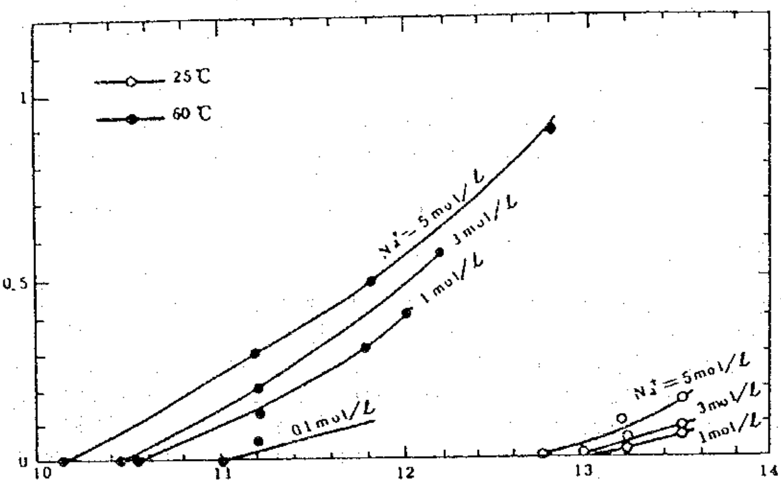
2. Method of use in special solution.

(1) Strong acids and alkaline fluid.

a. Although the relation between the EMF and pH of the glass electrode has a linear characteristic near neutrality, it deviates from this linear characteristic in strong acids and alkaline solution.

This deviation in strong acid and alkaline solution is called acid errors and alkaline errors of the glass electrode. The higher the density of fluorine ions and chlorine ions in the solution, the greater the acid error, and the higher the density of lithium and sodium ions, the greater the alkaline error.

The range of direct pH readings possible, as indicated in the table on electrodes, is the range within the linear characteristic of EMF and pH of the glass electrode. Our glass electrodes have linear characteristics with a chlorine ion density of 1 mol per litre at normal temperature. Compensating curves for the alkaline errors in GST-155C and HG-2005 are as indicated in the following graph. The true values may be obtained by adding the compensating values of the vertical factor to the glass electrode reading.



pH meter reading

Compensating curves for the alkaline errors
in the GST-155C and HG-2005

b. As a longer periods of time is required for the EMF of the glass electrode to stabilize after measuring strong alkaline solution than after measuring neutral or acidic solution, this must be taken into consideration when carrying out measurements. It is also necessary to wash the electrode thoroughly after measuring and to remove all traces of alkaline from the electrode membrane.

(2) High and low temperature solution

a. The life of the electrode will be shortened if used in temperature above those prescribed in the electrode table, and meter readings will be slow and unstable if used below those ranges.

b. When the glass electrode is subjected to sharp changes in temperature, its EMF will not immediately follow suit and as time is required for the temperature to equalize, allow sufficient time for the indications to stabilize before taking readings after sudden temperature change have been applied.

(3) Non-buffer solution

Measuring the pH value of distilled water and ion exchange water is normally thought to be meaningless. However when it does become necessary to do so, air (mainly carbon dioxide) must be sealed out to eliminate its effect, the solution must be poured at an even rate, and the measuring receptacles be standardized, etc. before carrying out measurements. Even in this case, it is difficult to obtain a reproduction of the measured values in solution of this type and it is also difficult to argue as to its absolute value.

(4) Non-aquerous solution

a. Carry out measurements in the same manner as in the case of water solutions.

b. However, the value of the solvents are only relative as comparisons cannot be made with the measured value of water solutions.

(5) Solution containing hydrogen fluoride

Glass electrode basically cannot be used in this type of solution as glass is dissolved in hydrogen fluoride.

Next, in relation to reference electrodes, as in normal solution with buffer action no potential difference arises between the immersed portion of the reference electrode and the solution being measured, stable measurements are possible but complicated errors in potential difference arise in the following solution with accompanying unstable readings, slow responses and errors.

(1) Strong acids and alkaline solution.

(2) Solution with weak buffer action such as pure water as described in article (2) and (3) on glass electrode, not only must the reference electrode be considered but the method of measuring must also be considered.

(3) Non-aqueous solution

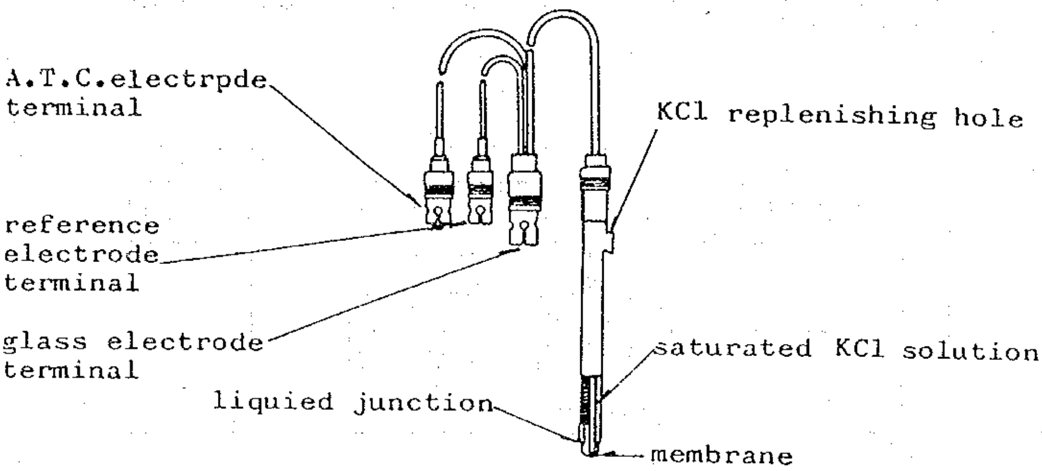
The sleeved type should be used in these cases and must invariably be used especially when the density of the non-aqueous solution is high. When readings cannot be stabilized, use a double junction type with the out compartment containing the same solution as the solution to be measured, but containing potassium chloride.

(4) Solution that should not react with chlorine ions.

In connection with solution that react with chlorine ions such as silver nitrate and latex solution, always use the double junction type with a saturated solution of potassium nitrate or sodium nitrate in the outer section (the side in contact with the solution being measured) to prevent or lessen the formation of sediments. Also, if for experimental purposes, another method is to use an ising glass bridge.

(5) Suspended solution

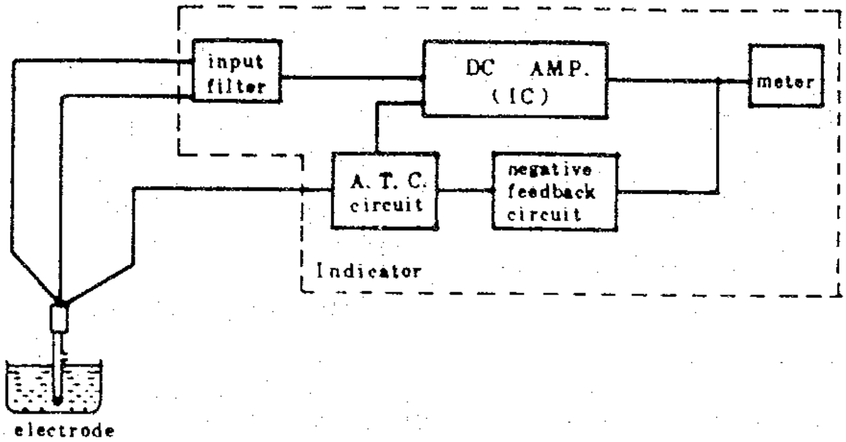
In this type of solution it may be necessary to clean or replace the immersed portion of the electrode from time to time as it is easily clogged with the suspended substance in the solution.



Structure of Three-in-one electrode

STRUCTURE

The indicator is composed of a direct current amplifier using IC's, for stable amplification of the potential (direct current) generated in the electrode, and a part of the output is fed back negatively to the input of the indicator to increase stability. However, a circuit to change the gain of the amplifier in accordance with changes in the temperature of the solution being measured (automatic temperature compensating circuit) has also been inserted in between.



Exchange of the battery and fuse

Exchange of battery

Turn to the left and pull out the rubber feet on the back panel, take the bottom cover, and exchange the battery

Exchange of fuse

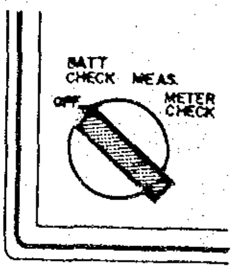
Fuse holder is attached inside of the meter, Use fuse of 0.5A.

7 - 6 pH METER MODEL HM-1K

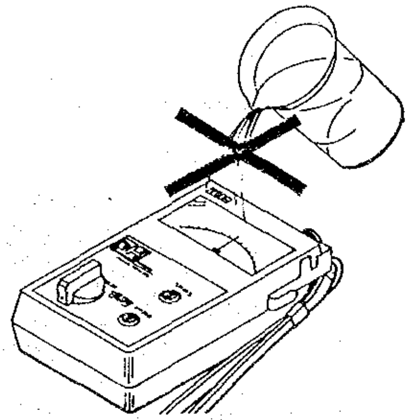
CONTENT

CAUTION

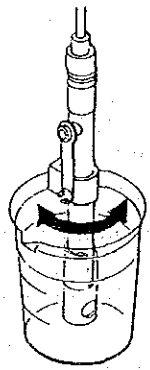
After use, set the change-over switch to "OFF" position.



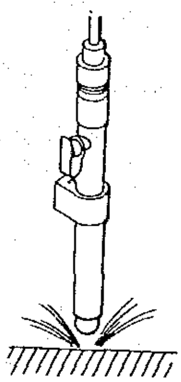
Do not spill the solution or water on the instrument



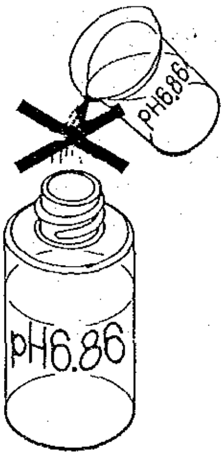
Rinse the electrode thoroughly with pure water etc.

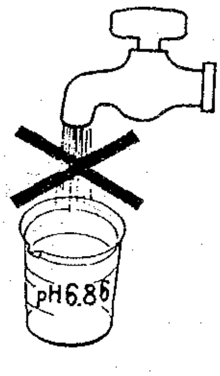


As the electrode is easily damaged, care must be taken of handling it.



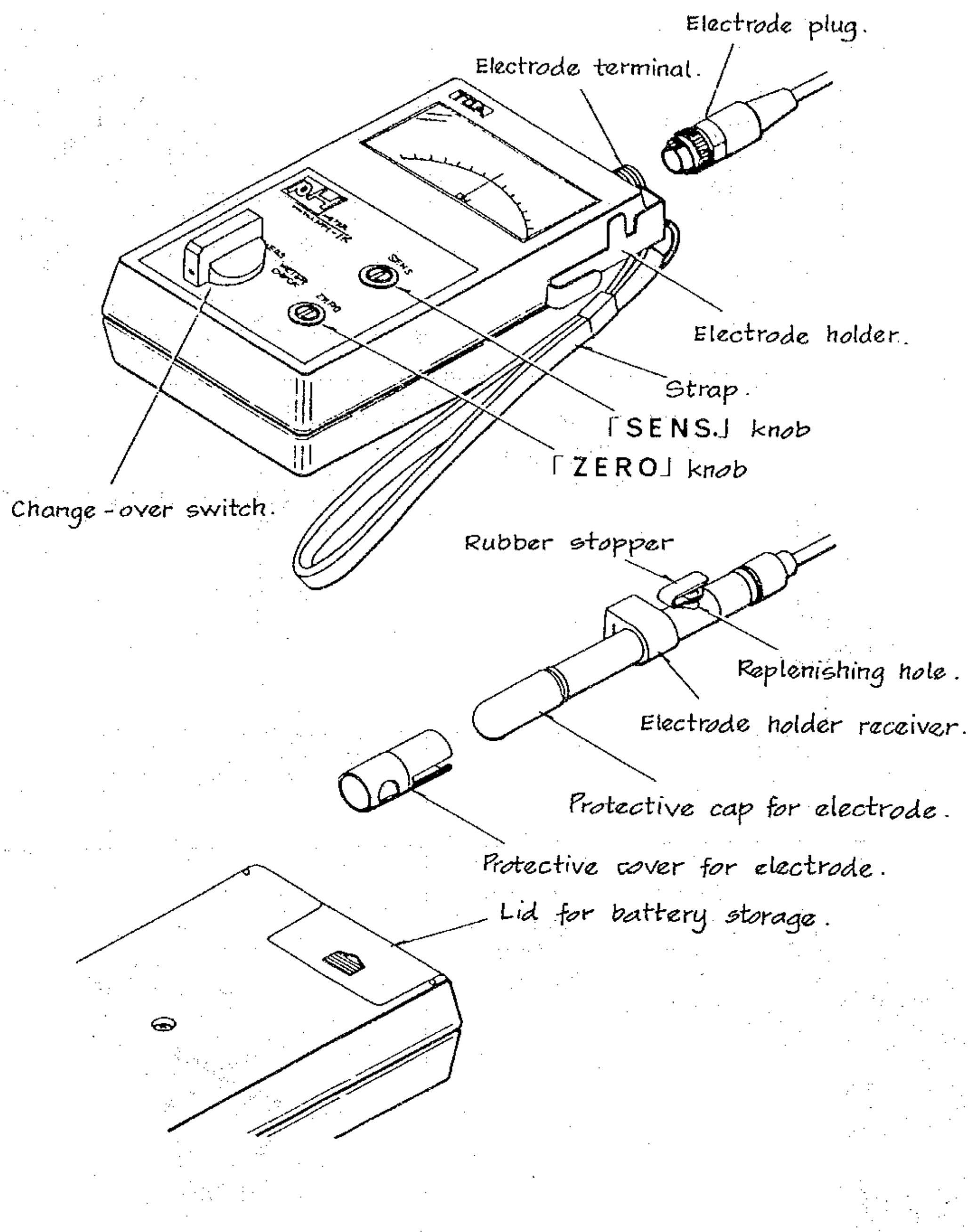
The used standard solution should not be put back into the stock solution bottle.





The standard solution is to be used without diluting.

1. NAME OF EACH PART

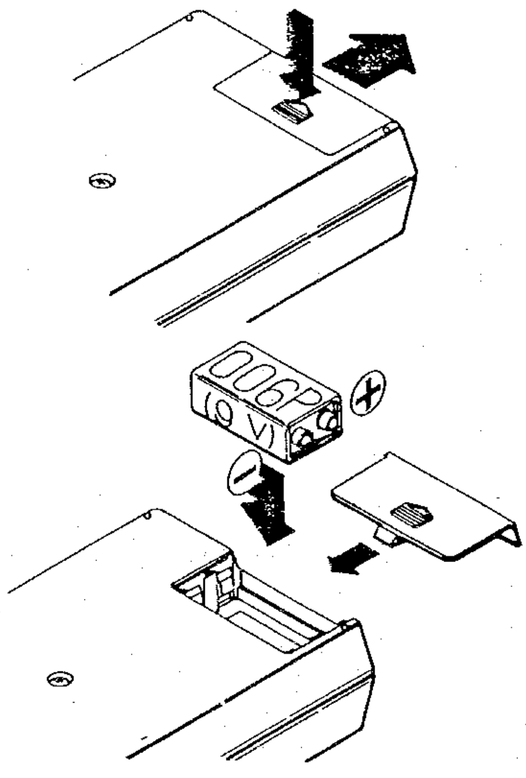


2. SPECIFICATIONS

Measuring range	:	0 - 14 pH
Minimum graduation	:	0.2 pH
Accuracy	:	± 0.1 pH
Temperature compensation	:	0 - 100°C, automatically
Power source	:	dry cell 006 P (DC 9V) 1 pce.
Dimensions	:	approx. 176 (d) x 104 (w) x 44 (h)mm
Weight	:	approx. 500 g

3. HANDLING

How to load the battery



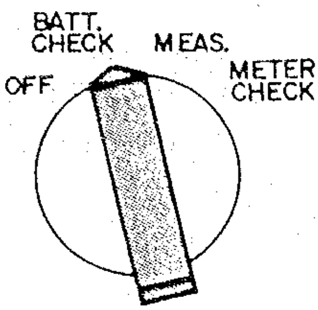
Push the lid for battery strongly, and it will be dislocated to the direction of the arrow.

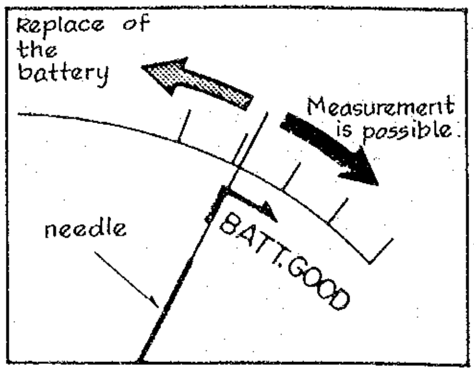
Put the battery, confirming the direction of battery and polarity of + , -.

Do not use the batteries other than 006 P (DC 9V).

When the instrument is not used for long period, remove the battery out.

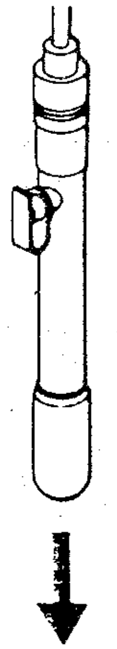
BATTERY CHECK



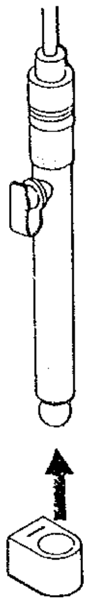


Turn the change-over switch to "BATT. CHECK" position.

PREPARATION OF ELECTRODE

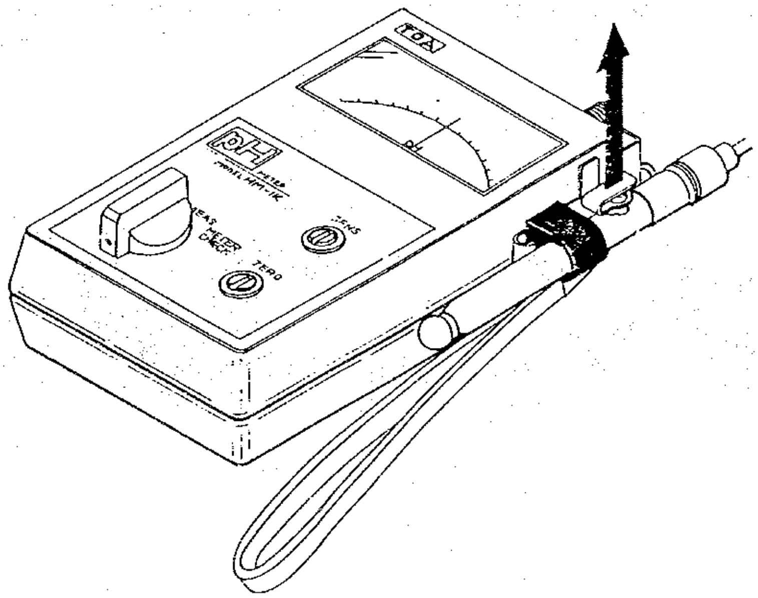


Take off the protective cap for electrode membrane.



Attach the electrode holder receiver.
Insert the electrode holder receiver through the electrode after wetting it.

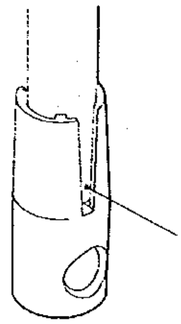
Attach the electrode holder receiver so that the KCL replenishment hole of the electrode is faced to upside when it is attached.



Attachment of protective cover for electrode.

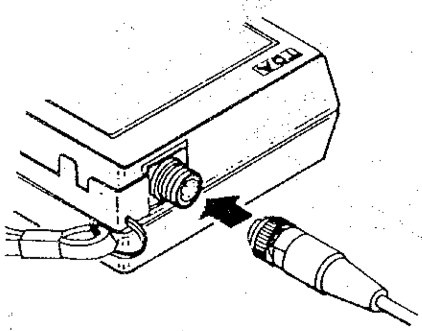
Attach the protective cover for electrode to the electrode.

Match the liquid junction of the electrode to the slit of the protective cover.

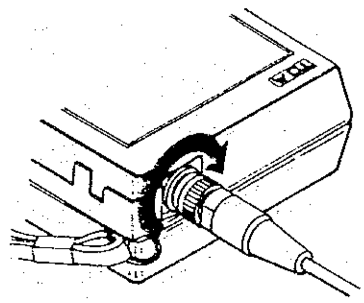


Connection of electrode plug

Match the direction of the electrode plug to the electrode terminal and insert it.



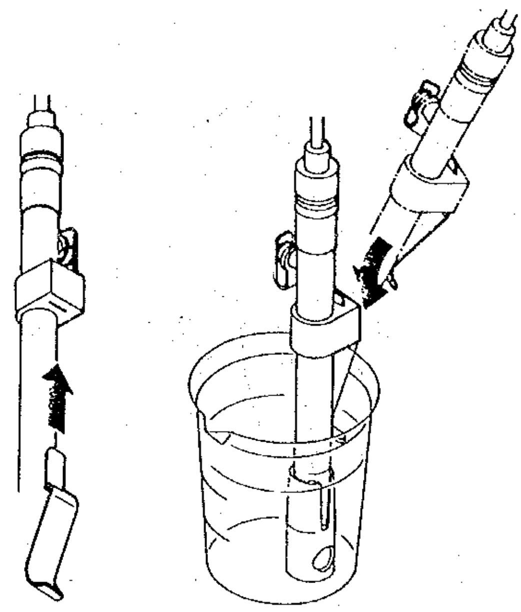
Turn the ring of the electrode plug to fix it.



HOW TO USE THE CLIP FOR BEAKER

Insert the clip for beaker into the electrode holder receiver.

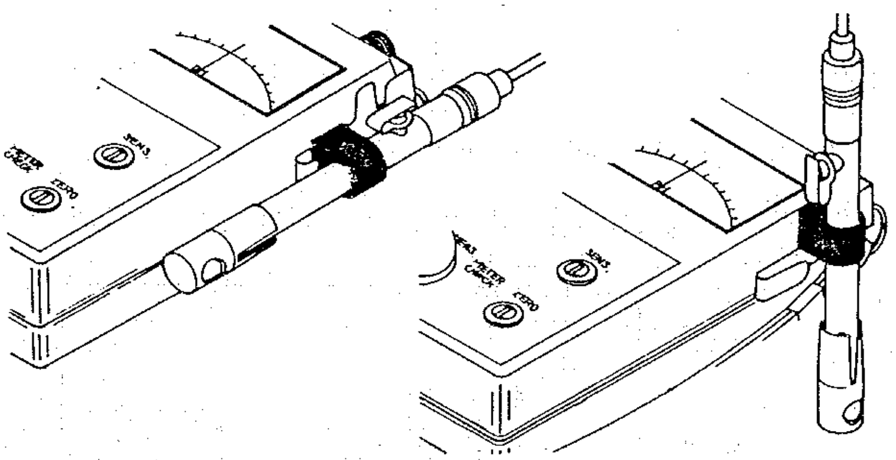
Use it for the beaker of more than 100 ml in capacity.



HOW TO USE THE ELECTRODE HOLDER RECEIVER

Use the electrode holder receiver when carrying the electrode with main body.

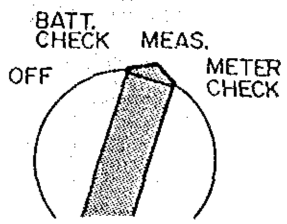
Make use of it when calibrating standard solution or measuring solution to be measured.



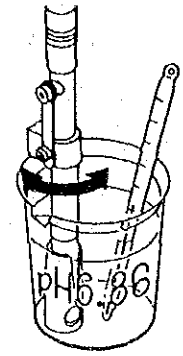
CALIBRATION OF PH-6.86 STANDARD SOLUTION

Put the pH-6.86 standard solution into the beaker to a depth of about 3 cm.

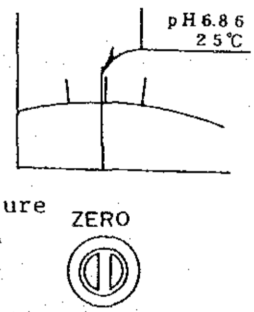
1. Turn the change-over switch to MEAS. Position.



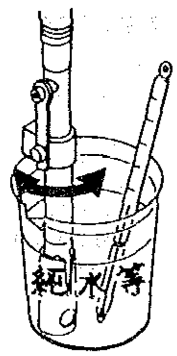
2. Soak the electrode and the thermometer into the standard solution and shake the electrode a few times. Electrode is used leaving the replenishment hole open.



3. Read the temperature. Turn the ZERO knob so that the needle may point pH value at the temperature of the solution correctly.



4. Turn the change-over switch to OFF position. Rinse the electrode and the thermometer with pure water thoroughly.



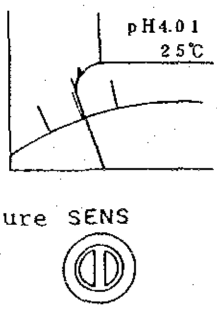
CALIBRATION OF PH-4.01 STANDARD SOLUTION

Put the pH-4.01 standard solution into the beaker to a depth of about 3 cm.

1. same as pH-6.86

2. same as pH-6.86

3. Read the temperature. Turn the SENS. knob so that the needle may point pH value at the temperature of the solution



4. same as pH-6.86

STANDARD SOLUTION

pH value at each temperature is shown in the following table.

Temp. (^{o}C)	pH value	pH value	pH value
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.83	9.04
50	4.06	6.83	9.01
55	4.08	6.84	8.99
60	4.10	6.84	8.96
70	4.12	6.85	8.93
80	4.16	6.86	8.89
90	4.20	6.88	8.85
95	4.23	6.89	8.83

NOTE: The pH values indicated in this table are determined on JIS (Japanese Industrial Standard).

1. This solution is to be used without dilution.

2. This solution may be used many times repeatedly if the electrode is rinsed with care, but the pH value may vary due to the condition of use. Therefore, keep the solution once taken out of the container in a bottle of hard glass of high quality steam-washed or in a polyethelene bottle, and do not put it back in the former container.

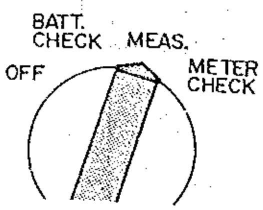
3. The solution used several times may vary in pH value, so use it after confirming that the pH value is the same as compared with the new standard solution.

4. After use, never fail to keep it stopped tightly.

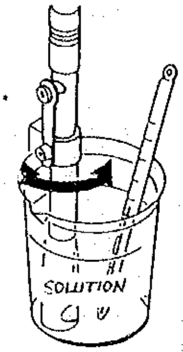
MEASUREMENT

After completing the two-point calibration, measure the sample solution in the following procedure.

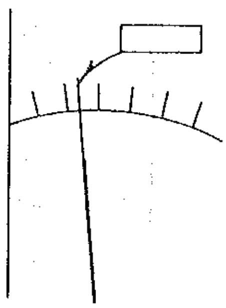
1. Turn the change-over switch to MEAS. position.



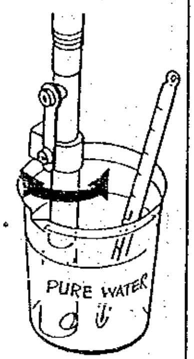
2. Soak the electrode and the thermometer into the solution to be measured and shake the electrode. Use the electrode, leaving the replenishment hole open.



3. Read the indicating value. At the same time, read the temperature



4. Remove the electrode and the thermometer and rinse them with pure water. When measuring continously, repeat the procedure from 2. After completing, set the switch to OFF position.

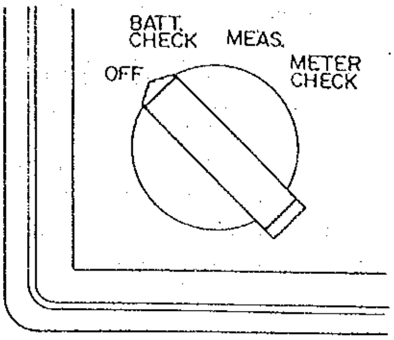


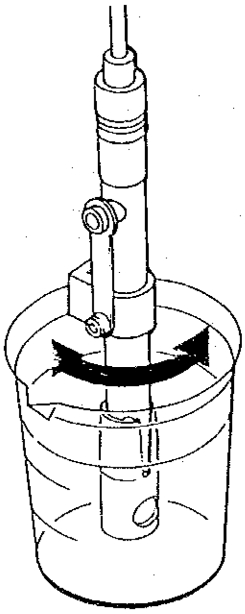
For a while after calibrating two point calibration, approximate measurement can be obtained only with pH-6.86 calibration.

In case of travelling measurement, turn the change-over switch to "METER CHECK" positoon. (The input is short-circuited.)

TREATMENT AFTER MEASUREMENT

After measurement, be sure to turn the change-over switch to "OFF" position.

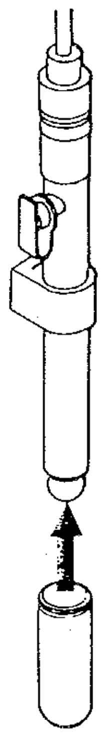




Rinse the electrode

Rinse the electrode thoroughly with pure water. Especially, rinse the part between electrode and the protective cover for electrode.

Put the protective cap for electrode membrane. When not used for a few days or more, or stored for a long period, put the protective cap, containing KCL solution, on the electrode.

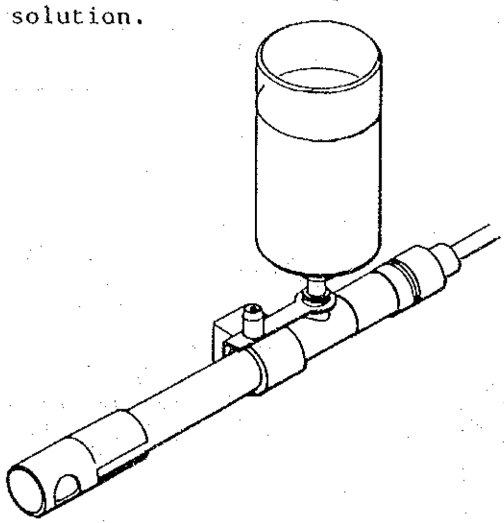


4. MAINTENANCE

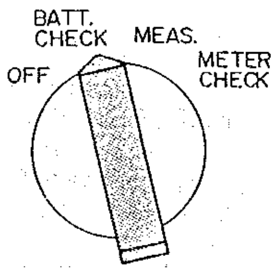
Replenishment of Saturated Potassium Chloride Solution into the Electrode

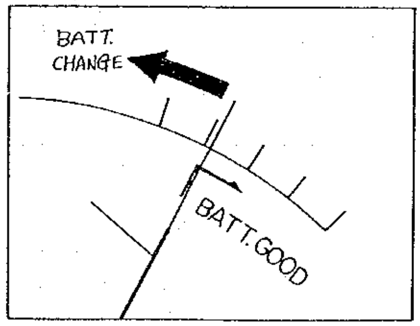
Fill the saturated potassium chloride solution to the replenishment hole.

When internal KCL crystals have disappeared, take out the inner solution from the hole, rinse the inside with saturated KCL solution, and replenish with a new supply of solution.



Exchange of Battery





Turn the change-over switch to "BATT. CHECK" position.

5. TROUBLESHOOTING

The needle of the meter does not move, when the change-over switch is turned to "EMAS." position.

1. Dead battery, poor contact of battery
2. Defective IC
3. Defective meter

The needle of the meter swings out, and calibration with ZERO knob is impossible, when the change-over switch is turned to "METER CHECK" position.

1. Defective IC
2. Defective meter
3. Poor contact of change-over switch

The needle of the meter swings out in the measuring condition.

1. Insufficient insertion of electrode plug.
2. Insufficient or empty KCL solution of the reference electrode
3. Disconnection of electrode lead.

CAUTION IN USE

1. When it is necessary for more accurate measurement, rinse the electrode more than 3 times repeatedly, and immerse it in water or suitable solution for more than 12 hours.

2. When the electrode membrane becomes dried, immerse it into pure water for more than a few hours or in 0.1N hydrochloric acid for approx. 30 minutes, and rinse with pure water before using. In this case, care must be taken not to let the liquid junction part soaked by pure water or hydrochloric acid.

3. If the membrane that was containimated can not be removed with pure water, rinse with gauze or some other soft material moistened with a dilute soap solution or a neutral cleaning material, or to dip into a solution of approx. 0.1N hydrochloric chromate acid. Then, rinse with pure water thoroughly and dip into pure water for a few hours.

   In this case, care must be taken not to let the liquid junction part soaked by soap solution, neutral cleaning material, hydrochloric acid, chromate acid mixing solution.

4. When replenishing the inner solution at high temperature, use the electrode at the time when the temperature of inner solution becomes same one of the solution to be measured.

5. As the electrode plug requires high insulation, do not dip it into solution.

6. Use the electrode within the usable temperature range.

6. COMBINATION ELECTRODE

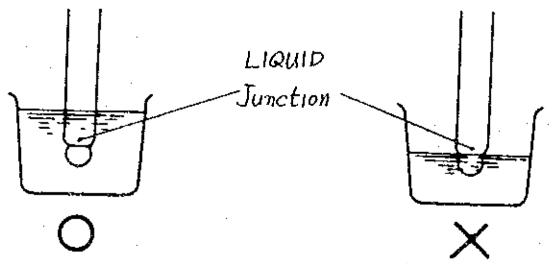
How to use it

1. Preparation

After use, take out the protective cap for membrane of the electrode and the rubber stopper covered with the replenishment hole. Then, rinse the electrode with pure water and remove the waterdrops by applying the filter paper or gauze.

2. Measurement

Soak the electrode membrane and the liquid junction part completely into the solution to be measured.



3. After use

After rinsing the electrode membrane and the liquid junction, soak the electrode into the saturated potassium chloride (KCL) solution.

4. Replenishment of Inner Solution

Fill the saturated potassium chloride solution to the replenishment hole.

When the inner solution is lack, repelnish saturated KCL solution, saturated at 60°C.

When the inner solution becomes unsaturated, take out the inner solution and replenish with a new supply of solution.

7 - 7. pH METER MODEL HM-1F

CARE IN HANDLING

Following items should be carefully noted in handling this instrument.

* Electrode must be thoroughly washed in fresh water before thrusting into a different solution.

* Handle electrodes carefully to avoid striking or dropping them.

* Take particular care to ensure that the MODE knob is turned to "OFF" after each test.

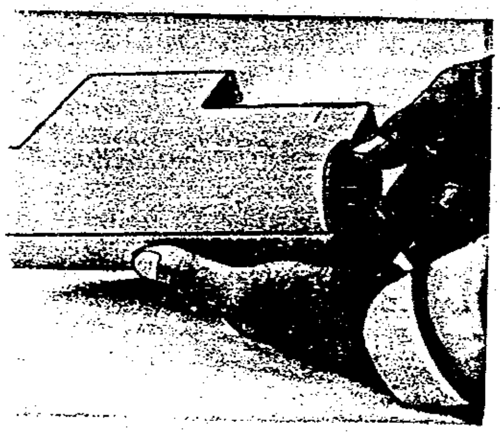
* Once the pH6.86, pH4.01 standard solution is used, do not return to its original receptacle but continue to use as is.

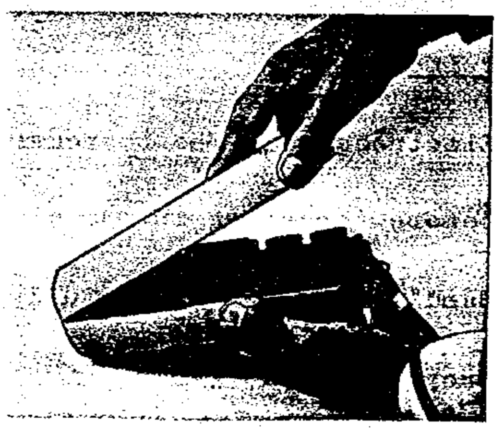
* The solution can be used for approximately one week.

* Open and close the upper lid as follows:

  First, as shown in photo 1, turn the knob in the handle 45° to the right or left and it will jut outwards approximately 5 mm, allowing the lid to be opened from the front.

  To close, first confirm that the MODE knob is turned to "OFF", then as shown in photo 2, insert the ridge at the back of the lid into the groove along the inside of the case and close. As the lid will not close if the knob in the handle is not pulled out, either turn the knob 45° or pull out to allow the lid to close.





Standard solution

1) Use the standard solution supplied with the HM-1F without diluting

2) This solution can be used repeatedly many times. Once the solution is removed from its original receptacle however, it must not be poured back.

3) If sealed and stored under constant temperature, the pH value of this solution will remain unchanged for one year. Although a white sediment may appear when stored for long periods, there will be no change in its pH value.

4) Care should be taken to prevent sudden sharp changes in its temperature and to store it well sealed.

Powder for standard solution

The powder supplied as a supplement to the standard solution should be prepared as follows prior to using.

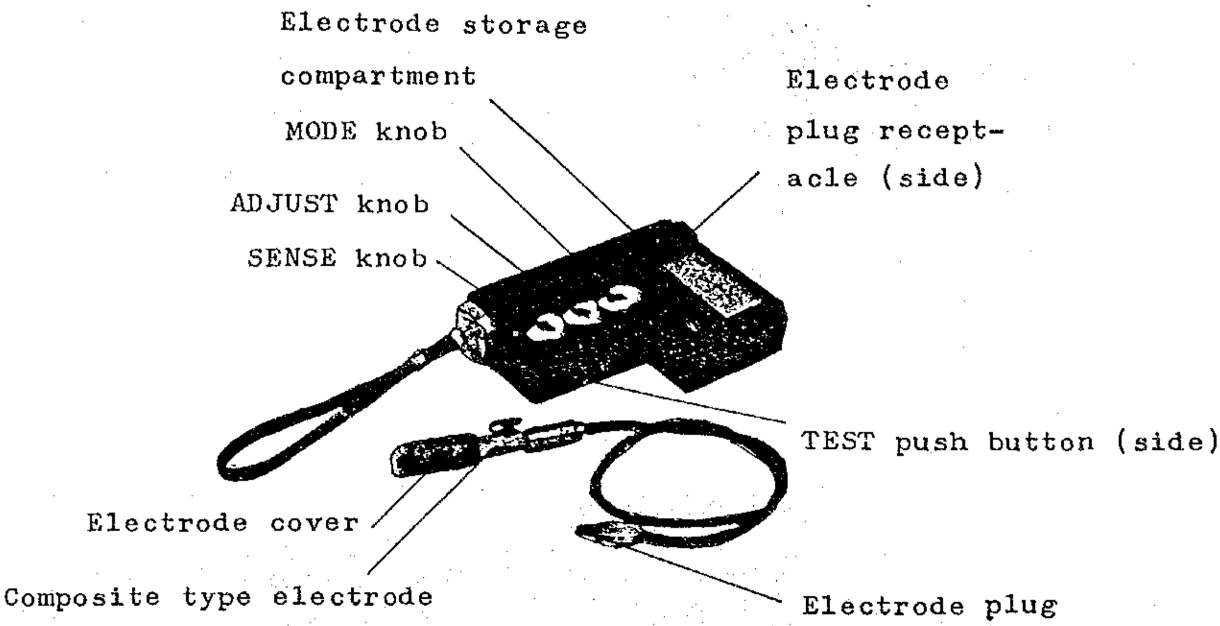
1) Dissolve powder completely in 500 cc of distilled water, ensuring that no powder remains in the receptacle.

2) We recommend use of our "standard solution receptacle" to store the solution.

3) As the prepared solution is practically the same as the standard solution, refer to notes on the care of standard solution as per the above.

Description and operation of the various parts

MODE knob:	Knob to switch to OFF, MEAS and BATT. check.
ADJ. knob:	Knob to adjust to the standard solution value of pH 6.86.
SENSE knob:	A control incorporated to obtain true measured values at all times by changing the sensitivity of the instrument in relation to the temperature of the solution to be measured.
TEST push button:	A push button that turns the indicator on or off electrically and will operate when in the "ON" position.
Electrode plugs:	A plug to connect the electrode leads to the indicator.



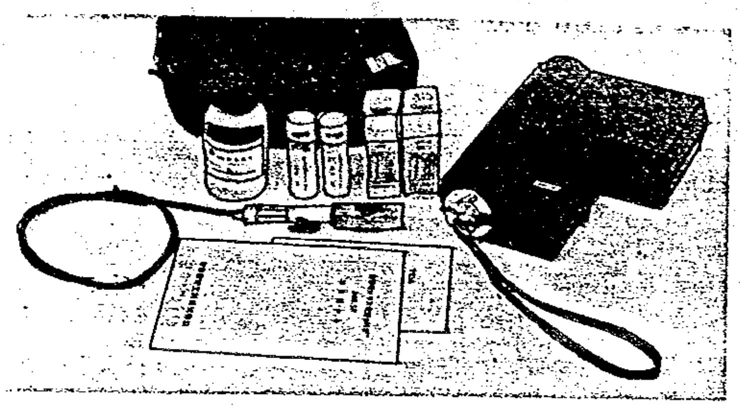
<u>Performance</u>

Test range	1 - 13 pH
Minimum graduations	0.2 pH
Precision	± 0.1 pH
Power supply	Type 006P dry cell 1 each
Weight & Measurement	Approx. 0.8 kg, W.146.5 x L.179 x H.60

<u>Standard accessories</u>

Composite electrode GS-2C			1 each
Standard neutral phosphatic solution	pH 6.86	40 ml	1 btl.
Standard phthalate solution	pH 4.01	40 ml	1 btl.
Saturated KCl solution		100 ml	1 btl.

Powder for standard solution	pH 6.86	500 ml use 1 pkt.
	pH 4.01	500 ml use 1 pkt.
Polyethylene beaker	15 ml	2 each
Thermometer	0 – 100°C	1 each
Soft storage case		1 each
Syringe		1 each
Instruction manual		1 each



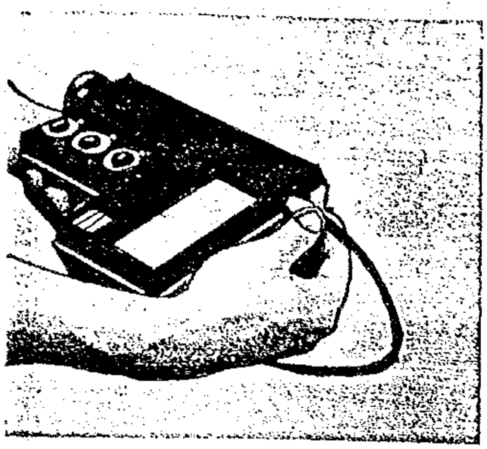
Operation

As a basic rule, the indicator must be removed from the soft case when making adjustments or measurements.

Normal tests

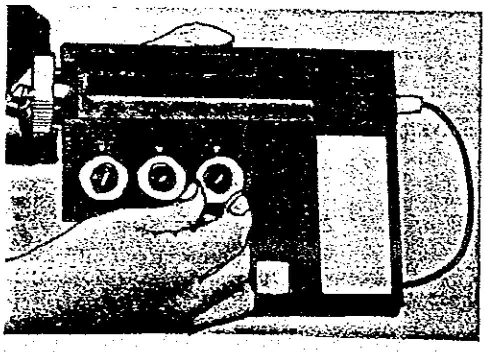
- Inserting the electrode plug -

Remove lead from the cover of the electrode case and insert plug at the end of the lead into the socket of the indicator (matching the red dot on the plug to the white dot on the socket), and turn 90 in the direction of the arrow.



- Turn switch to MEAS. -

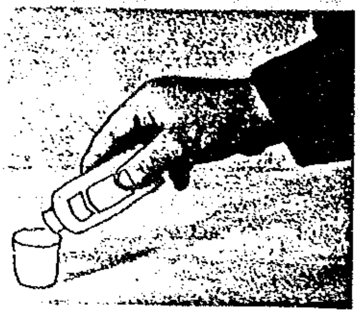
Leaving the test push button on the side of the instrument in the OFF position, turn the MODE knob to MEAS. After leaving in this position for 10 - 20 seconds, the instrument will be ready for stable operation.



- Preparation of the electrode -

Remove polythlene cover attached to single-type electrode. Also remove rubber caps covering the tip of the electrode and the hole at the top for refilling the internal solution of the reference electrode. Then remove the thin film protecting the electrode membrane. Place the polythylene cover back to its original position.

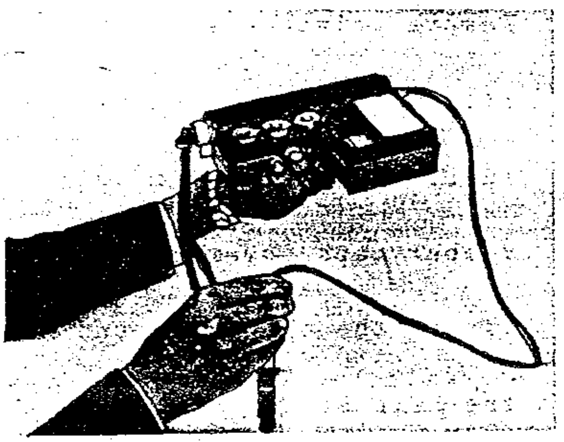
- Pouring the pH 6.86 and pH 4.01 standard solution into a beaker -



Pour the pH 6.86 and pH 4.01 standard solution into the square beaker provided to a depth of about 1 cm. It is essential that the beaker be thoroughly washed with fresh water at this time.

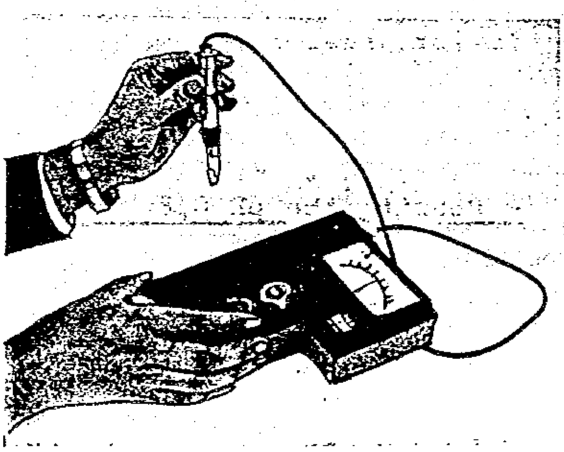
- Immerse the electrode into the standard solution and press the test button -

Immerse electrode in the pH 6.86 standard solution, stir lightly 2 or 3 times, and press button to "ON".



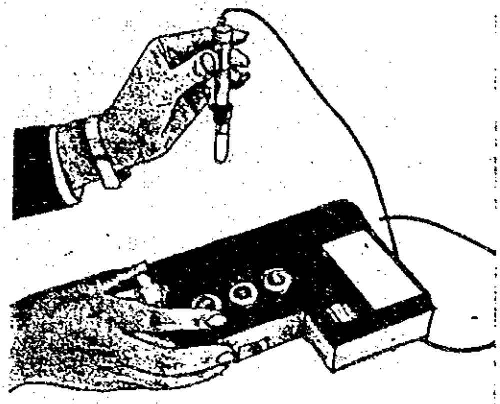
- Adjust indicator needle to pH 6.86 -

Use ADJ. knob to adjust indicator needle to 6.86. Turn button to "OFF" when this operation is completed and remove electrode from standard solution and wash well with fresh water.



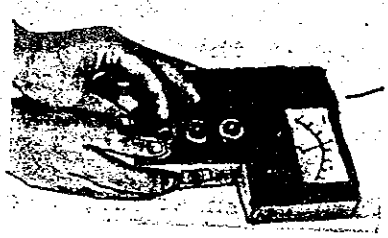
- Adjust indicator needle to pH 4.01 -

Next immerse electrode in the pH 4.01 solution in the same manner, press button and adjust indicator needle to 4.01 by means of the SENSE knob. Remove electrode from the standard solution and wash well with fresh water. If the temperature of the standard solution differs from that shown on the temperature scale, when the SENSE knob is adjusted as above, holding knob stationary in its present position, turn the graduated portion only to match the temperature of the solution by hooking your finger nails to the center ridge.



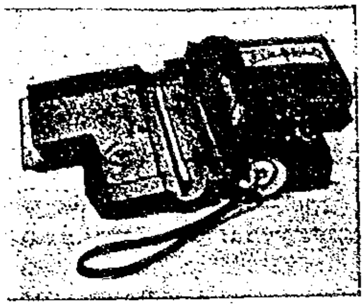
- Measuring -

The pH indication can be immediately obtained by dipping a clean electrode into the solution to be measured and stirring lightly 2 or 3 times. After obtaining the desired value, press button, remove electrode from the solution and wash well in preparation for the next measurement.



After performing these two adjustments, it is possible to make close adjustments of pH 6.86 only for a while. At this time, adjust the SENSE knob correctly to the temperature of the solution to be measured.

Disposition after measurement



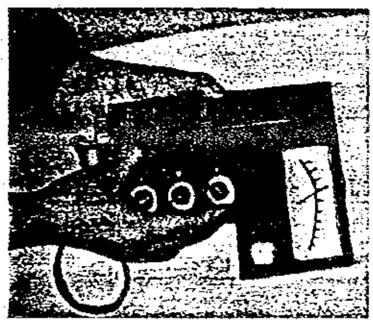
Turn MODE button to "OFF" position and also confirm that the test button in also in the "OFF" position. Wash electrodes thoroughly with fresh water. Store thermometer and electrodes as shown in the photo. In case it is not used for a few days or more, or in case it is to be stored for a long time, wash thoroughly the electrode membrane and the liquid junction section, place a rubber stopper to the refilling hole and cover the tip of the electrode with a rubber cap filled with saturated potassium chloride solution. Then put the polyethylene cover on for storage. Except when the equipment is to be carried, it is recommended that the above procedure should be followed to keep the electrode membrane from getting dry.

- Maintenance -

To obtain correct measurements at all times, correct maintenance is essential

Checking and replacing battery

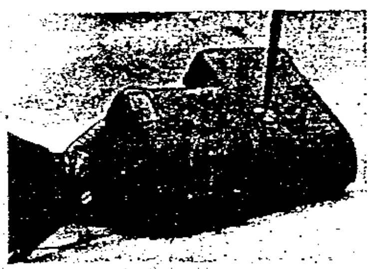
- Check for battery life -



Turn MODE knob to "BATT" and if the indicator needle is within the red portion or beyond, when the push button is pressed to the "ON" position, the battery is still useable, however, it must be replaced if the needle is below the red portion.

- Opening the panel -

The panel and the case may be opened by loosening the signal ornamental screw at the bottom of the case.



- Replacing the battery -

Replace worn battery with a new one, ensuring that the polarity is correct. The battery used is one type 006P Hi Top which can be readily purchased on the market.

If the instrument is not used for long periods, the battery must always be removed. If a dead battery is allowed to remain in the instrument, leakage of the battery solution may cause damage to the mechanism and case.

Refilling potassium chloride solution in the relative electrodes

Always keep saturated potassium chloride solution up to the lower edge of the refilling hole. In case the internal solution is insufficient, supplement it with a solution saturated with potassium chloride at 60°C. In case the inner solution becomes unsaturated, remove it and put saturated potassium chloride solution in. As it is not necessary to put silver chloride powder into the internal solution, the usual internal solution of saturated calomel electrode can be used as it is. In case the inner solution becomes unsaturated, remove it and put saturated potassium chloride solution in. As it is necessary to put silver chloride powder into the internal solution, the usual internal solution of saturated calomel electrode can be used as it is. In case KCl crystals can not be found inside, remove the internal solution completely through the refilling hole and put new KCl solution in.

Distinguishing troubles and counter measures

Although there are many features built in to prevent trouble from arising, it can be imagined that some defects may arise after long periods of use and a few method of distinguishing the source of troubles is listed below.

If the indicator needle fails to move when the MODE knob is turned to "MEAS".

- Bad connections or battery dead.
- Defective transistor.
- Defective current-meter.

If the indicator needle swings to the extreme right, or cannot be controlled, when the MODE knob is turned to "MEAS".

- Defective transistor.
- Bad connection in the push button.

If the indicator needle swings to the extreme right when the test push button is pressed.

- Insufficient immersion of the electrode plug.
- Supply of potassium chloride solution in the electrode low or empty.
- Open in the electrode leads.

(We will now go into a slightly more detailed description in the handling of the electrode and standard solution as an example for performing measurements).

ELECTRODE

1. Notes on handling

   1) According to standards for Testing Pollution Measuring Equipment, glass electrodes are to be consecutively washed more than three times and then left soaked in water or in appropriate solutions for more than 12 hours to make the membrane surface have enough afficity with water.

   2) In case the electrode diaphragm gets dry, soak it in pure water for a few hours, or soak it in approximately 0.1N hydrochloric acid solution for about 30 min. and wash it with pure water thoroughly before its use.

      Here, care must be taken not to have water or hydrochloric acid permeate the liquid junction section.

   3) In case the electrode membrane is stained to a large extent and can not be cleaned with pure water, remove the stain by wiping with gauge soaked with soap or neutral detergent solution, or soak it in approximately 0.1N hydrochloric acid solution or in chromic acid mixture, wash it thoroughly with pure water and soak it in pure water for a few hours before its use. Here care must be taken not to have soap, neutral detergent, hydrochloric acid or chromic acid mixture permeate the liquid junction section.

   4) In case the internal solution is filled at a high temperature, use the equipment after the temperature of the internal solution becomes the same as that of the solution to be tested.

5) Care must be taken not to soak the glass terminal in water solutions as it needs a high degree of insulation.

6) Use the electrode within the designated temperature range.

2. Measuring special solutions

To measure weak solutions such as distilled water, after washing well, dip 2 or 3 times before immersing in the solution and measure after stirring several times. Measuring strong alkaline solutions. When measuring the pH value of strong alkaline solutions by employing the glass electrode, the following 2 problems may arise.

1) Alkali discrepancies

In the case of strong alkaline solutions, the relation between the electromotive force of the glass electrode and the pH value of the solution (mV/pH) will not follow a straight pattern and discrepancies will arise. In cases of this nature, the difference increases with the increase in density of Na^+, Li^+.

For this reason, when making precision measurements of strong alkaline solutions, the limits of the electrodes straight line pattern must be taken into consideration and suitable selections made.

2) Slow indications

As a slightly longer time is required for the electric potential to stabilize when measuring strong alkaline solutions than when measuring standard solutions, take readings after indicator needle has become steady. Again, it is essential that the electrode be especially well washed after measurement to remove all traces of alkali. In these cases, the effectiveness of washing can be improved by dipping the electrode once into a 1/10 normal hydrochloric acid solution and washing in fresh water.

Measurement of strong acid solutions.

There are no special points to consider when using HM-1F electrodes as they generally show little discrepancy when measuring strong acids.

However, long periods of measurement of strong acids will shorten its life. Special care must be taken in measuring hydrofluoric acid as deterioration will develop in the glass film.

Measuring non-water solutions.

When measuring alcohol and other non-water solutions, it will be necessary to take into consideration the differences in the solvents involved.

Measurements under high and low temperature conditions.

When measuring the pH value of solutions under high and low temperature conditions, care must be taken not to exceed the temperature limits set for each type of electrodes.

(1) If the prescribed temperature limits are exceeded on the high end, there will be fear of rapidly shortening the life of the electrode. If exceeded on the low end, indications will slow and unstable, and discrepancies in readings will become great.

(2) Care should be taken as discrepancies in alkali content increases with increases in solution temperature.

3. <u>Care and troubles when storing electrodes.</u>

1) When the glass electrode is not in continuous use, it is desireable to keep it immersed in standard neutral solution or water so it will be available for immediate use when required. The cover provided should be slipped over the end of the relative electrodes to prevent leakage of the KCl.

2) If the amount of KCl in the relative electrode becomes acutely low and falls below the internal electrode, the meter will swing sharply to the extreme limit, and if left in this state for any length of period, characteristics of the relative electrodes will change and it will take considerable time for it to return to its original state. As the same conditions will arise if the electrode is allowed to remain for long periods when its KCl crystal are depleted, always confirm the amount of KCl crystals prior to using.

3) Insulation and internal resistance.

Much consideration was given to maintain an extremely high degree of insulation of all parts within the temperature limits of the glass electrode with the use of several film resistors of under some 10s of M . If this insulation deteriorates, the needle will swing too far and unstable operation will result. Special care must therefore be taken not to wet the terminals, cap etc. when handling the electrode and care must also be taken to refrain placing a still wet electrode cover into the case.

4) Deterioration and restoration.

As surface deterioration will occur, and errors in readings result, if a glass electrode is used for long periods of time in measuring various solutions, the following timely treatments should be performed.

a) When inorganic substanfes such as coal etc. adhere to the surface (sometimes turns white), treat in a suitable acid such ashydrochloric acid (1-2 minutes in 1-2 normal).

b) When fats, protein etc. adhere to the surface, immerse in a chromium sulfate solution for approximately 10 minutes.

c) In the case of natural deterioration of the surface due to long usage, immerse in a 10% solution of ammonium fluoride for approximately 3 minutes and rinse in dilute hydrochloric acid to remove all traces of fluoride. The instrument will be ready for use after washing in fresh water following the above treatment. However we do not recommend the ammonium fluoride treatment (c) as the electrodes are easily damaged in this treatment.

5) In troubles where approximately the same readings are obtained when measuring 2 or more types of standard solutions, the trouble steams, in many cases, from a crack in the glass membrane caused by a mechanical jar and this can usually be detected by close scrutiny, however there are times when this cannot be detected. In these cases, immerse the electrode in a sodium chloride solution and measure the resistance between the tip of the electrode and both sides by means of tester, and if the resistance is under a MΩ under normal temperature, a crack has developed. In this case there is no alternative but to replace it with a new unit.

TABLE OF VARIOUS ELECTRODES FOR HM-1F USE

Type of electrodes	Use	Possible limits direct pH reading	Scope of Usable Temperature	Fluid to be measured
GS-2C	General use	1 - 13.0	0 - 60°C	All types of water solution excluding hydrofluoric acids.
GS-4C	High temp.	1 - 12.0	0 - 100°C	All types of water solution excluding hydrofluoric acid.

Further, please do not hesitate to write us if there are any unclear items in our explanation of the HM-1F.

INSTRUCTIONS IN THE USE OF POWDER FOR NEUTRAL PHOSPHATE STANDARD SOLUTIONS

1) This substance is a powder to regulate the neutral phosphate standard solution, and the solution prepared in accordance with directions in paragraph (2) is equivalent to the neutral phosphate standard solution prescribed for pH measurements under JIS standards, and is pH 6.86±0.02 at 25°C.

2) Method of use is as follows.

   a) To dissolve this powder, use pure water under 25°C with a conductivity of $2x10^{-6}$ ℧/cm.

   b) Ascertain that the powder has completely dissolved.

   c) As one package of this powder is for 500 cc use, care should be taken to use a measuring flask to ensure that the prepared solution will be 500 cc.

3) For storing the prepared standard solution, we recommend use of the neutral phosphate standard solution receptacle, marketed by this company. Or store in a steam cleaned well-sealed good grade tempered glass receptacle.

4) The pH values of the standard solution at various temperature are as indicated in the table below.

TABLE OF TEMPERATURE CHARACTERISTICS

Solution temperature °C	pH Value	Solution temperature °C	pH Value	Solution temperature °C	pH Value
0	6.98	30	6.85	60	6.84
5	6.95	35	6.84	70	6.85
10	6.92	40	6.84	80	6.86
15	6.90	45	6.83	90	6.88
20	6.88	50	6.83	95	6.89
25	6.86	55	6.84		

Note: The pH values in this table are JIS standard values

5) Use standard undiluted solution.

6) If the electrodes are carefully washed, the standard solution can be used repeatedly many times, however, as the pH values may change according to conditions of usage, once the solution is removed from its storage receptacle, it must be stored in a steam cleaned high grade tempered glass receptacle, or in polyethylene container, and must not be returned to its original receptacle.

7) As the pH value of the standard solution may change after several repeated uses, compare it with new soltuion and use after confirming it is the same.

8) Always ensure that the solution is well sealed when storing.

7 - 8 REDOX POTENTIAL METER MODEL RM - 1F

1. Component function

A. Electrode

The compound electrode PS-2111C contains platinum and calamel electrodes.

1) Platinum electrode is generates an e.m.f. corresponding to the potentials of the solution.

2) Calomel electrode is used as a standard for comparison with the platinum electrode, and generates a fixed e.m.f. independent of the test solution.

B. ORP Meter

Front panel contains the indication meter, mode switch, meter zero adjustment screw, "ADJUST" knob, "FINE" knob, and groove.

a) Indication meter

Indicates the potentials of oxidation & potentials, and battery condition.

b) Mode switch - 3 positions.

(1) "OFF" power to instrument is turned off

(2) "BATT" used to check the condition of the internal battery.

(3) "MEAS" used to change to measure mode.

c) Meter zero adjustment screw

Used to set meter position to 0 MV position with the power "OFF".

d) "ADJUST" knob

For rough adjustment of the zero point of the meter.

e) "FINE" knob

For fine adjustment of the zero point of the meter.

f) Groove

Used for keeping the electrode

C. Right side panel

"ON-OFF" push switch for make & break of the electrode and the meter.

D. Top side panel

Probe receptacle - used to connect the electrode to the instrument.

E. Down side panel

Rotary metal knob is used to remove or fit the front and/or rear cover.

F. Front cover

The holders are provided to hold the thermometer

G. Rear cover

Screw - to remove the rear cover, unscrew by turning counterlockwise. The rear cover can be removed.

2. Measurement

A. Preliminary procedure

1) Remove the front cover by turning the rotary metal knob 45° clockwise or counterclockwise.

B. Measurement

1) MODE switch is put at "MEAS". In about 10-20 seconds the indicating pointer will begin working stably.

2) Take the electrode out of the groove, insert the plug of electrode into the receptacle on the top side, and make the ring tight.

3) In the use of the electrode PS-2111C take off the protecting cover which is fitted over the electrode and gently remove the rubber cap on the head of the calomel (reference) electrode, and fit the rubber band onto the kcl solution repelnishment opening.

Make certain that the surface of platinum is clean and kcl is sufficient in the solution of the calomel electrode. Then put the protecting cover on again.

4) In the use of the submerging cell, taking off the stainless cover, make certain of the surface of platinum and the internal solution of the calomel electrode in the same way as above and put the cover on again.

5) Make certain that the side on-off switch is put on "OFF" and adjust the indicating pointer to the scale "O" by turning the "ADJUST" knobe and "FINE" knobe.

6) Insert the electrode into the test solution, and shake it slowly two or three times. If you push the side switch to the "ON" position, the oxidation reduction potential of the test solution will be indicated at once.

7) After the indication is obtained, push the side switch to "OFF" position and take the electrode out of the test solution to get ready for the next measurement.

The above values indicate the potential difference of a saturated calomel electrode, but if that of the standard hydrogen electrode is required, the value indicated will be added to the value in the following table.

Solution Temperature C°	Potential difference mV	Solution temperature C°	Potential difference mV
0	260 (223)	25	244 (199)
10	254 (214)	30	240 (194)
15	251 (209)	35	238 (189)
18	249	40	234 (184)
20	248 (204)	50	227 (173)

Potential in the ( ) is for Agcl electrode PS-2111C.

3. Procedure after measurement

After the measurement is ended, replace the "MODE" switch to the "OFF" position.

Wash thoroughly in clean water the electrode. As for PS-2111C, put the rubber cap on the tip of the calomel electrode, and remove the rubber band to cover the hole.

Take the plug out of the meter, loosing the ring, to be put into the groove.

4. How to check and replace battery

1) Checking battery consumption

Turn the MODE switch to "BATT" position and check if the needle remains in the red portion.

If it fails to reach the red portion, battery must be replaced with a new one.

2) Removing rear cover from body

Turn the screw on the rear cover in a counterclockwise direction turn the rotary knob 45°. Then the rear cover is ready for removing.

3) Replacing battery

Insert battery "006P" into the battery storage compartment. MAKE ABSOLUTELY CERTAIN THAT THE BATTERY IS REMOVED THE COMPARTMENT WHEN NOT IN USE FOR A LONG PERIOD OF TIME.

Damage to the compartment and the other adjacent mechanical parts may result due to leakage if left loaded on.

5. Direction and maintenance

1) Never fail to replace the Mode switch in the position "OFF" at the end of measurement.

2) Put in or pull out the plug slowly without too much force.

3) Take care not to give a hard blow on nor to let fall an electrode or other.

6. Faultfinding

The indicator does not work with the "MODE" knob at "MEAS"

—— Battery consumed or poor contact
—— Disconnection in the meter
—— Transistor out of order

Incapable of zero-adjustment of the meter with the "MODE" knob at "MEAS"

—— Poor contact of the on-off switch

The indicator does not work in the course of measurement

—— Excessive fall of insulation of the input circuit
—— The electrode lead is short-circuited

The indicator runs out of the scale in the course of measurement

—— Lack of internal solution of the calomel electrode
—— Imperfect insertion or poor contact of the plug of the electrode lead.
—— Disconnection of the electrode lead.

7 - 9 SOIL TENSIONMETER

SOIL TENSIOMETERS

Terada Type

This meter had been performed by Dr. Kisuke Terada after his long research. By using this meter, soil moisture, the most important matter for growing the plants, is measured simply, quickly and exactly.

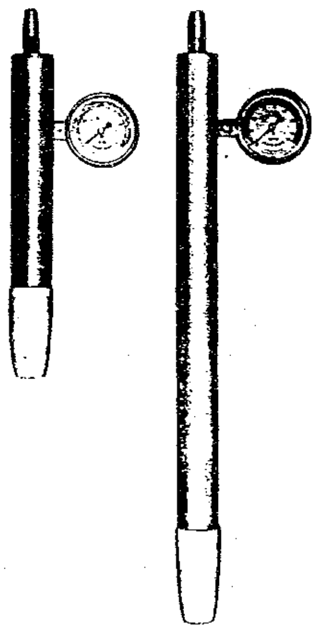
The moisture in the soil, one of the most essential element for plant growing is easily measured by using this meter. This is a big guide to the general farming, particularly for upland irrigation, besides, this will be applied extensively in the fields of civil engineering and meteorological survey.

* Advantages

Water in the soil is essential to the growth of plants. Indeed, they cannot grow without it. Measuring this moisture, and that frequently, is a troublesome and timeconsuming job, but the meter will do it quickly and accurately. Once put in position, it will tell you the moisture of the soil every day. Because it is handy, moreover, you can easily take it with you to the fields or into the forests where you want to use it. Any farmer can use it without difficulty; it does not wear off by use; and it is considerably cheaper than any similar instruments hitherto used.

*Specifications

Measuring range: 0 - 76 cmHg
Graduation : 1 cmHg
Ceramic cup : 40ϕ x 100 mm



Type	Length	Use
S-1	20 cm	hothouse, hotbed, seedbed, strawberry, small vegetables, flowering-plants, shallow-rooted crops, etc.
S-2	40 cm	vegetables, taroes, pulse, wheat and barley, cane, etc.
M	80 cm	apple, tea, orange, pear, peach, grape, fruit-trees, etc.
L	150 cm	loquat, nut,persimmon, rooted big plants, etc.

* Recommendation

Dr. Kinjiro Yamanaka, former agricultural technial official, the Ministry of Agriculture and Forestry says:

"It is well known that plants draw water from the soil by menas of the osmotic pressure, or evaporative pressure, of the cytoplasm of their roots. This, however, must be done against the strong force attracting the water to the grains of soil. Before irrigating field, therefore, it is essential to measure the capillary attraction of the soil.

"Dr. Kisuke Terada has been in Japan for many years devoting himself to experiments on tension meters. Recently he has developed a simple and handy Terada Tensiometer. This must be called a great achievement today when interest in the capillary attraction is lamentably low.

" I wish his future studies will bear still better fruit."

* May be Used at any Depth

There are four types of Tensiometers; 20 cm, 40 cm, 80 cm and 150 cm types, but any type may be used at any depth within its range.

* Where the Meters may be Used

1) Practical:

a) Irrigation of fields, orchards, vegetable gardens, greenhouses, tea plantations, forests, seed-beds, etc.

b) Civil engineering works.

c) Weather installations.

2) Experimental:

a) Engineering sections of the agriculture-forestry office and the construction office of the government, sites of public work.

b) State and public agricultural, forestry laboratories, forestry stations.

c) Civil engineering, forestry, farmland, farming and other agricultural sections of governments.

d) Agricultural technique demonstration agents of prefectures, leaders of farmers cooperatives and farmers in general.

3) Educational:

a) Science courses, chemical, physical studies at schools; in studies of agriculture and forestry.

b) Various departments of universities specializing in agriculture (plants, seeds, raising), agricultural chemistry (soil, fertilizer), agricultural engineering (civil engineering, dynamics), forestry (afforestation, sand guards), etc., and even other engineering and science departments.

* How to Use

1. Preparation for Use

1) First, remove the upper plug, then fill the cooled water which had been boiled before into the tube to drive the air out, then seal it tightly and leave it as it is. Indicator, at first will point to 0 of the gauge, however, as the water evaporates from the surface of the ceramic cup, the indicator rises gradually. And wait until the time when the indicator points to 35, then add the said water to fill the tube.

2) Repeat this treatment, two or three times, then the air in the tube is completely driven out. Also every tiny crevice in the afore said cup is to be filled with water accordingly.

3) If this preparation be treated carelessly, the air, even a bit, will remain inside of the tube or in the tiny crevices of the tip-cup. This does not bring exact results.

4) In such reasons, a complete preparation before applying, is strictly wanted.

2. How to Insert the Meter into the Soil

1) Dig a small hole, the diameter of which should not be larger than that of the tube; and the depth is enough as long as the tube you use. Then insert is quietly into the farm soil. The closer the contact of the tip-cup and soil is, the more quick and exactly the gauge points to the available soil moisture.

2) Therefore, after inserting it, stamp the soil around well with a fine stick and stuff the fine soil around the tube, then the earlier the exact sign of the gauge will be shown.

3. The Depth of Insertion

1) When it is used for farming, the tube should be inserted in the soil, near the plant roots to know if the soil contains enough water available for the plant use.

2) Generally, it is desirable that the middle part of the tube be placed at about middle or a little lower part of the Active Root System which absorbs water and nutriment actively.

3) The depth of the plant roots differs depending upon the kind, age, and period of the plants, however, in case of general farm crops, insert the tube into the farm soil up to 15 cm deep from the surface. In case of orchards or forest land, apply our larger one. When survey the moisture of the very soil surface, insert the tube diagonally.

4. How to Irrigate

1) Strictly speaking, signs of the gauge do not point the time of irrigation being many kind of plants, however, as a general standard, 0 to 10 represent Wet; 10 to 40, Medium; over 40, Dry, it is considered.

2) Accordingly, when gauge points over 40 in an ordinary croo field, irrigation must be made immediately, but the fields of white potatoes, sweet potatoes or Indian corn should be irrigated before the gauge points to 40, they having poorer absorbing roots.

3) To determine the signs of irrigation and the depth of tube inserted are most important matter to the users, and complete studies are deeply desired.

5. How to Handle the Meter

1) The gauge has signs up to 75 cm but in successive use, fill the water again in the tube whenever the indicator passes 55 degree.

2) To get exact and worthy signs, inside the tube should be filled with the water and any air bubble should not be left.

6. Various Applications

Besides the aforementioned application for irrigation, this meter has many uses:

1) Important data for farming will be obtained by measuring soil moisture at definite hours and places everyday through the year, as the gauge shows the correlation of precipitation and evaporation amount.

2) Current direction or velocity of the underground water will be measured by setting them at different places and depths; also the change of the underground water height will be revealed by the successive measuring at every stratum. For these exact investigations, automatic apparatus are ready for use.

3) Applying for Civil Engineering

   Reasonable soil moisture should be measured when a banking works starts. Various disasters, after the heavy rains, including breaking down the banks, landslide and others may be prevented previously by measuring the soil moisture using this meter. Besides these, some new uses of this meter will be performed by your good idea in future, it is expected.

7. Care in Handling

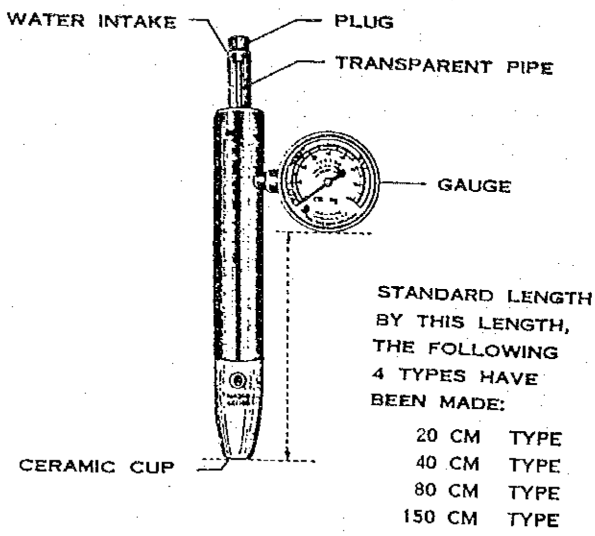
1) Having been made of the best material, taking the size of capillary tubes, water-permeation and other terms into consideration, the ceramic-cup can be used permanently and exactly, if it is handled with care. The meter might be broken or out of order if it is handled roughly. Your care in handling it is deeply wanted especially when you insert it into the soil.

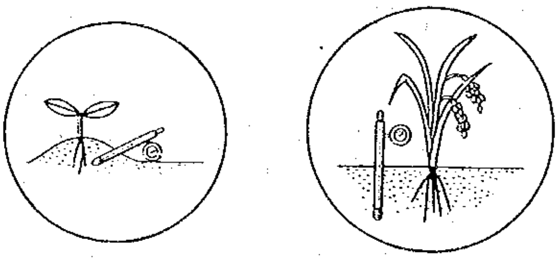
2) Do not let the water evaporate from the surface of the ceramic cup except the time when you make preparation for use. Do not use water containing dissolved substances, but use the cooled water which had been boiled before. When not in use, remove the water completely from the meter, otherwise residue might stick inside after the water has evaporated.

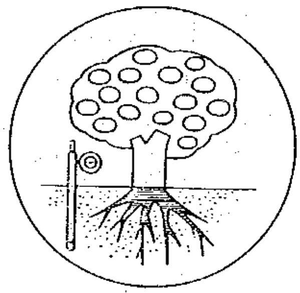
3) The joint part of gauge and the tube has been adhered with a speical sticky substance, however, strict care should be taken not to move this joint unreasonably, otherwise this meter might not work out by the air leakage.

4) Do not coat oil or fat on the ceramic cup, as this checks the permeation of water.

* Explanatory Figures







* Conversion Table of pF Values

cmHg \ pF	for 20cm	for 40cm	for 80cm	for 150cm	cmHg	for 20cm	for 40cm	for 80cm	for 150cm
1					41	2.7	2.7	2.7	2.6
2	0.9				42	2.7	2.7	2.7	2.6
3	1.3				43	2.8	2.7	2.7	2.6
4	1.5	1.2			44	2.8	2.7	2.7	2.7
5	1.7	1.4			45	2.8	2.8	2.7	2.7
6	1.8	1.6	0.2		46	2.8	2.8	2.7	2.7
7	1.9	1.7	1.2		47	2.8	2.8	2.7	2.7
8	1.9	1.8	1.5		48	2.8	2.8	2.8	2.7
9	2.0	1.9	1.6		49	2.8	2.8	2.8	2.7
10	2.1	2.0	1.7		50	2.8	2.8	2.8	2.7
11	2.1	2.0	1.8		51	2.8	2.8	2.8	2.7
12	2.2	2.1	1.9	1.1	52	2.8	2.8	2.8	2.7
13	2.2	2.1	2.0	1.4	53	2.8	2.8	2.8	2.8
14	2.2	2.2	2.0	1.6	54	2.9	2.8	2.8	2.8
15	2.3	2.2	2.1	1.7	55	2.9	2.9	2.8	2.8
16	2.3	2.2	2.1	1.8	56	2.9	2.9	2.8	2.8
17	2.3	2.3	2.2	1.9	57	2.9	2.9	2.8	2.8
18	2.4	2.3	2.2	2.0	58	2.9	2.9	2.9	2.8
19	2.4	2.3	2.3	2.0	59	2.9	2.9	2.9	2.8
20	2.4	2.4	2.3	2.1	60	2.9	2.9	2.9	2.8
21	2.4	2.4	2.3	2.1	61	2.9	2.9	2.9	2.8
22	2.4	2.4	2.3	2.2	62	2.9	2.9	2.9	2.8
23	2.5	2.4	2.4	2.2	63	2.9	2.9	2.9	2.8
24	2.5	2.5	2.4	2.2	64	2.9	2.9	2.9	2.9
25	2.5	2.5	2.4	2.3	65	2.9	2.9	2.9	2.9
26	2.5	2.5	2.4	2.3	66	2.9	2.9	2.9	2.9
27	2.5	2.5	2.5	2.3	67	2.9	2.9	2.9	2.9
28	2.6	2.5	2.5	2.4	68	3.0	2.9	2.9	2.9
29	2.6	2.5	2.5	2.4	69	3.0	3.0	2.9	2.9
30	2.6	2.6	2.5	2.4	70	3.0	3.0	2.9	2.9
31	2.6	2.6	2.5	2.4	71	3.0	3.0	2.9	2.9
32	2.6	2.6	2.6	2.5	72	3.0	3.0	3.0	2.9
33	2.6	2.6	2.6	2.5	73	3.0	3.0	3.0	2.9
34	2.6	2.6	2.6	2.5	74	3.0	3.0	3.0	2.9
35	2.7	2.6	2.6	2.5	75	3.0	3.0	3.0	2.9
36	2.7	2.7	2.6	2.5	76	3.0	3.0	3.0	2.9
37	2.7	2.7	2.6	2.5					
38	2.7	2.7	2.6	2.6					
39	2.7	2.7	2.7	2.6					
40	2.7	2.7	2.7	2.6					

METHOD FOR MEASURING AND INDICATING
THE SOIL MOISTURE
FROM THE PRACTICAL POINT OF VIEW

BY KISUKE TERADE

The majority of people know that the main element for the growth of vegetables are by the moisture of soil. Method of indication and measurement of this varies so much that it's quite difficult to compare the result of the research. So far the method was to indicate against dryness of the collected material or against the capacity or capacity of moisture in the soil. But, if the soil differs the specific gravity differs too. Therefore, though they contain same amount of moisture, they do not show the same result. Furthermore, these figures were indicated by percentage (%) so it was very difficult to know immediately that how these figures were effecting physically to the vegetables.

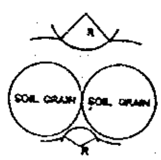
I, therefore, would like to state the following method of indication and explain the measuring instrument which was designed for the purpose of finding the soil moisture.

1. <u>Method for Dynamical Indication of Moisture in the Soil</u>

As the soil dries, the water-film around the soil grain become thin and the pressure below this surface grow great. (Fig. 1) "Pressure" in simple formula are:

$$P = (\frac{1}{R_1} + \frac{1}{R_2})T, \text{ if } R_1 = R_2, \text{ it will be}$$

$$P = 2T/R.$$



P : Adhering strength of water around the soil grain. (Negative pressure)

R : Radius of curvature

T : Surface tension of water

Fig. 1

Buchingham indicated this "P" by the height of water column (unit of mm), and named it as Capillary Potential. Later, Richard, Shaw and Gardener stressed that this method is valuable to agriculture. But all of these people's methods were different from that of Buchingham and were indicated by the height of mercury column. What the writer wish to stress on this page is none other than this method. I presume, the reason for not having this method generalized was not able to measure it simpler.

2. <u>Measurement for Dynamical Indication</u>

This is special ceramic cup with special made vacuum gauge attached to it. Size of the cup is 3 cm inner diameter, 4 cm outer diameter, 0.5 m thickness and 10 cm in height. This gauge is graduated by height of mercury column up to 760 mm. When using, bury the part of the cup which is filled with the water boiled to the point of removing the air, in the ground where you want to measure. At such time, it is necessary to have the cup and soil closely adhered of the hand of the gauge may not move delicately. And system of soil must be carefully laid in natural condition.

3. <u>Illustration of Couple Observation</u>

Place: South 16, West 9, Sapporo, Hokkaido, Japan. Observation started at the evining of Aug. 15, 1952. We buried the cup 10 cm deep in the ground at the corner of the vegetable garden (where less pebles). And from the 16th. on to October 4th. for 50 days the observation was carried 5 times a day, on 8 a.m., 10 a.m., 2 p.m., 4 p.m., and 6 p.m. According to this observation, it showed 355 mm by non of 19th. but there was a heavy rain storm following a typhoon and the gauge went down to zero (0). Later the weather recovered and it showed 130 mm on the 24th. It went down again due to little rain but soon started to go up following the weather and on Sept. 3rd, it showed 260 mm. It goes up and down according to the dryness and rainfall. This indicate the changes of soil moisture are by the dryness and rainfall.

According to this chart the dryness of the soil on Aug. 18th. was remarkable and it showed 335 mm, and when it showed the dampness, was due to the rainfall and they were on Aug. 19th., Sept. 5th., Sept. 25th., and on the 26th.

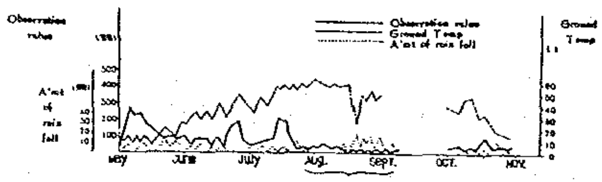
Plantfied at Bifuka: The observation was carried out for 60 day from May 1st., 1952 to Oct., 30th. It disclosed the bearing between the amount of rainfall, temperature and humidity. The observation took place 3 times a day at 8. a.m. 12 noon and 3 p.m. and we took the average.

Pebble	soil Fine grain	Rough grain soil	Fine sand	sand Super fine	Clay	Soil
(%) 1.70	(%) 98.30	(%) 6.80	(%) 16.05	(%) 25.20	(%) 50.95	less pebble

Height of mercury column (mm)(H)	48	90	122	154	232	248	354	372	402	419
(against indication A'mt of moisture of measurement) %(G)	60	37	32	31	24	23	20	20	19	18

according to this chart, it does not show the clear bearing between temperature, underground temperature and h midity, but it does show the connection between rainfall, like it did in Sapporo. The highest one during the observation was 270 mm on May 9th. But since it was on the plant field, if changed the soil moisture by the irrigation and feeding fertilizer, and it does not necessarily coincide with that of natural condition.

For instance, during July 25th. and Aug. 19th., though there was no rainfall, it did not go up becauce of irrigation. And like after September, when the temperature drops, though no rainfall, the evaporation of the soil moisture slacked and the observation value did not easily go up. (Fig. 2)



Irrigation term   It indicate fower and average at the irrigation term

Fig. 2

4. Method of Conversing Observation Value to Soil Moisture

In order to know the amount of moisture from the observation value, measure the observation on each step and the amount of moisture, (either dampness, dryness, capacity and it's moisture amount) and make a graph or experiment formula beforehand. I shall explain from the observation at Bifuka plant field as example. The physical characteristics of this soil of plant field are as follows.

Hyperbola of this is expressed by:

$H = 145.500G^{-2.2012}$ and substitute with the actual observation value.

Accordingly, if we know the observation value (H), we will know the amount of moisture (G). (Fig. 3).

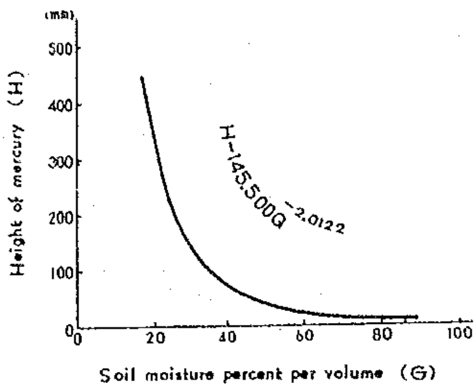


Fig. 3

As started above, the writer insist to indicate with the height of mercury for Dynamical Indication of soil moisture from the practical point of view and announced the couple observation made with this newly designed instrument at the same time. When this indication method is used, it is much easier to learn the physiological bearing against vegetables than by indication of percentage.

For example, the growth of sweet potatoes are restrained at 250 - 300 mm and apples at 400 mm and soon they stop growing as the growth of tobacco stops at 240 mm.

Accordingly, if the point of suspension of growth and wither point of each vegetable is known, this indication will show the physiological effect of soil moisture against the vegetables. Therefore, this method has more practical value than by that of percentage system. It was also learned that is is possible for a long term observation by this simple measuring instrument. The research subject, such as how it effects the growing vegetable if the gauge goes up and keeps the certain degree for sometime and so forth, is remain to be seen.

TENSIOMETER DATA SHEET

month , 19 .

date	time	weather	lot No.	20 cm		40 cm		80 cm		150 cm		notes ,
				(cmHg)	PF	(cmHg)	PF	(cmHg)	PF	(cmHg)	PF	

calculation of PF

- reading of gauge cmHg
- calibrate to water height

$$\frac{\qquad \times 1{,}033}{76} = \qquad \text{cm} \quad \ldots\ldots \quad (1)$$

- PF = log ((1) − x)

where, x : each length of tensiometer

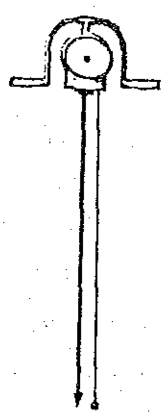
7 - 10. SELF-RECORDING CONE PENETROMETER

SELF-RECORDING CONE PENETROMETER

Being developed from the usual proving ring type, this penetrometer is newly designed to automatically record both penetration depth and cone bearing capacity at the same time, and is the most convenient instrument for the determination of bearing capacity of soils or for compaction control.

* Specifications

Maximum capacity:	100 kg
Continuous measurement depth:	100 cm
Recording paper:	carbon-stailess paper
Cone bearing capacity:	0 - 15 kg/cm^2 (in case of cone area 6.45 cm^2)
	0 - 30 kg/cm^2 (in case of cone area 3.23 cm^2)
Measurement depth:	0 - 100 cm, one graduation 5 cm
Cone area:	6.45 cm^2 and 3.23 cm^2
Cone top:	30 degree



* A set consists of

Recording proving ring with a handle	..... 1 pc.
Extention rod (50 cm)	..... 2 pcs.
Cone	..... 2 pcs.
Spanner	..... 2 pcs.
Recording paper	..... 1 pack.
Carrying case	..... 1 pc.

* <u>Operation</u>

1) For assembly of this unit, as illustrated in Fig. 1, assemble the rod (2) and top cone (3) to the recording proving ring (1) with a handle. Prior to starting test, if there is any mixture of debris on surface course, dig them up in such a way that natural ground is exposed.

2) Standing erect this unit on the ground vertically, set the weight (5) at the tape (4) and put on the ground. When the top of cone and weight will be to touch together, adjust the recording pen to ZERO point on the chart.

3) Grasp the handle and give pressure vertically so that no shock is given or it is not inclined. Penetrate the top cone gently at a speed of 1 cm/sec or so.

4) Measurement on penetrating load must be made more than twice in the same testing point in order to seek for the mean value according to each measuring depth.

Fig. 1

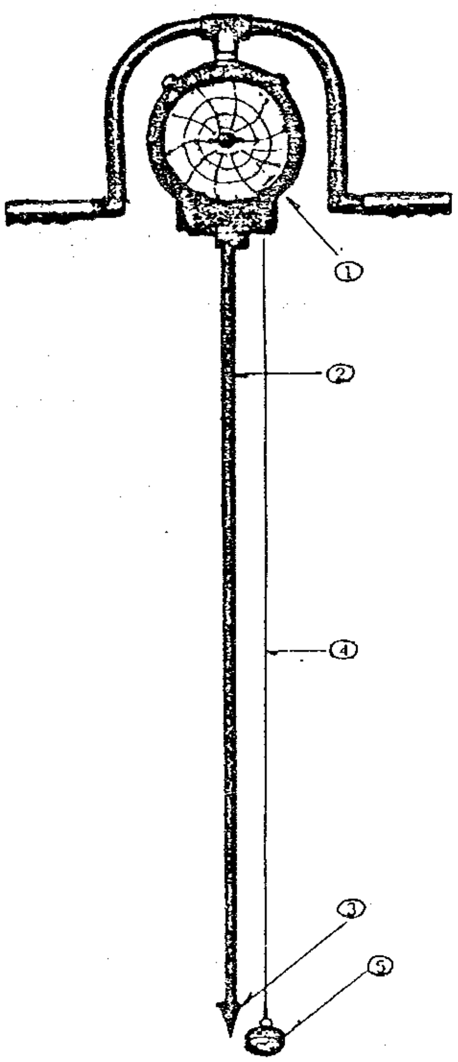
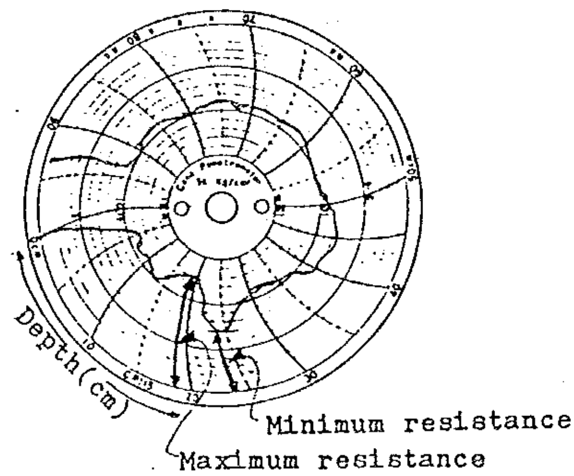


Fig. 2



* Calculation

1) The penetration resistance can be sought for by the following equation.

$$qc = \frac{P}{A}$$

Where, qc : penetration resistance

A : cone corss area

P : cone penetration load

2) The bearing capacity can be sought for by the following equation.

$$qa = a\frac{P}{A} = a.qc$$

Where, qa : converted bearing capacity

a : 0.1 to 0.2 bearing capacity converting factor

3) For converting the bearing capacity (kg/cm^2) sought from the above equation to a unit of t/m^2, multiply it by 10.

* In order to seek for cohesion (C) of cohesive soil

1) The following equations can be established from the comparative test results of penetration resistance (qc) in cohesive soil and unconfined compression strength (qu) though it depends on cohesive soil.

$$qc \fallingdotseq 5\ qu \text{ (unit is } kg/cm^2) \quad ..... \quad (1)$$

2) Generally speaking, if internal frictional angle can be regarded to be $\phi = 0$:

$$qu \fallingdotseq 2\ C \quad ..... \quad (2)$$

3) From equation (1) and (2),

qc ≒ 10; where, C = cohesion of cohesive soil.

Therefore,

$$C : \frac{1}{10}\ qc$$

That is, the cohesion of cohesive soil can be sought as 1/10 of the bearing capacity.

* On the bearing capacity of the foundation actually

1) In order to pass judgement on the bearing capacity of the foundation actually, if the minimum value shown by the penetrometer is taken in a range up to the depth which is 2 times as much as foundation width under foundation bottom, it will be safe.

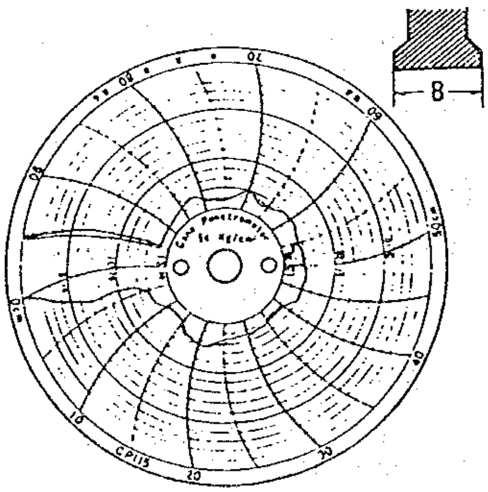
2) The bearing capacity converting factor a = 0.1 to 0.2 is the roughly calculated value obtained in the course of studying in the soil engineering laboratory of the Railway Technical Research Institute of Japan.

3) When the loading area of the cone is made to be made larger, the value of penetration resistance will approach the flat plate loading test value. The penetration resistance is considered to be a value in proportion to the bearing capacity.

4) Accordingly, if this value is multiplied by an appropriate constant, the presumed value of bearing capacity can be sought for. Therefore, with a = 0.1 to 0.2, a calculation equation seeking for the presumed bearing capacity.

5) From this chart, if the presumed bearing capacity when a foundation base of 1 m width is placed 1 m below surface is 12 t/m^2, it will be safe.

Fig. 3.



* Cautions for handling of this unit

1) If the cone penetration resistance is 15 to 17 kg/cm^2 (31 kg/cm^2 in case of small cone), the soil layer is not object for application even if it is cohesive soil. If forced to do so, the rod will be broken.

2) If the top cone pushes stones or gravels, the penetration load will become large markedly. Pay attention to it fully. In such a case, stop the test and change the position and conduct the test again.

7 - 11. CORN PENETROMETER

* Outline and Scope

This unit gets a grop on the outline of weak foundation section (hard and soft, compacting condition, and arranging condition of soil), makes rapid measurement on the depth of weak foundation and cohesion of cohesive soil, and makes a theoretical presumption of bearing capacity.

A rod provided with a cone is pushed into ground statically by human labour and measurement is made on the change of penetration load in each depth by means of a proving ring.

The object ground of this unit is weak foundation and the limit of measuring depth is normally 5 meters.

* Constitution

The constitution of this unit is as follows and shown in Fig. 1.

1. Handle for pushing-in .... 1 pc.
2. Proving ring (capacity 100 kg) .... 1 unit
3. Top cones (top angle 30^{o}) .... 2 pcs.
4. Extension rods (50 cm) .... 10 pcs.

Accessories:

Single ended spanners .... 2 pcs.
Carrying wooden case ofr main parts .... 1 pc.
Carrying canvas sack for extension rods ...... 1 pc.

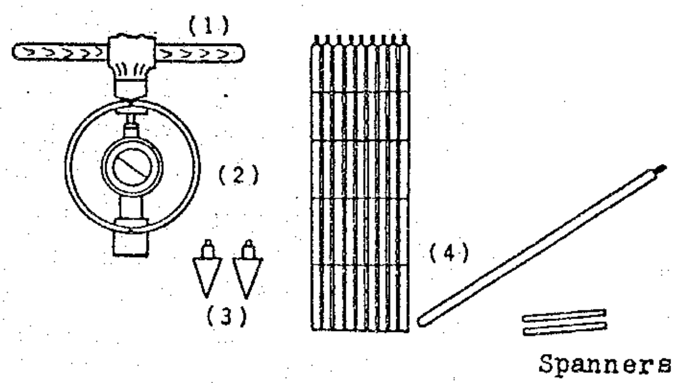


Fig. 1

* Usage

1. For assembly of this unit, as illustrated in Fig. 2, assemble the rod (3) and top cone (4) to the proving ring (2) with a handle (1). Prior to starting test, if there is any mixture of debris on surface course, dig them up in such a way that natural ground is exposed.

2. Standing erect the cone penetrometer on the ground vertically, turn the dial gauge of the ring (2) in such a way that only the weight of the handle (1) is given to the proving ring (condition of applying no manual force) and adjust the big pointer to ZERO.

3. Standing erect this unit on the ground to be tested, grasp the handle (1) and give pressure vertically so that no shock is given or it is not inclined. Penetrate the top cone (4) gently at a speed of 1 cm/sec. or so.

4. Whenever the marked line (marked line is provided with each 5 cm) at intervals of 10 cm provided in rod (3) passes through the surface, read off the dial gauge of the proving ring (2) and seek for the penetrating load. For reading off of the dial gauge for seeking for penetration load, when the marked line of 10 cm is in accord with the surface, stop penetrating, and give pressure to it again. Then, read off the dial gauge the moment the cone (4) starts moving.

5. Measurement on penetrating load must be made more than twice in the same testing point in order to seek for the mean value according to each measuring depth.

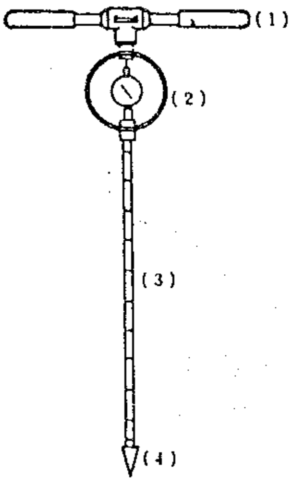


Fig. 2

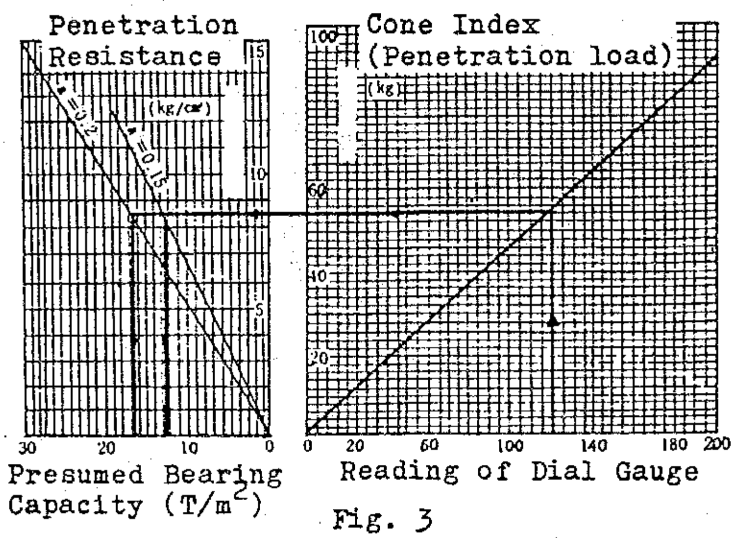


Fig. 3

* Calculation

1. From the reading of the dial gauge sought, the bearing capacity must be sought for, as follows.

   If the reading of the dial gauge is 120, the cone index (penetration load) is 54 kg and penetration resistance is 85 kg/cm^2 in Fig. 3. The presumed bearing capacity is 12.6 T/m^2 when a = 0.15 and 16.8 T/m^2 when a = 0.2

   That is, the read off value at penetration can be converted to the presumed bearing capacity (T/m^2) immediately at site by employing a chart (Fig. 3).

* Cautions for handling of this unit

1. If the cone penetration resistance is 15 to 17 kg/cm^2 (penetration load 100 to 110 kg), the soil layer is not object for application even if it is cohesive soil. If forced to do so, the rod will be broken.

2. If the top cone pushes stones or gravels, the penetration load will become large markedly. Pay attention to it fully. In such a case, stop the test and change the position and conduct the test again.

3. The limit of measuring depth by this unit differs considerably depending on weakness of soil. Usually, it is 5 m. If weak, measurement can be made up to 10 m (5 m with the attached rod of this unit). If more than 5 m, the peripheral friction of the rod will be increased and it must be corrected for removing it. For correction, comparison can be made with the measured value (taking into consideration rod weight) by this unit in the auger boring hole (checking the condition of soil at test point, general judgement is passed on it, taking into consideration the results of the test in order to make presumption) and the vane shear test results.

(NO. /)

CONE PENETRATION TEST DATA SHEET

Date:		Weather		Place	
Time:		Surveyor			
Lot Condition:					
Implement:	Cone angle	30°	Cone area	6.45 cm^2, 3.23 cm^2	

1st.		2nd.		3rd		a e	Cone Index	Remark
Depth	Dial Gauge	Depth	Dial Gauge	Depth	Dial Gauge	Dial Gauge	qc(kg/cm^2)	
cm m								↑ Initial number ↓
0 – 5		0 – 5		0 – 5				
5 – 10		5 – 10		5 – 10				
10 – 15		10 – 15		10 – 15				
15 – 20		15 – 20		15 – 20				
20 – 25		20 – 25		20 – 25				
25 – 30		25 – 30		25 – 30				
30 – 25		30 – 35		30 – 35				
35 – 40		35 – 40		35 – 40				
40 – 45		40 – 45		40 – 45				
45 – 50		45 – 50		45 – 50				
50 – 55		50 – 55		50 – 55				
55 – 60		55 – 60		55 – 60				
60 – 65		60 – 65		60 – 65				
65 – 70		65 – 70		65 – 70				
70 – 75		70 – 75		70 – 75				
75 – 80		75 – 80		75 – 80				
80 – 85		80 – 85		80 – 85				
85 – 90		85 – 90		85 – 90				
90 – 95		90 – 95		90 – 95				
95 –100		95 –100		95 –100				

$qc = (0.3378X + 0.9914)/6.45$

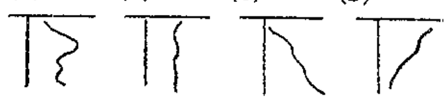
Initial Number		Soil Hardness Type	
Suffix Number		Judgement Mark	

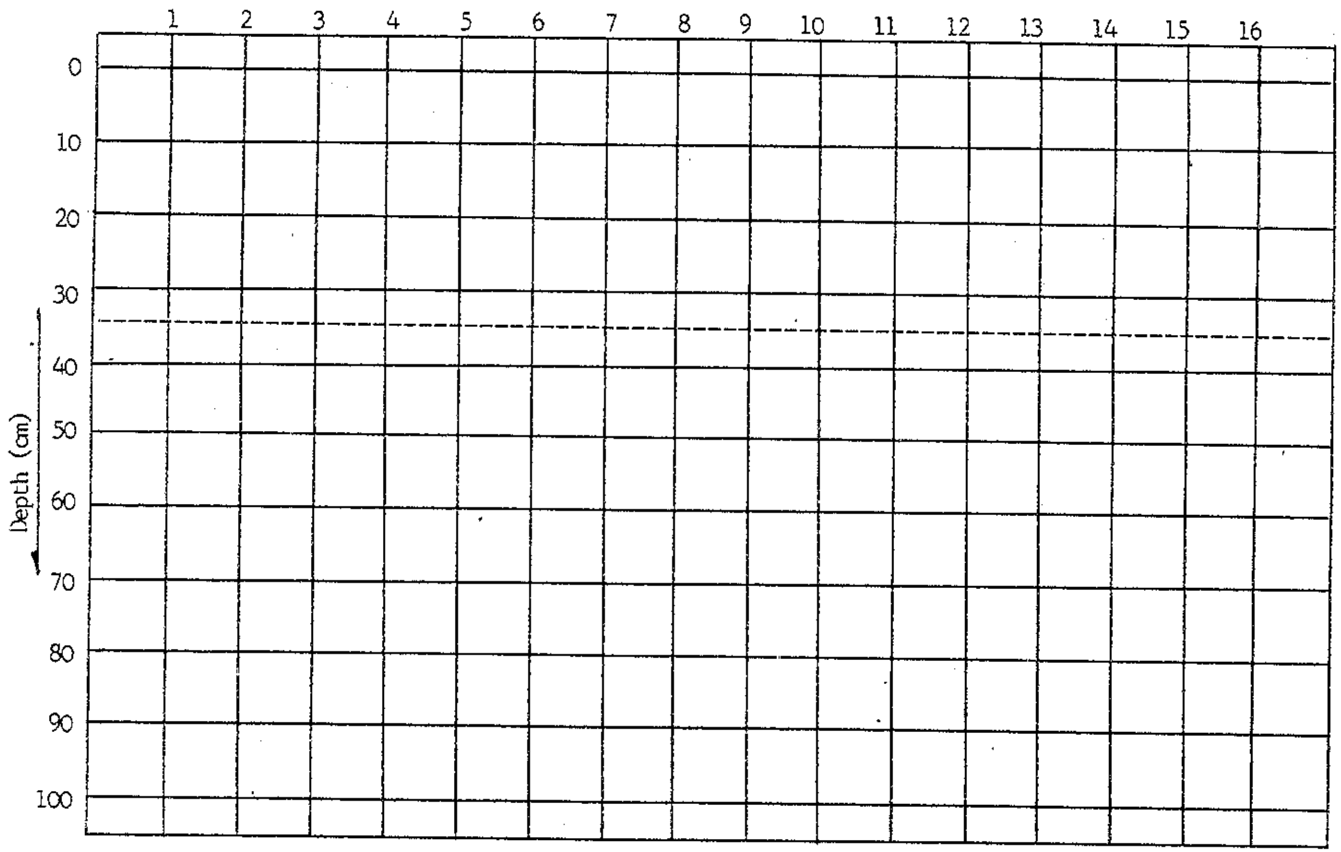
Figure – Soil Hardness

Cone Index qc (kg/cm^2)

Soil Hardness Type:

(A) (B) (C) (D)



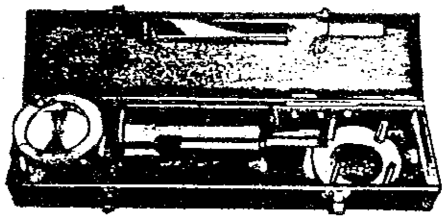


7 - 12 SOIL RESISTANCE TESTER (SR-2)

SOIL RESISTANCE TESTER

Model SR-2

This tester is used for predicting the trafficability of tractor and other off-the-road vehicles and the draft of soil engaging implements, by measuring cone penetrating resistance, rectangular plate sinkage, shear and frictional resistances of soil.



* Specifications

Designed by:	Institute of Agricultural Machinery
Overall length:	650 mm
Weight:	6.4 kg
Spring:	25 & 50 kg (2 kings)
Measuring depth:	400 mm
Torque wrench:	0.05 - 2 kg-m
Resistance parts:	(Exchange of the tip end makes it possible to make various measurements on resistance)
Cone A:	top angle 30^{o}, length 30 mm, base area 2 cm^2
Cone B:	top angle 30^{o}, length 51 mm, base area 6 cm^2
Rectangular plate A:	50 x 100 x 10 mm
Rectangular plate B:	25 x 100 x 10 mm
Shear ring:	inner diameter 60 mm, outer diameter 100 mm, with grouser
Friction ring:	inner diameter 60 mm, outer diameter 100 mm, without grouser
Case:	metallic box, hand carrying type

* Measuring Method

Operating and reading (or recording) are done by two (or one) persons.

1) For cone penetrating test, 50 kg spring is used and cone (small or large according to the soil condition) is attached to the tip of rod.

   Normal load is applied from the top of instrument by both hands, and penetrating resistance (kg) at each depth is read. The resistance at 0 depth is read when the base of cone is on the same level as ground surface. The operator then applies normal load successively and the recorder reads the resistance at intervals of 5 cm (or any other interval by the purpose of test).

   N.B.: The reading when the instrument is placed on the ground is not zero, which shows the weight of the instrument.

2) For sinkage test, rectangular plate (small or large) is attached in place of cone. Sinkage (cm) of plate is read at intervals of 10 kg load (or any other intervals).

3) For shear or friction test, the nurled sleeve on the upper side of spring box is removed and 25 kg spring is inserted in place of 50 kg spring. Shear or friction ring is attached to the tip of rod.

   The grousers of shear ring is penetrated into the soil. Normal load is applied by left hand and torque is applied with torque wrench by ringt hand, and maximum torque (kg-m) is read. The same process is repeated at the intervals of 5 kg normal load.

* Treatment of Data

1) Prediction of trafficability:

   The trafficability of tractor can be predicted from Table 1, using cone index (penetrating resistance divided by base area of the cone) or sinkage of rectangular plate.

Table 1. Prediction of trafficability

Instrument	Operation	Trafficability		
		Easy	Possible	Impossible
Cone Index (kg/cm^2)	Rotary tilling	More than 5.0	2.5 - 5.0	Less than 2.5
	Plowing	More than 6.5	4.0 - 6.5	Less than 4.0
	Plowing (with girdle)	More than 3.5	2.0 - 3.5	Less than 2.0
Plate sinkage (cm)	Rotary tilling	Less than 6.0	6.0 - 10.5	More than 10.5
	Plowing	0	0 - 3.0	More than 3.0
	Plowing (with girdle)	Less than 3.5	3.5 - 11.0	More than 11.0

Note: Cone: top angle 30°, base area 2 cm^2, mean value in the range of 0 to 15 cm depth.

Plate: rectangular plate 10 x 2.5 cm, pressure 1.6 kg/cm^2

2) Prediction of sinkage:

The relation between pressure and sinkage of rectangular plate is expressed by the following equation reduced by M.C. Bekker.

$$P = \left(\frac{Kc}{b} + K\phi\right) Z^n \quad \ldots\ldots\ldots \quad (1)$$

where, P: normal pressure (kg/cm^2)

Z: sinkage (cm)

b: width of plate (cm)

Kc, $K\phi$: coefficient of deformation

n: exponent of sinkage

The relation between pressure P and sinkage Z is almost linear as shown in Fig. 2. The exponent of sinkage n can be calculated by $\tan\alpha = n$. The a_1 and a_2 on the abscissa show $\left(\frac{Kc}{b} + K\phi\right)$,

and $a_1 = \frac{Kc}{b_1} + K\phi$

$a_2 = \frac{Kc}{b_2} + K\phi$

then,

$$K_c = \frac{(a_1 - a_2)b_1 b_2}{b_2 - b_1} = \frac{(a_1 - a_2) - 2.5 \times 5}{5 - 2.5}$$

$$= 5(a_1 - a_2)$$

$$K\phi = \frac{a_2 b_2 - a_1 b_1}{b_2 - b_1} = \frac{5a_2 - 2.5a_1}{5 - 2.5} = 2a_2 - a_1$$

The sinkage of running device can be calculated by the following equation, knowing n, Kc, $K\phi$, b and P.

$$Z = \left(\frac{P}{\frac{Kc}{b} + K\phi} \right)^{1/n} \quad \ldots\ldots\ldots\ldots \quad (2)$$

3) Shear and friction test:

Shear or friction resistance can be calculated from ring torque by the following equation.

$$S = \frac{3T \times 100}{2\ (r_1^3 - r_2^3)} \fallingdotseq \frac{T}{2} \quad \ldots\ldots\ldots\ldots \quad (3)$$

where, S: shear or friction resistance (kg/cm^2)

T: torque (kg-m)

r_1: ring outer radius (cm) = 5 cm

r_2: ring inner radius (cm) = 3 cm

By plotting shear or frictional resistance at several normal load, cohesion c and internal friction angle ϕ, or adhesion a and external friction angle ϕ_o can be obtained as shown in Fig. 3.

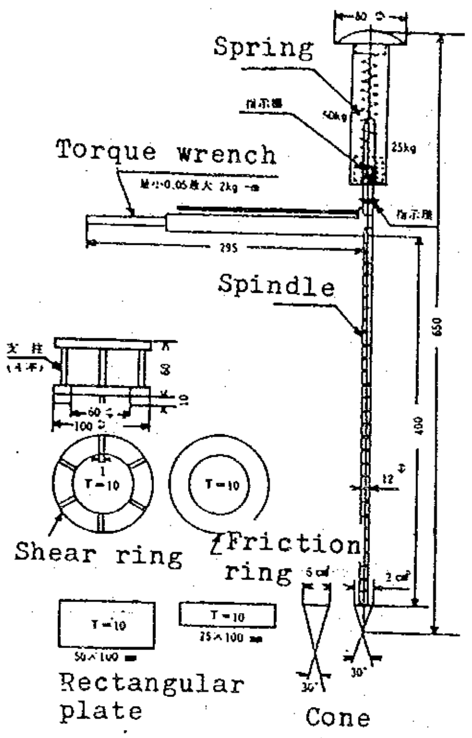


Fig. 1

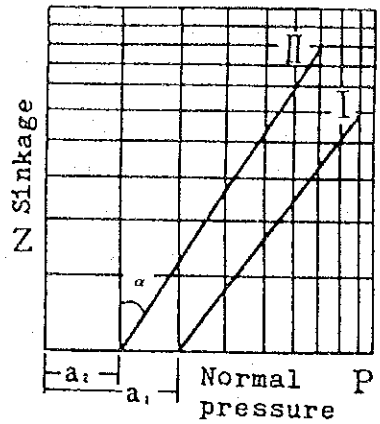


Fig. 2

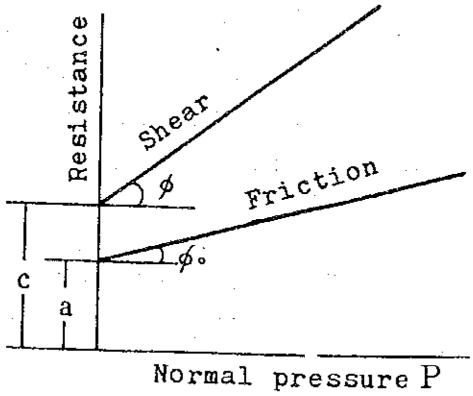


Fig. 3

SR - II DATA SHEET (1)

Date ______________________ Weather ______________

Place ______________________ Time ______________

Surveyer ______________________________________

Lot condition __________________________________

(1) Cone Penetration Test

Implement: spring: 25, 50 kg, cone: 30, area: 2.6 cm^2

depth (cm)	penetration load (kg) 1st.	2nd.	3rd.	ave. (kg)	qc (kg/cm^2)	*q6.45 (kg/cm^2)
0						
5						
10						
15						
20						
25						
30						
35						
40						

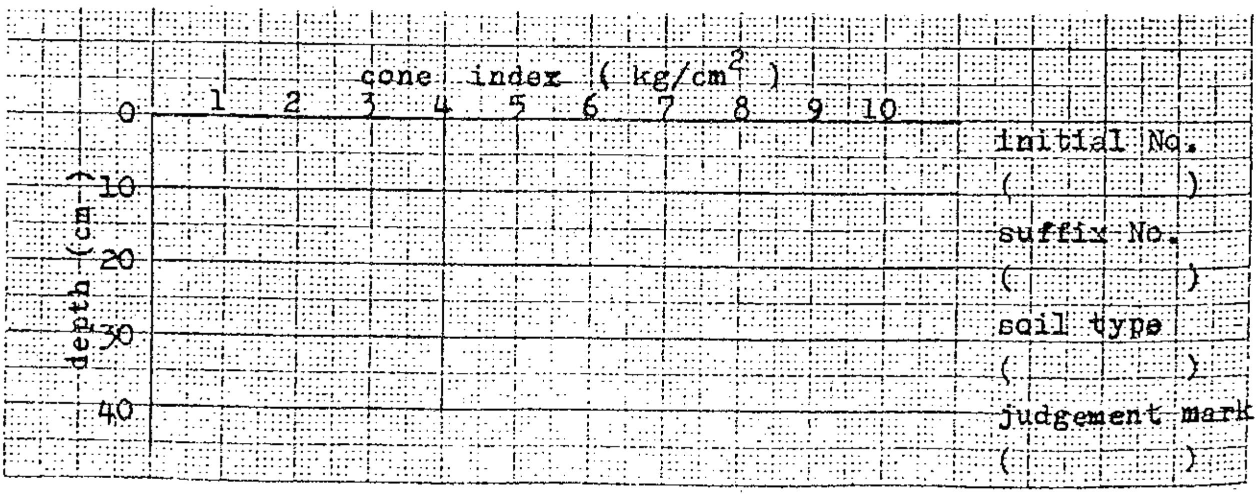
* $qn = q_c + 2.7\ (1/An - 1/A2)$

where, qn : calibrated cone index to 6.45 cm^2

qc : actual cone index

An : expected cone area to calibrate

A2 : actual cone area



SR - II DATA SHEET (2)

Date ________________ Weather ________________

Place ________________ Time ________________

Surveyer ________________________________

Lot condition ________________________________

(2) Settlement Test

Implement : spring : 25, 50 kg,
rectangular settlement plate : 50 x 100 x 10 (A plate)
25 x 100 x 10 (B plate)

surcharge (kg)	settlement (cm)								
	A plate				B plate				
	1st.	2nd.	3rd.	ave.	1st.	2nd.	3rd.	ave.	note
dead weight	-----	-----	-----	-----	-----	-----	-----	-----	
10	-----	-----	-----	-----	-----	-----	-----	-----	
20	-----	-----	-----	-----	-----	-----	-----	-----	
30	-----	-----	-----	-----	-----	-----	-----	-----	
40	-----	-----	-----	-----	-----	-----	-----	-----	
50	-----	-----	-----	-----	-----	-----	-----	-----	

* Surcharge-settlement Curve

$$P = \left(\frac{Kc}{b} + K\phi \right) Z^n$$

where, P : surcharge (kg/cm^2)

Z : settlement (cm)

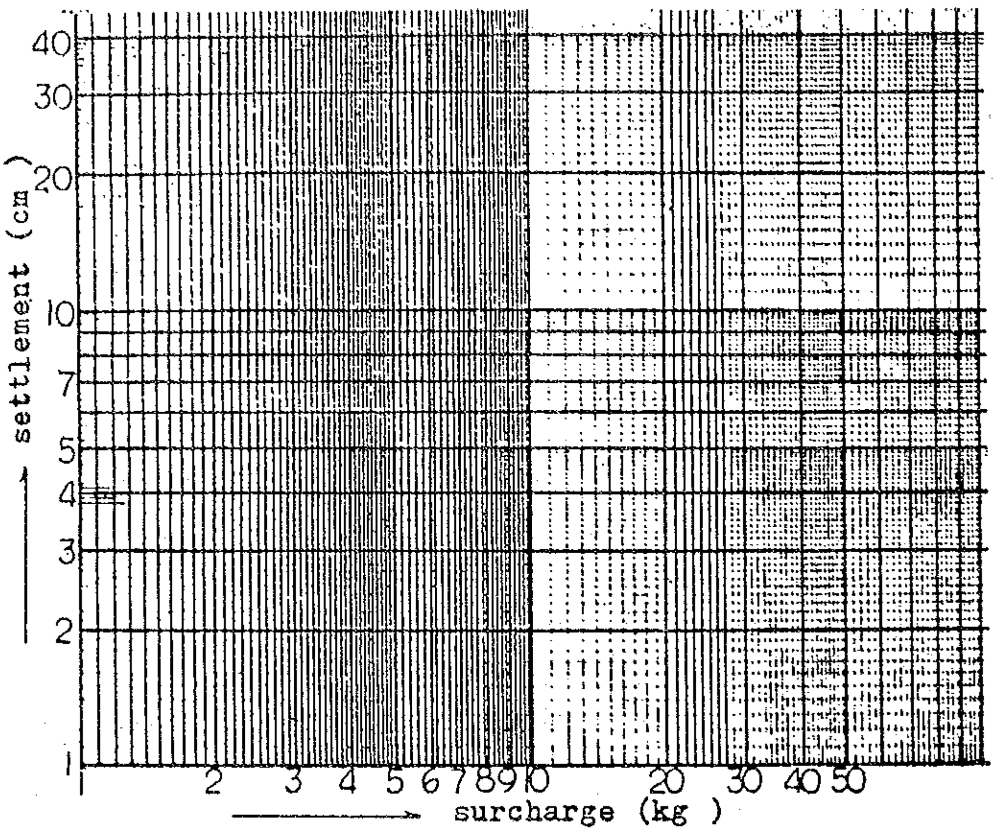
b : width of plate (cm)

Kc, K_ϕ: deformation coefficient

n : settlement index

The settlements that are measured by using both A and B type rectangular settlement plates are indicated in the logarithmic graph.

Fig. Surcharge - settlement graph



Calculation

1. Settlement index

$\tan\alpha$ = n

= surcharge/settlement

= (log - log)/ (log - log)

=

$\tan^{-1}$ = α

= ° ′ ″

2. Deformation coefficient

a1 = $Kc/b_A + K\phi$ .... (1)

a2 = $Kc/b + K\phi$ .... (2)

where, b_A = 5.0 cm

b_B = 2.5 cm

Kc = (a2 - a1) x 5.0 = (-) x 5.0 =

$K\phi$ = 2a1 - a2 = - =

∴ P = $(Kc/b + K\phi)\ Z^n$ = (/b +) Z

SR - II DATA SHEET (3)

Date ____________________ Weather ____________________

Place ____________________ Time ____________________

Surveyer ____

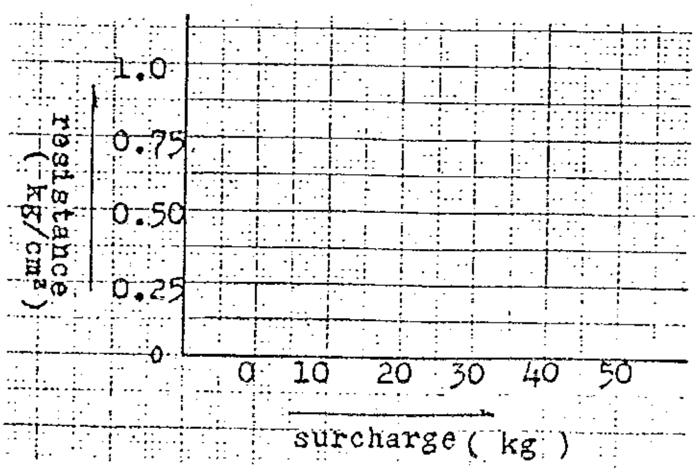
Lot condition ____

(3) Shear/Friction Test

Implement : spring : 25 kg, torque range : 0.05 - 2 kg-m,
shearing ring : 60 x 100 (6 wing)
friction ring : 60 x 100

surcharge (kg)	Max. torque (kg-m)				
	1st.	2nd.	3rd.	ave.	S (kg/cm^2)
dead weight					
5					
10					
15					
20					
25					

* Surcharge - resistance graph



- cohesion (C) =
- internal friction angle (ϕ) =
- adhesion (a) =
- external friction angle (ϕ_o) =

Calculation

$$S = \frac{3T \times 100}{2\pi (r1^3 - r2^3)} \doteqdot \frac{T}{2}$$

where, S : shear/friction resistance (kg/cm^2)

T : torque (kg - m)

r1 : outer radius = 5 cm

r2 : inner radius = 3 cm

--------- note ---------