ERRATA

Page	Line	Read	For
4	12 (from the bottom)	$\Delta H=H\theta^2/2(1-\cos\varphi)^2$,	$\Delta H=H\theta^2/2(1-\cos\varphi)$, ^{2}
	Table 2, Kakioka	ΔH	H
16	Table 8, (4)	Time (JST)	Time (GMT)
18	9 (from the bottom)	Magnetic	May

Intercomparison Observations at Kakioka and Memambetsu by means of QHM magnetometers during 1952~1953

By Tadao Kuboki and Kikuo Kurusu

§ 1. Introduction

It is a well-known fact that the geomagnetic intercomparison of the national standard instruments by means of QHM magnetometers has contributed very much to the maintenance of the geomagnetic national unit and world-wide cooperation of this branch of science. In 1952 the Kakioka Magnetic Observatory had an opportunity to carry out such an intercomparison observation with Cheltenham by the courtesy of V. Laursen, Chairman of the 7th Committee of IATME, and Robert W. Knox, Acting Director of U. S. Coast and Geodetic Survey. The observations were conducted at Kakioka and Memambetsu during December, 1952 to March, 1953 by means of three QHM magnetometers, No. 50, 51 and 52. This paper contains the results and some discussions regarding various sources of possible errors due to temperature, accuracy of horizontal circles and resolving power of telescope, and so on.

§ 2. Outline of QHM-Magnetometer

For the convenience of further explanation of the results, some brief description of this instrument will be given below. The main part of QHM-magnetometer consists of a suspension tube, telescope and counter-balance (Fig. 1). A small magnetic needle, approx. 1.5cm long and approx. 20 Γ magnetic moment, is suspended in the tube by means of a fine quartz fibre of 30~40μ in diameter. In general, the horizontal

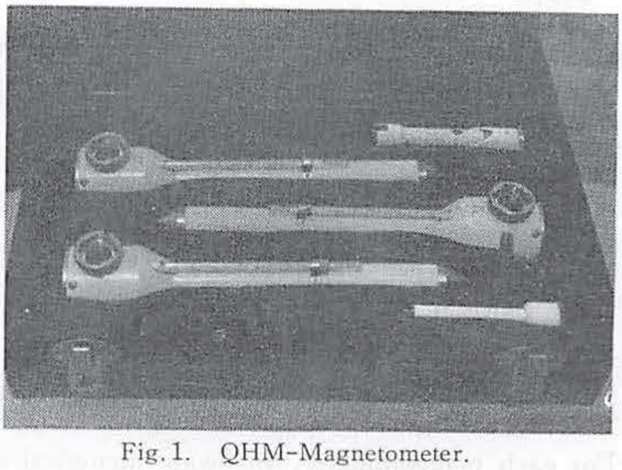

Fig. 1. QHM-Magnetometer.

circle prepared at each observatory is used for measuring the deflection angle of QHM. (Figs. 2 and 3.)

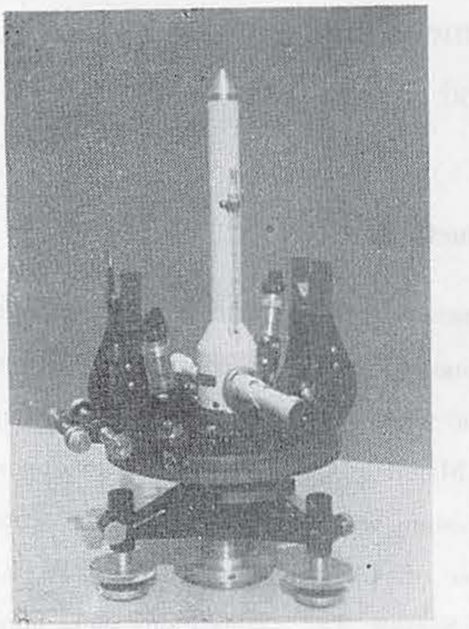

Fig. 2. QHM-Magnetometer installed on the horizontal circle of the "Nippon Suirobu" type magnetometer at Kakioka.

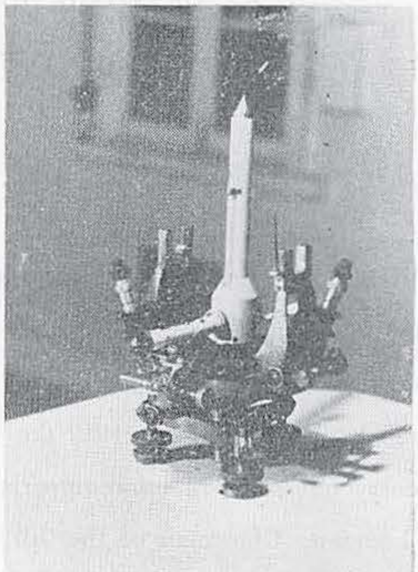

Fig. 3. QHM-Magnetometer installed on the horizontal circle of the "Nippon Suirobu" type magnetometer at Memambetsu.

Let H denotes the horizontal component of geomagnetic field, M the magnetic moment of the magnetic needle and T the torsion coefficient of the quartz fibre, then after La Cour, [1] the expression of H is given by,

$$H=\frac{2\pi T}{M}\cdot\frac{1}{\sin\varphi}. \qquad (1)$$

Taking the effects of temperature and magnetic induction into account, it becomes

$$H=\frac{2\pi T_0(1-\nu_T t)}{M_0(1-\nu_m t)(1+\mu H\cos\varphi)}\cdot\frac{1}{\sin\varphi}, \qquad (2)$$

where

M_0 : magnetic moment of magnetic needle at 0°C,

ν_T : temperature coefficient of torsion quartz fibre,

ν_m : temperature coefficient of magnetic moment,

t : temperature,

μ : induction coefficient of magnetic needle.

Since μ, ν_T, ν_m are generally of order of 10^{-4}, the expression (2) can be written approximately as follows;

$$\log H=C-\log\sin\varphi+c_1 t-c_2 H\cos\varphi. \qquad (3)$$

For each magnetometer, following numerical expressions[6] can be used,

$$\left.\begin{array}{ll}\log H=9.14770-\log\sin\varphi+0.000158\,t-0.0003\,H\cos\varphi\,; & \text{No. 50,}\\ \log H=9.14408-\log\sin\varphi+0.000149\,t-0.0004\,H\cos\varphi\,; & \text{No. 51,}\\ \log H=9.14930-\log\sin\varphi+0.000167\,t-0.0011\,H\cos\varphi\,: & \text{No. 52.}\end{array}\right\}\quad\cdots(3)$$

These numerical expressions are obtained at the torsion of 2π, but if both sides of mirrors attached to the magnetic needle are used, that is to say, on the observations at the torsions of 3π and 4π more accurate result can be obtained in lower magnetic latitudes. For such torsions, the reduction formulae are given as follows;

$$\left.\begin{array}{ll}\log H=C-\log\sin\varphi+C_1\,t-C_2\,H\cos\varphi & ;2\pi,\\ \log H=C-\log{}^{1}/_{2}-\log\sin\varphi'+C_1 t-C_2\,H\cos\varphi' & ;\ \pi,\\ \log H=C+\log{}^{3}/_{2}-\log\sin\varphi''+C_1\,t-C_2\,H\cos\varphi'' & ;3\pi,\\ \log H=C+\log 2-\log\sin\varphi'''+C_1\,t-C_2\,H\cos\varphi''' & ;4\pi,\\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots & ;\ \ .\end{array}\right\}\quad\cdots\cdots\cdots(3)''$$

In the case of π, deflection angles φ' are too small in the middle and lower latitudes to obtain an accurate measurment as mentioned in the next paragraph. Therefore, all observations at this time were made at the torsion of 2π, 3π and 4π.

§ 3. Possible errors of observations

(1) Errors of φ

The errors of φ are originated in both the accuracy of a horizontal circle used as well as the resolving power of the attached telescope.

The smallest readings of our horizontal circles used are $0.2'$ for the "Nippon Suirobu" type magnetometer (Japanese Hydrographic Office pattern; a sine galvanometer), and then possible errors introduced from the horizontal circle are of the order $0.1'\sim0.2'$. Meanwhile, the angle scale value for one division of the QHM-telescope is $5'$ and then even if the telescope scale is read to $^{1}/_{10}$ division, namely to $0.5'$, the principal part of errors of φ can be introduced from the telescope reading. On the other hand, the error of H due to φ can be estimated by the following expression;

$$\frac{\Delta H}{H}=-\cot\varphi\Delta\varphi.\quad\cdots\cdots\cdots\cdots(4)$$

If we accept an error $\Delta\varphi=0.5'$ for φ, values of $\Delta H/H$ for various angles of φ are given in Table 1.

In case of our observations, we can estimate possible errors of H, or ΔH, as

Table 1 Error due to $\Delta\varphi$ ($\Delta\varphi=0.'5$)

φ	$\Delta H/H$
20°	39.8×10^{-5}
30	25.1 〃
40	17.3 〃
50	12.2 〃
60	8.4 〃
70	5.3 〃
80	2.6 〃

shown in Table 2. If the telescope scale can be read to $^1/_{20}$ division the errors become one half of these values.

If we want, therefore, to maintain the accuracy of 1γ at such stations of the larger horizotal intensity as our observatories, we meet practically with various difficulties in technique of observations and design of instruments.

Table 2. ΔH at Kakioka and Memambetsu

	Kakioka			Memambetsu		
Torsion	φ	$\Delta H/H$	H	φ	$\Delta H/H$	ΔH
2π	28°	27.3×10^{-5}	8.2γ	32°	23.5×10^{-5}	6.2γ
3π	45°	14.5×10^{-5}	4.3γ	53°	11.1×10^{-5}	2.9γ
4π	70°	5.3×10^{-5}	1.6γ	—	—	—

(2) Errors due to the deviation of φ

The value of φ in (1) is given by the mean of two deflection angles corresponding to clockwise and anticlockwise torsions, but generally they have different values. Then, let these two values of deflection be a_1 and a_2, and one half of difference between them be θ, and we have[2]

$$\left.\begin{aligned} &\Delta H = H\theta^2/2(1-\cos\varphi)^2, \\ \text{or}\quad &\theta\,(\text{in minutes}) < \sqrt{\Delta H(1-\cos\varphi)^2/H\times4.23\times10^{-8}} \\ &\qquad = \sqrt{2.36\times10^7\frac{\Delta H}{H}(1-\cos\varphi)^2}\,, \end{aligned}\right\} \quad\cdots\cdots\cdots\cdots (5)$$

where $a_1=\varphi+\theta$, $a_2=\varphi-\theta$,

$$\varphi=\frac{a_1+a_2}{2}, \qquad \theta=\frac{a_1-a_2}{2}.$$

At the Kakioka Magnetic Observatory ($H=0.3011\Gamma$) the conditions under which errors are less than 0.5γ are as follows;

$\theta<2.3'$, when the torsion is 2π and $\varphi=28°$,

$\theta<5.8'$, when the torsion is 3π and $\varphi=45°$,

$\theta<13.0'$, when the torsion is 4π and $\varphi=70°$.

In our observations, the maximum values of θ observed at Kakioka, amount to only $1.0'$, $3.5'$ and $2.5'$ for the torsion of 2π, 3π and 4π, respectively. While at the

Memambetsu Magnetic Observatory, they were also about one half of the expected values corresponding to H there. Thus, it can be said that the errors due to θ are negligibly small as far as our present comparison observations are concerned.

(3) Errors due to temperature

The temperature coefficients of the three QHM's No. 50, 51 and 52, are all about $11\gamma/c°$ when reduced to the horizontal intensity at Kakioka; that is, the error of H may become 1γ, even if the temperature is read to 0.1°C accurately.

On the other hand, as the temperature coefficient of quartz fibre is generally the order of 1×10^{-4}/°C, the error due to this factor might amount to the order of $3\sim4\gamma$ at Kakioka.

On the present writers has been able to keep the temperature coefficient of magnetic system of a variometer as low nearly equal to zero by means of magnetic shunt alloy[3].

However, for the present observation, such a devise is not valid, and it should be carefully taken into consideration that the instrument has a long torsion-tube and the face of an observer must be kept so near to the instrument that the uniformity of temperature of all portions of it could not be obtained within the limit of accuracy desired. The comparison observations, therefore, were so arranged as to begin when the temperature of the instrument had become unchanged by the presence of the observer by setting up an electric lamp of 40~60 watts at the position of the observer's face, at least two hours before the observation. By this means, it was seldom that the temperature was varied more than 0.3°C during one series of observations, which consisted of five measurements. On the other hand, at Kakioka the temperature of the absolute room, in which the present observations were made, has been controlled to change from vary in the range 0°C to 20°C, and was kept constant by means of the automatical thermostat during each series of observation at any individual day, and at Memambetsu artificially by the heat of a copper stove. In spite of these precautions, temperature-effect remained presumably to some extent.

Regarding the induction coeficients of those instruments, we adopted the new values[4], [6].

§ 4 Results of comparison observations at the Kakioka Magnetic Observatory.

The results of intercomparison observations at the Kakioka Magnetic Observatory are tabulated in Table 3. The adopted values for each day are given in unit of gamma, considering the order of errors as discussed in § 3. The accuracy of a magnetic theodolite to be compared with the QHM magnetometer is principally determined by the accuracy of base line value of magnetic variometer. For this reason, the comparison observation was conducted so as to cover as long a period as possible.

Table 3. Comparison observation with the Q. H. M. Kakioka Magnetic Observatory.

The figures of each column of the table are to be read as follows;

(11) Schmidt : Schmidt normal theodolite. No. 5 (North pillar in the New Absolute room)

(12) Diff : QHM-Schmidt.

(13) Suirobu : Nippon Suirobu type magnetometer. (Sine galvanometer). No. 15

(14) Diff : QHM-Suirobu. (Middle pillar in the New Absolute room, magnetometer circle No. 15 A)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	H QHM	Schmidt	Diff	Suirobu	Diff
		1952	h m	° ′	′	° ′	°C	′	γ	γ	γ	γ	γ
50	2 π	Dec. 8	1 14.3	27 57.45	0.0	27 57.45	7.3	0.3	30045	30051	− 6	30051	− 9
			18.7	57.9	0.0	57.9	7.55	0.2	40	51	−11	54	−14
			21.5	57.9	0.0	57.9	7.75	0.0	42	51	− 9	54	−12
			24.0	58.0	0.0	58.0	7.9	0.2	43	51	− 8	54	−11
			29.6	58.3	0.0	58.3	8.2	0.2	41	52	−11	55	−14
	〃	14	0 30.6	56.45	0.0	56.45	5.75	0.0	44	55	−11	57	−13
			33.4	56.3	0.0	56.3	5.9	0.1	48	55	− 7	57	− 9
			36.8	56.3	0.0	56.3	6.15	0.1	51	55	− 4	57	− 6
			39.9	66.5	0.0	56.5	6.25	0.0	49	54	− 5	56	− 7
	〃	18	5 40.4	57.05	+0.1	57.15	9.75	0.1	77	88	−11	92	−15
			44.9	56.85	0.0	56.85	9.8	0.0	82	89	− 7	93	−11
	〃	25	6 18.8	56.55	0.0	56.55	7.7	0.2	64	66	− 2	68	− 4
			25.0	56.8	−0.1	56.7	7.7	0.0	62	66	− 4	68	− 6
			30.0	56.6	+0.1	56.7	7.8	0.2	63	66	− 3	68	− 5
			35.5	56.9	−0.2	56.7	7.8	0.3	63	66	− 3	68	− 5
			41.0	56.85	0.0	56.85	7.8	0.2	60	65	− 5	67	− 7
		1953											
	〃	Jan. 23	5 46.3	54.8	0.0	54.8	5.8	0.2	73	80	− 7	81	− 8
			52.0	54.65	−0.2	54.45	5.8	0.05	78	83	− 5	84	− 6
			57.7	54.4	+0.1	54.5	5.8	0.2	77	83	− 6	84	− 7
			6 01.9	54.4	0.0	54.4	5.8	0.2	79	85	− 6	86	− 7
			06.3	54.4	+0.1	54.5	5.8	0.4	77	86	− 9	87	−10
	〃	28	6 33.3	55.4	0.0	55.4	5.60	0.4	64	70	− 6	70	− 6
			36.9	55.4	0.0	55.4	6.0	0.2	65	70	− 5	70	− 5
			39.9	55.7	−0.1	55.6	6.0	0.1	61	70	− 9	70	− 9
			43.6	55.8	−0.1	55.7	6.0	0.0	59	69	−10	69	−10
			46.6	55.65	−0.1	55.55	6.0	0.1	62	68	− 6	68	− 6
	〃	Mar. 3	6 05.5	28 01.9	0.0	01.9	18.0	0.4	89	101	−12	99	−10
			08.2	01.8	+0.5	02.3	18.1	0.2	83	99	−16	97	−14
			10.4	01.85	+0.2	02.05	18.0	0.0	86	100	−14	98	−12
			15.3	01.65	+0.1	01.75	18.0	0.3	91	97	− 6	95	− 4
	〃	11	5 33.9	27 59.9	0.0	59.9	12.3	1.25	59	66	− 7	66	− 7
			39.2	59.8	0.0	59.8	12.35	0.2	61	67	− 6	67	− 6
			44.5	59.8	+0.1	59.9	12.4	0.2	60	67	− 7	67	− 7
			49.2	28 00.0	−0.1	59.9	12.5	0.05	61	67	− 6	67	− 6
			52.9	00.2	+0.2	00.2	12.55	0.0	57	68	−11	68	−11

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	*H* QHM	Schmidt	Diff	Suirobu	Diff
		1953	h m	° ′	′	° ′	°C	′	γ	γ	γ	γ	γ
50	3π	Mar. 3	6 21.3	44 49.95	0.0	27 49.95	18.0	0.3	30086	30095	− 9	30093	− 7
			24.8	50.25	0.0	50.25	18.0	0.6	84	93	− 9	91	− 7
			27.8	50.45	−0.1	50.35	18.05	1.1	83	90	− 7	88	− 5
			36.4	51.9	0.0	51.6	18.15	1.4	73	86	−13	84	−11
	〃	11	6 12.4	46.15	+0.1	46.25	13.0	1.3	64	69	− 5	69	− 5
			17.7	46.35	0.0	46.35	13.1	0.9	64	69	− 5	69	− 5
			22.9	46.4	+0.1	46.5	13.1	1.15	63	70	− 7	70	− 7
			28.6	46.3	−0.1	46.2	13.1	0.85	65	71	− 6	71	− 6
			32.9	46.4	0.0	46.4	13.1	0.5	64	70	− 6	70	− 6
		1952											
	4π	Dec. 18	6 12.5	69 38.8	+0.1	69 38.9	10.4	1.3	30084	30087	− 3	30091	− 7
			17.0	38.15	0.0	38.15	10.4	2.0	86	87	− 1	91	− 5
			22.2	38.25	0.0	38.25	10.4	1.7	86	87	− 1	91	− 5
			26.6	38.65	0.0	38.65	10.45	1.1	86	88	− 2	92	− 6
			31.1	38.25	+0.1	38.35	10.4	1.5	86	88	− 2	92	− 6
	〃	25	5 41.9	34.2	0.0	34.2	6.85	1.0	60	64	− 4	66	− 6
			48.0	34.8	0.0	34.8	7.1	0.4	62	65	− 3	67	− 5
			53.5	35.6	0.0	35.6	7.4	1.2	62	65	− 3	67	− 5
			6 04.5	35.95	0.0	35.95	7.6	0.6	63	66	− 3	68	− 5
		1953											
	〃	Jan. 23	5 05.3	25.5	−0.1	25.4	5.5	2.3	75	79	− 4	80	− 5
			16.0	26.9	+0.1	27.0	5.55	0.7	70	76	− 6	77	− 7
			22.4	27.6	0.0	27.6	5.6	1.6	69	76	− 7	77	− 8
			28.4	27.7	−0.1	27.6	5.7	1.1	70	76	− 6	77	− 7
			34.1	27.6	−0.1	27.5	5.8	1.4	71	77	− 6	78	− 7
	〃	28	6 11.4	30.9	0.0	30.9	5.7	0.9	59	60	− 7	66	− 7
			15.7	30.7	0.0	30.7	5.8	1.0	60	67	− 7	67	− 7
			19.2	30.7	0.0	30.7	5.8	1.1	60	68	− 8	68	− 8
			22.3	30.35	0.0	30.35	5.8	1.1	62	69	− 7	69	− 7
			25.4	30.35	0.0	30.35	5.8	1.3	62	69	− 7	69	− 7
	〃	Mar. 3	6 43.2	70 07.4	+0.4	70 07.8	18.15	2.0	77	84	− 7	82	− 5
			46.5	07.2	+0.2	07.4	18.2	1.8	79	83	− 4	81	− 2
			49.0	08.0	0.0	08.0	18.2	3.2	77	83	− 6	81	− 4
			51.5	08.4	0.0	08.4	18.2	2.0	76	82	− 6	80	− 4
			54.6	09.0	0.0	09.0	18.2	2.2	74	78	− 4	76	− 2
	〃	11	6 50.6	69 53.4	+0.1	69 53.5	13.1	1.25	66	71	− 5	71	− 5
			56.1	54.0	0.0	54.0	13.1	0.6	65	71	− 6	71	− 6
			7 01.2	53.65	+0.1	53.75	13.1	0.8	66	71	− 5	71	− 5
			07.5	53.6	−0.2	53.4	13.1	0.4	67	72	− 5	72	− 5
			12.4	53.65	0.0	53.65	13.15	1.0	67	72	− 5	72	− 5

Reduction formula :

2π ; $\log H = 9.14770 - \log \sin \varphi + 0.000158\,t - 0.0003\,H \cos \varphi$

3π ; $\log H = 9.32379 - \log \sin \varphi + 0.000158\,t - 0.0003\,H \cos \varphi$

4π ; $\log H = 9.44873 - \log \sin \varphi + 0.000158\,t - 0.0003\,H \cos \varphi$.

(1) QHM No.	(2) Torsion	(3) Date	(4) Time (GMT)	(5) φ (obs)	(6) ΔD	(7) φ (corr)	(8) Temp.	(9) θ	(10) H QHM	(11) H Schmidt	(12) H Diff	(13) H Suirobu	(14) H Diff
			h m	° ′	′	° ′	°C	′	γ	γ	γ	γ	γ
51	2π	1952 Dec. 14	5 22.1	27 40.3	+0.1	27 40.4	6.55	0.1	30063	30064	− 1	30066	− 3
			30.1	40.65	0.0	40.65	6.7	0.2	67	66	+ 1	68	− 1
			32.7	40.45	0.0	40.45	6.75	0.2	64	66	− 2	68	− 4
			37.7	40.5	0.0	40.5	7.05	0.6	66	66	− 0	68	− 2
	〃	23	5 25.5	41.25	+0.1	41.35	8.7	0.0	69	74	− 5	77	− 8
			27.5	41.25	0.0	41.25	8.7	0.0	70	75	− 5	78	− 8
			31.4	41.25	0.0	41.25	8.7	0.0	70	76	− 6	79	− 9
			34.8	41.55	−0.1	41.45	8.7	0.3	68	76	− 8	79	−11
			39.8	41.15	0.0	41.15	8.75	0.2	73	76	− 3	79	− 6
	〃	1953 Jan. 24	2 26.2	40.3	0.0	40.3	8.4	0.3	84	84	0	85	− 1
			30.3	40.35	0.0	40.35	8.35	0.15	82	84	− 2	85	− 3
			36.1	40.3	0.0	40.3	8.3	0.5	83	85	− 2	86	− 3
			38.7	40.3	−0.1	40.2	8.3	0.5	84	85	− 1	86	− 2
	〃	29	1 19.1	40.6	0.0	40.6	5.55	0.2	49	57	− 8	57	− 8
			22.4	40.5	0.0	40.5	5.6	0.3	51	56	− 5	56	− 5
			25.0	40.6	−0.1	40.5	5.6	0.4	51	56	− 5	56	− 5
			27.7	40.6	+0.2	40.8	5.6	0.4	46	56	−10	56	−10
			30.3	40.55	−0.1	40.45	5.6	0.5	52	56	− 4	56	− 4
	〃	Mar. 4	6 08.2	47.6	0.0	47.6	19.7	0.4	78	86	− 8	85	− 7
			11.7	47.95	0.0	47.95	19.7	0.8	73	85	−12	84	−11
			13.8	47.75	0.0	47.75	19.7	0.7	76	86	−10	85	− 9
			17.9	47.6	0.0	47.6	19.7	0.4	79	85	− 6	84	− 5
	〃	12	4 55.1	44.0	0.0	44.0	13.9	0.0	78	86	− 8	86	− 8
			58.4	44.1	−0.1	44.0	13.9	0.05	79	87	− 8	87	− 8
			5 00.7	43.8	0.0	43.8	13.9	0.25	81	87	− 6	87	− 9
			03.5	44.05	−0.1	43.95	13.9	0.4	79	88	− 9	88	− 9
	3π	1953 Mar. 4	6 22.9	44 23.4	0.0	44 23.4	19.8	3.7	30076	30085	− 9	30084	− 8
			30.8	23.45	0.0	23.45	19.9	2.3	76	85	− 9	84	− 8
			33.2	23.45	0.0	23.45	19.9	2.4	77	85	− 8	84	− 7
			35.7	23.5	0.0	23.5	20.0	2.8	77	86	− 9	85	− 8
	〃	12	5 14.4	16.05	+0.1	16.15	14.0	4.5	81	88	− 7	88	− 7
			19.0	16.0	0.0	16.0	14.1	4.0	83	88	− 5	88	− 5
			22.8	15.9	0.0	15.9	14.1	3.9	84	88	− 4	88	− 4
			26.9	16.55	0.0	16.55	14.15	3.0	79	87	− 8	87	− 8
			30.7	16.55	0.0	16.55	14.12	3.4	79	86	− 7	86	− 7
	4π	1952 Dec. 23	3 18.6	68 21.45	0.0	68 21.45	8.1	0.6	30062	30062	0	30065	− 3
			24.3	21.45	0.0	21.45	8.1	0.8	62	63	−1	66	− 4
			30.4	21.45	0.0	21.45	8.2	0.8	64	63	+1	66	− 2
			35.9	22.4	−0.1	22.3	8.2	1.8	61	64	−3	67	− 6
	4π	1953 Jan. 24	1 47.3	68 17.3	−0.2	68 17.1	8.7	1.3	30084	30083	+ 1	30084	0
			56.9	16.98	0.0	17.0	8.65	1.25	84	83	+ 1	84	0
			2 03.5	17.2	0.0	17.2	8.6	0.6	82	83	− 1	84	− 2
			08.6	16.7	0.0	16.7	8.5	0.9	84	84	0	85	− 1
			14.2	17.0	−0.1	16.9	8.5	0.2	83	84	− 1	85	− 2
	〃	29	0 53.4	11.7	0.0	11.7	5.3	1.1	68	70	− 2	70	− 2
			56.7	12.7	0.0	12.7	5.4	1.9	65	68	− 3	68	− 3
			1 00.0	13.2	−0.2	13.0	5.4	1.2	64	67	− 3	67	− 3
			08.5	15.8	−0.1	15.7	5.35	2.4	55	58	− 3	58	− 3
			12.5	16.35	0.0	16.35	5.45	1.3	53	58	− 5	58	− 5
	〃	Mar. 4	6 42.6	52.6	0.0	52.6	20.05	0.0	79	85	− 6	84	− 5
			46.7	52.65	−0.1	52.55	20.05	1.0	79	86	− 7	85	− 6
			49.4	52.25	0.0	52.25	20.1	0.8	80	86	− 6	85	− 5
			52.1	52.1	−0.1	52.0	20.1	0.9	82	87	− 5	86	− 4
			54.4	52.6	0.0	52.6	20.1	0.4	79	87	− 8	86	− 7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	*H* QHM	*H* Schmidt	Diff.	Suirobu	Diff.
		1953	h m	° ′	′	° ′	°C	′	γ	γ	γ	γ	γ
51	4 π	Mar. 12	5 42.2	68 34.15	+0.1	68 34.25	14.3	0.5	30082	30085	− 3	30085	− 3
			48.8	34.65	−0.1	34.55	14.3	1.0	82	84	− 2	84	− 2
			56.3	33.95	+0.3	34.25	14.3	1.1	83	84	− 1	84	− 1
			6 03.8	34.4	−0.1	34.3	14.4	1.4	84	86	− 2	86	− 2
			13.1	33.55	+0.5	34.05	14.5	2.3	85	86	− 1	86	− 1

Reduction formula :

2π ; $\log H = 9.14408 - \log \sin \varphi + 0.000149\,t - 0.0004\,H \cos \varphi$

3π ; $\log H = 9.32017 - \log \sin \varphi + 0.000149\,t - 0.0004\,H \cos \varphi$

4π ; $\log H = 9.44511 - \log \sin \varphi + 0.000149\,t - 0.0004\,H \cos \varphi$.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	*H* QHM	*H* Schmidt	Diff.	Suirobu	Diff.
		1952	h m	° ′	′	° ′	°C	′	γ	γ	γ	γ	γ
52	2 π	Dec. 15	0 56.6	28 01.85	0.0	28 01.85	6.2	0.5	30061	30067	− 6	30069	− 8
			1 01.4	02.45	0.0	02.45	6.6	0.7	55	66	−11	68	−13
			03.4	02.6	0.0	02.6	6.7	0.4	54	65	−11	67	−13
			05.6	02.7	−0.1	02.6	6.9	0.5	56	65	− 9	67	−11
	〃	24	2 29.8	02.25	−0.1	02.15	8.0	0.2	77	79	− 2	82	− 5
			33.3	02.4	0.0	02.4	8.0	0.15	73	79	− 6	82	− 9
			36.4	02.6	+0.1	02.7	8.0	0.4	68	79	− 1	82	−14
			39.7	02.4	−0.1	02.3	8.1	0.1	75	79	− 4	83	− 8
			42.9	02.1	0.0	02.1	8.1	0.05	79	80	− 1	83	− 4
		1953											
	〃	Jan. 25	4 45.4	01.1	+0.1	01.2	7.4	0.1	85	92	− 7	93	− 8
			50.2	01.25	−0.2	01.05	7.45	0.15	88	92	− 4	93	− 5
			55.0	00.9	+0.3	01.2	7.55	0.1	87	95	− 8	96	− 9
			59.1	01.1	+0.3	01.4	7.5	0.3	84	96	−12	97	−13
			5 04.1	01.0	+0.2	01.2	7.5	0.4	87	96	− 9	97	−10
	〃	30	8 07.7	01.85	0.0	01.85	5.35	0.3	50	57	− 7	57	− 7
			10.5	01.75	+0.1	01.85	5.4	0.6	52	57	− 5	57	− 5
			13.0	02.2	0.0	02.2	5.5	0.8	47	57	−10	57	−10
			15.5	02.4	0.0	02.4	5.5	0.6	43	58	−15	58	−15
			17.8	02.5	0.0	02.5	5.5	0.7	42	57	−15	57	−15
	〃	Mar. 13	6 23.7	04.35	+0.1	04.45	13.0	0.0	96	30103	− 7	30104	− 8
			25.9	04.6	0.0	04.6	13.0	0.2	94	02	− 8	03	− 9
			28.0	04.6	+0.1	04.7	13.0	0.2	93	02	− 9	03	−10
			29.8	04.6	−0.1	04.5	13.05	0.0	96	02	− 6	03	− 7
			31.5	04.5	0.0	04.5	13.1	0.1	96	02	− 6	03	− 7
		1953											
	3 π	Mar. 13	6 37.2	44 54.8	+0.1	44 54.9	13.1	1.0	30096	30102	− 6	30103	− 7
			40.8	55.1	0.0	55.1	13.2	1.5	95	01	− 6	02	− 7
			43.1	55.05	0.0	55.05	13.2	1.7	95	01	− 6	02	− 7
			46.1	54.95	−0.1	54.85	13.2	2.3	97	01	− 4	02	− 5
			48.8	55.45	0.0	55.45	13.3	1.2	93	00	− 7	01	− 8
		1952											
	4 π	Dec. 15	1 12.1	70 09.2	0.0	70 09.2	7.25	2.7	30062	30064	− 2	30066	− 4
			20.5	09.55	0.0	09.55	7.45	0.4	64	64	0	66	− 2
			24.1	11.1	0.0	11.1	7.6	2.1	61	64	− 3	66	− 5
			27.6	10.95	+0.2	11.15	7.75	1.6	61	64	− 3	66	− 5
			31.4	11.4	0.0	11.4	7.85	1.6	62	65	− 3	67	− 5

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	*H*				
									QHM	Schmidt	Diff.	Suirobu	Diff.
		1952	h m	° ′	′	° ′	°C	′	γ	γ	γ	γ	γ
52	4π	Dec. 24	1 59.3	70 02.5	0.0	70 02.5	7.45	1.9	30086	30086	0	30089	− 3
			2 07.3	04.1	+0.1	04.2	7.7	0.6	83	82	+ 1	85	− 2
			12.3	05.6	0.0	05.6	7.7	1.8	79	80	− 1	83	− 4
			17.3	06.05	+0.1	06.15	7.8	0.6	78	79	− 1	82	− 4
			21.9	06.5	+0.1	06.6	7.9	0.5	78	79	− 1	82	− 4
		1953											
	〃	Jan. 25	4 14.0	69 59.8	0.0	69 59.8	7.0	1.6	89	90	− 1	91	− 2
			19.0	70 00.4	0.0	70 00.4	7.1	1.0	89	90	− 1	91	− 2
			23.1	00.45	+0.2	00.65	7.15	1.05	88	90	− 2	91	− 3
			28.7	00.5	0.0	00.5	7.3	0.9	91	91	0	92	− 1
			34.5	00.2	0.0	00.2	7.35	1.0	93	93	0	94	− 1
	〃	Jan. 30	7 48.2	70 03.0	−0.2	70 02.8	4.85	2.6	30055	30061	− 6	30061	− 6
			51.5	03.7	+0.1	03.8	4.95	1.7	53	59	− 6	59	− 6
			54.7	04.6	0.0	04.6	5.1	2.4	52	58	− 6	58	− 6
			57.7	04.7	0.0	04.7	5.15	2.3	52	58	− 6	58	− 6
			8 00.9	05.2	−0.2	05.0	5.2	2.8	52	57	− 5	57	− 5
	〃	Mar. 13	6 54.3	22.45	+0.1	22.55	13.4	1.2	92	30100	− 8	30101	− 9
			57.0	21.9	0.0	21.9	13.4	1.8	94	00	− 6	01	− 7
			7 00.7	22.05	0.0	22.05	13.4	1.9	93	00	− 7	01	− 8
			03.7	21.35	−0.1	21.25	13.45	1.8	97	00	− 3	01	− 4
			07.0	21.35	0.0	21.35	13.5	1.9	96	30099	− 3	00	− 4

Reduction formula :

$$2\pi\ ;\ \log H = 9.14930 - \log\sin\varphi + 0.000167\,t - 0.0011\,H\cos\varphi$$

$$3\pi\ ;\ \log H = 9.32539 - \log\sin\varphi + 0.000167\,t - 0.0011\,H\cos\varphi$$

$$4\pi\ ;\ \log H = 9.45033 - \log\sin\varphi + 0.000167\,t - 0.0011\,H\cos\varphi.$$

Unfortunately, all the values obtained at Memambetsu with QHM, No. 52 and those at Kakioka on March 5, 1953 (five measurements for each torsion 2π, 3π and 4π, total number 15) with the same instrument sent back from Memambetsu (about 20γ) too large to be adopted. These abnormal values were due to the same magnetic impurities contained in the modelling wax which was used for the fixing at both places, because all values after the exchange of the wax were reasonably consistent.

The base line values and scale values of horizontal variometer at Kakioka during a year including the period of comparison observation are illustrated in Fig. 4.

The procedure to obtain the adopted base line value is as follows. The temperature coefficient of the variometer in the old variation house is maintained about $1\gamma/^{\circ}C$ by means of the magnetic shunt alloy, and the observed base-line value every week changes very little, for this reason, the the adopted base line value is calculated by the next formula

$$B_m = \frac{b_{m-1} + 3b_m + b_{m+1}}{5},$$

where B_m is the adopted base-line value, and b_{m-1}, b_m and b_{m+1} are the successive observed values.

The scale value is observed at many various deflections by means of the field produced by electric current through the Helmholtz-Gaugain coil. The adopted scale value is the average of the two values in a month.

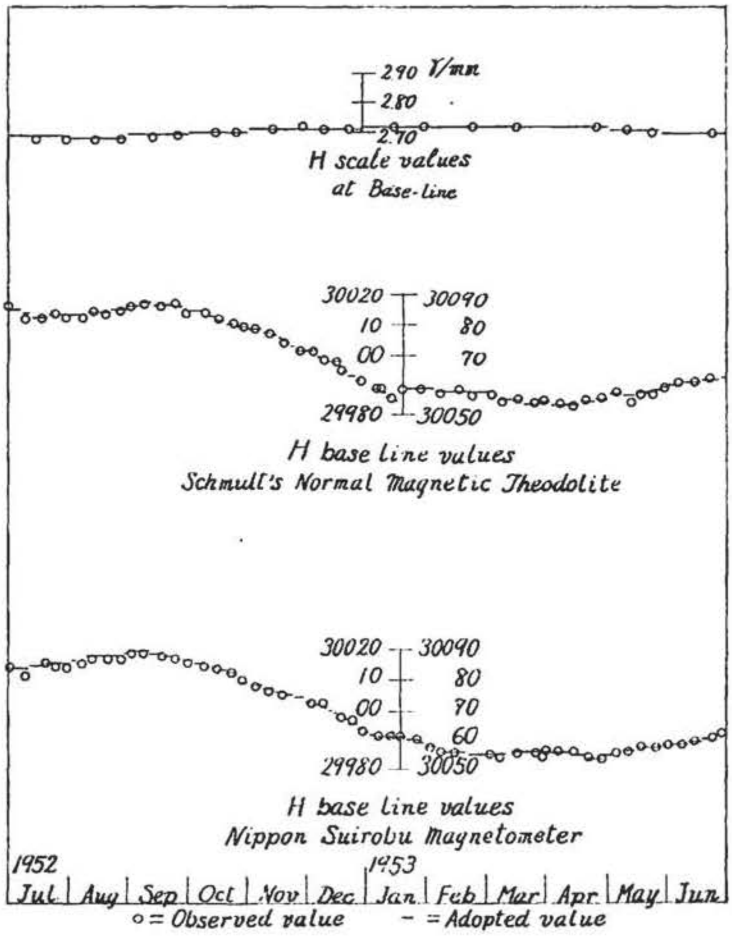

Fig. 4. Base-line values and scale values for horizontal intensity at Kakioka.

§ 5. Results of comparison observations at the Memambetsu Magnetic Observatory

Unfortunately, the intercomparison observation at Memambetsu was performed only in very short interval, Feb. 6∼12, 1954, of the coldest season at this place. All observations were then conducted taking special care of temperature effect, but they could not always be made under satisfactory conditions as done at Kakioka. The magnetic theodolite used at Memambetsu, which is the "Nippon Suirobu" type magnetometer (sine galvanometer), (Japanese Hydrographic Office pattern), has been occasionally compared with the magnetic standard at Kakioka. The latest result of comprison is given in Table 4. It is interesting to note that the mean difference, 12γ, shows good coincidence with the similar difference, 11γ, deduced from the intercom-

Table 4. Comparison between Kakioka and Memambetsu for horizontal intensity (By the Helmholtz coil and standard current)

Date		(Memambetsu–Kakioka)
Jan.	8, 1954	13γ
	14	10
	22	13
	28	12
Feb.	4	13
	10	12
	16	10
	25	13
Mar.	26	12
	Mean	12.0

Note, At Memambetsu ; old standard current, coil A, of the "Nipon suirobu" type magnetometer No. 11.
At Kakioka ; New standard current, coil B of the "Nippon suirobu" type magnetometer No. 11.

parison by means of QHM magnetometer (Table 5), although this difference between two QHM's, No. 50 and No. 51 seems to be less consistent. Meanwhile, the standardization of the current standard at Kakioka has been carried out once or twice a year by direct comparison of standard cells and resistances with those of the Japanese electric standard of the Electrotechnical Laboratory in Tokyo. The accuracy of the comparison is about 1/300,000, and the reduction factors to the international unit are as follows,

voltage: one international unit = 1.000335 absolute unit,
resistance: 〃 = 1.000470 〃 ,
current: 〃 = 0.999865 〃 .

The procedure to obtain the adopted base-line value at Memambetsu is as follows. The temperature coefficient of the variometer used in this period is about 12γ/°C (without shunt alloy), and so the observed base line value is plotted against the temperature of the variometer as Fig. 5.

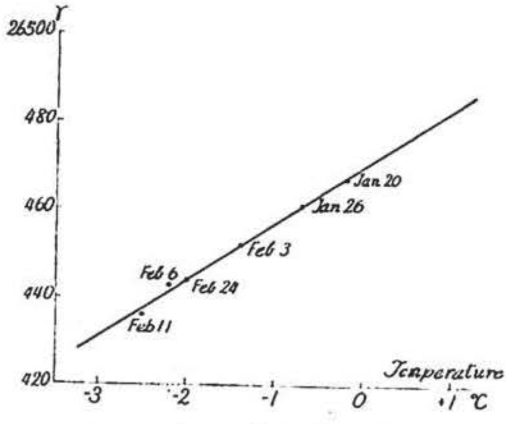

Fig. 5. Base-line values for horizontal intensity at Memambetsu. Scale value : 3.20 γ/mm

Table 5. Comparison observation with the Q. H. M., Memambetsu Magnetic Observatory.
The figures of each column of the table are to be read as follows ;

(11) Suirobu : Nippon Suirobu type magnetometer. (Sine galvanometer). No. 11.
(12) Diff : QHM-Suirobu. (pillar No. 1, magnetometer circle No. 11).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	H QHM	H Suirobu	Diff.
		1953	h m	° ′	′	° ′	°C	′	γ	γ	γ
50	2π	Feb. 6	7 46.0	32 13.00	0.0	32 13.00	16.55	0.0	26511	26520	−9
			49.1	12.80	0.0	12.80	16.3	1.1	510	520	−10
			51.9	12.45	+0.05	12.50	16.1	1.1	512	520	−8
	〃	9	4 27.2	10.1	0.0	10.1	13.15	0.1	514	528	−14
			30.9	10.2	0.0	10.2	13.2	0.4	512	527	−15
			33.5	10.85	0.0	10.85	13.3	0.6	505	526	−21
			35.9	09.95	0.0	09.95	13.35	0.2	517	526	−9
			39.1	10.50	0.0	10.50	13.45	0.7	511	526	−15
	3π	Feb. 6	8 02.6	53 04.35	0.0	53 04.35	15.5	2.1	26511	26520	−9
			07.2	04.50	0.0	04.50	15.2	1.5	508	520	−12
			10.7	04.40	0.0	04.40	15.1	1.5	507	520	−13
			14.3	03.60	0.0	03.60	14.9	1.7	509	520	−11
			17.8	03.05	0.0	03.05	14.65	1.3	510	520	−10
	〃	9	4 44.6	01.00	0.0	01.00	13.6	1.6	513	524	−11
			48.8	01.70	0.0	01.70	13.9	1.1	511	522	−11
			51.7	02.50	−0.1	02.40	14.1	1.8	508	520	−12
			54.9	02.95	0.0	02.95	14.3	1.4	508	520	−12
			57.7	03.45	0.0	03.45	14.4	1.8	505	517	−12

Reduction formula :

2π ; $\log H = 9.14770 - \log \sin \varphi + 0.000158\,t - 0.0003\,H \cos \varphi$

3π ; $\log H = 9.32379 - \log \sin \varphi + 0.000158\,t - 0.0003\,H \cos \varphi$

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	H QHM	H Suirobu	Diff.
		1953	h m	° ′	′	° ′	°C	′	γ	γ	γ
51	2π	Feb. 7	1 05.2	31 43.45	0.0	31 43.45	0.4	0.5	26497	26518	−21
			08.1	43.35	+0.1	43.45	0.4	0.4	498	518	−20
			10.4	43.45	0.0	43.45	0.4	0.5	497	518	−21
			12.8	43.6	0.0	43.6	0.5	0.4	496	518	−22
			15.1	43.25	0.0	43.25	0.5	0.2	501	518	−17
	〃	10	4 34.6	56.6	0.0	56.6	18.6	0.8	500	513	−13
			37.3	56.7	0.0	56.7	18.4	1.1	497	513	−16
			39.3	56.3	0.0	56.3	18.2	1.1	499	514	−15
			41.3	56.2	0.0	56.2	18.0	1.4	499	514	−15
			43.3	55.95	0.0	55.95	17.8	1.4	500	513	−13
	3π	Feb. 7	1 22.1	52 04.55	0.0	52 04.55	0.6	5.3	26497	26518	−21
			27.4	04.2	0.0	04.2	0.6	5.4	500	518	−18
			30.6	04.2	0.0	04.2	0.6	5.8	500	519	−19
			33.5	04.55	+0.05	04.6	0.6	5.1	497	519	−22
			36.7	04.7	0.0	04.7	0.7	5.3	498	519	−21

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	H		
									QHM	Suirobu	Diff.
		1953	h m	° ′	′	° ′	°C	′	γ	γ	γ
	〃	Feb. 10	4 48.8	29.8	0.0	29.8	17.2	7.6	498	514	−16
			54.1	29.0	0.0	29.0	16.6	7.6	498	514	−16
			56.7	28.6	0.0	28.6	16.3	8.2	498	513	−15
			59.2	28.4	0.0	28.4	16.1	8.0	497	512	−15
			5 01.6	28.1	0.0	28.1	15.9	7.7	497	513	−16

Reduction formula :

$$2\pi\ ;\ \log H = 9.14408 - \log\sin\varphi + 0.000149\,t - 0.0004\,H\cos\varphi.$$

$$3\pi\ ;\ \log H = 9.32017 - \log\sin\varphi + 0.000149\,t - 0.0004\,H\cos\varphi.$$

§ 6 Summary and discussions

The final results obtained at Kakioka and Memambetsu are shown conclusively in Table 6, in which mean values are weighted means calculated in such a manner as shown below, taking account of possible errors due to φ. At Kakioka, say, when

Table 6. Results of intercomparison at Kakioka and Memambetsu

Inst.		QHM-Kakioka (Schmidt) φ : 36°14′ N λ : 140°11′ E			QHM-Kakioka (Suirobu)			QHM-Memambetsu (Suirobu) φ : 43°55′ N λ : 144°12′ E		
	Torsion	φ	*	Diff	φ	*	Diff	φ	*	Diff
		°		γ γ	°		γ γ	°		γ γ
No. 50	2π	28	35	−7 ±2.2		35	−9 ±2.3	32	8	−13 ±2.9
	3π	45	9	−8 ±1.8		9	−7 ±1.3	53	10	−11 ±0.8
	4π	70	29	−5 ±1.3		29	−6 ±1.1			
	Mean		73	−5.4 ±1.4		73	−6.2 ±1.2		18	−11.4±1.2
No. 51	2π		26	−5 ±2.4		26	−6 ±2.1		10	−17 ±2.3
	3π		9	−7 ±1.2		9	−7 ±1.0		10	−18 ±1.8
	4π		24	−3 ±1.7		24	−3 ±1.3			
	Mean		59	−3.5 ±1.7		59	−3.5 ±1.3		20	−17.8±1.9
No. 52	2π		24	−7 ±2.6		24	−9 ±2.1			
	3π		5	−6 ±0.8		5	−7 ±0.7			
	4π		25	−3 ±1.8		25	−4 ±1.4			
	Mean		54	−3.4 ±1.7		54	−4.5 ±1.4			
			186	−4.1 ±1.6		186	−4.7 ±1.3		38	−14.6±1.5

* Number of observations

the weight for the case of torsion 4π is taken as unit, weights for 3π and 2π are $\left(\frac{1.6}{4.3}\right)^2$ and $\left(\frac{1.6}{8.2}\right)^2$, respectively (see Table 2). The observational errors given in this table are approximately similar to those estimated in the paragraph 3, (1). On the other hand, it may also be pointed out that the differences QHM-Kakioka as well as QHM-Memambetsu show rather systematic values depending upon the torsional angles (Table 7).

Table 7. Difference due to torsion angle

At Kakioka (Schmidt)	(Suirobu)	at Memambetsu
$4\pi-2\pi=\ 2.6^{\gamma}$	$4\pi-2\pi=3.7^{\gamma}$	$3\pi-2\pi=0.5^{\gamma}$
$4\pi-3\pi=\ 3.3$	$4\pi-3\pi=2.7$	
$3\pi-2\pi=-0.7$	$3\pi-2\pi=1.0$	

This is probably due to the fact that the material constant of the quartz fibre does angle. not remain constant, but slightly varies with the magnitude of torsion Therefore, it is suggested that the intercomparison observation should be well conducted to fit for any remote station with so different magnitude of intensity of the horizontal component. For that purpose a suitable set of QHM's with very wide deflection angles should be used. But it is difficult to design an instrument with the same accuracy, say, 1γ at various stations.

At Kakioka, in near future, the new type standard magnetometer (electromagnetic type) will be constructed to observe the "*true absolute value*" at very high accuracy.

In connection with the present intercomparison, the writers made some preliminary experiments to promote the accuracy of such observations by using a telescope of 1.5′ per one division and horizontal circle of 1′ per one division and by adopting suitable quartz fibre, "New K-S steel magnet" with small temperature coefficient 1—2γ/°C (reduced by the magnetic shunt alloy), copper case and corkcover. The result of this experiment performed in 1951～1952 was satisfactory. We must announce, however, such an important fact that the magnetic damper used in general to accelerate shorter the observation are detrimental to an accurate observational result. That is to say, as shown in Fig. 6, when the torsion 2π is given on our trial QHM magnetometer, the time required to approach the final value after the cease of oscillations is much longer in the case of employment of a damper (about 10 minute), than without a damper (about 20～30 seconds). For convenience sake, this phenomenon is called tentatively the "magnetic viscosity" and it may not be due to the property of quartz fibre, but due to the impurities contained in the copper, because the more the impurities are contained, the more striking this property is. Consequently, similar

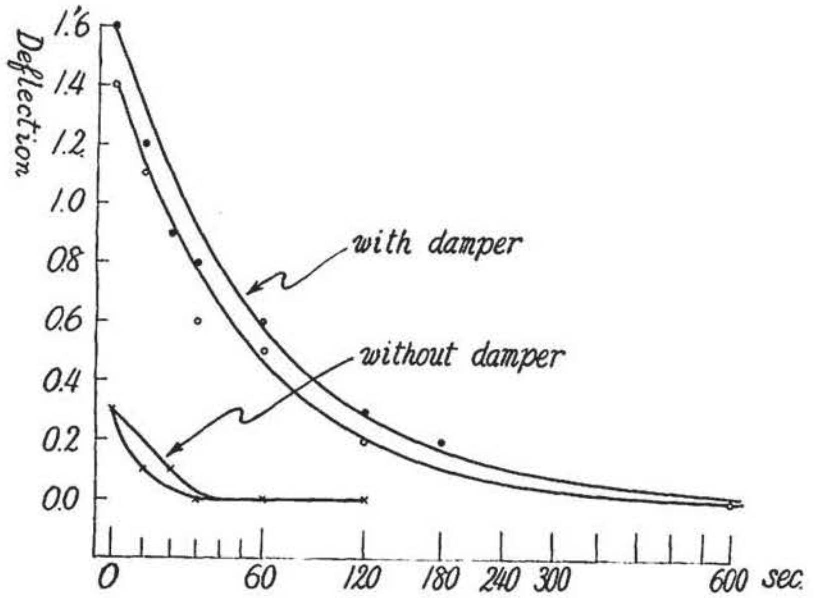

Fig. 6. Example of the "Magnetic viscosity".
1.0′ (Deflection) 10.4γ (Horizontal intensity)

things happen in the case of magnetic variometers, other absolute magnetic instruments and QHM magnetometers, even if pure copper such as electrolytic one is used as their damper.

The results of the first intercomparison made at Kakioka[5], given in Table 8, are here quoted to recalculate the data from the adopted horizontal component (determind value).

The similar data obtained at various stations during the period 1948 ~ 1950[4] are referred in Table 9 in order to see in what way the reduction constant of the

Table 8. Comparison observation with the Q.H.M. (1936)

The figures of each column of the table are to be read as follows;

(11) K-std : Wild-Edelmann's magnetic theodolite,

(12) Diff : Q.H.M.-Wild-Edelman's magnetic theodolite.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	*H*		
									QHM	K-std.	Diff.
18	4 π	1939	h m			° ′	°C		γ	γ	
		Sept. 1	13 18.4			74 18.9	28.5		29712	29 729	−17
			13 24.6			74 19.5	28.6		29712	729	−17
			13 30.5			74 19.1	28.7		713	730	−17
			13 49.0			74 18.9	28.8		715	733	−18
			13 56.2			74 18.9	28.9		716	733	−17
			14 04.2			74 18.9	28.9		716	733	−17
			14 23.3			74 19.75	29.0		715	732	−17
			14 30.2			74 20.0	29.0		715	732	−17
			14 36.9			74 20.5	29.1		714	732	−18
			14 59.9			74 21.3	29.1		713	729	−16
			15 07.6			74 21.0	29.1		713	730	−17
			15 15.1			74 21.0	29.1		713	729	−16
										means	−17.0

Reduction formula, $\log H = 9.45249 - \log \sin \varphi + 0.000143\,t - 0.00137\,H \cos \varphi$.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	D	φ (corr,)	Temp.	θ	*H* QHM	K-std.	Diff.
		1936	h m			° ′	°C		γ	γ	
17	4π	Sept. 2	11 23.2			75 28.2	28.4		29 701	29 715	−14
			11 31.1			75 28.4	28.5		702	715	−13
			11 39.9			75 28.7	28.6		702	716	−14
			13 35.9			75 26.9	28.8		709	724	−15
			13 44.5			75 27.05	28.8		708	726	−18
			13 53.4			75 26.6	28.9		711	728	−17
			14 20.4			75 26.0	29.1		714	730	−16
			14 26.8			75 26.0	29.2		715	731	−16
			14 35.6			75 25.5	29.2		716	731	−15
			15 40.8			75 25.9	29.4		718	734	−16
			15 48.6			75 26.45	29.55		718	732	−14
			15 57.0			75 26.1	29.55		719	732	−13
										mean	−15.1

Reduction formula; $\log H = 9.45428 - \log \sin \varphi + 0.000161\,t - 0.00261\,H \cos \varphi$

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QHM No.	Torsion	Date	Time (GMT)	φ (obs)	ΔD	φ (corr)	Temp.	θ	*H* QHM	K-std.	Diff.
		1936	h m			° ′	°C		γ	γ	
12	4π	Sept. 3	10 21.2			75 09.6	28.3		29 694	29 704	−10
			10 30.2			75 09.0	28.4		696	705	−09
			10 40.2			75 09.0	28.5		697	708	−11
			11 02.0			75 08.8	28.6		699	710	−11
			11 09.6			75 08.9	28.7		699	710	−11
			11 17.6			75 08.9	28.7		700	711	−11
		Sept. 4	10 24.4			75 10.4	28.0		690	697	−07
			10 31.7			75 10.85	28.2		690	699	−09
			10 38.5			75 10.95	28.2		690	698	−08
										mean	−09.7

Reduction formula ; $\log H = 9.45375 - \log \sin \varphi + 0.000150\,t - 0.00080\,H \cos \varphi$

mean of means. -13.9γ

magnetic standard changes with time. It shows how difficult it is to keep constant high accuracy of the geomagnetic standard.

Lastly the differences between QHM and Rude Skov, Cheltenham, Kakioka, and Memambetsu are shown in Table 9[4][5][7][8]. The result in Table 13 is corrected for the change of constant of the QHM's No. 50, 51 and 52 themselves.

In conclusion, the authors wish to express their sincere thanks to V. Laursen and Robert W. Knox for their kind help and cooperation offered for our Observatory. At the same time the authors' cordial thanks are also due to Dr. S. Imamiti, former director and T. Yoshimatsu, the present director of the Kakioka Magnetic Observato-

Table 9. Comparison Observations carried out during 1948~1950 by means of QHM-magnetometers

1948	April	QHM	33 51 52	—	Cheltenham	= 3.0 γ
1949	June	QHM	90 91 92	—	Pilar	= 1.7
1949	August	〃		—	La Quica	= −30.6
1949	Sept.	〃		—	Huancayo	= 16.8
1949	Dec.	〃		—	Cheltenham	= − 0.6
1949	Mar.—Aprl	QHM	33 51 52	—	Amberley	= − 4.6
1949	July	〃		—	Toolangi	= −23.3
1950	Nov.—April	〃		—	Toolangi	= −32.6
1949	Nov.—Dec.	〃		—	Watheroo	= 8.4
1950	May	QHM	90 91 92	—	Abinger	= 4.1
1950	Nov.	〃		—	Abinger	= 5.6
1950	June	〃		—	Lerwich	= 3.2
1950	July—Sept.	QHM	91 92	—	Eskdalemuir	= − 6.1

ry, who gave an opportunity to carry out the present observation and helpful criticism and encouragement. They also cordially express thanks to Mr. M. Hirayama, the chief of Geomagnetic Section for his kind guidance, and to the members of the Memambetsu Magnetic Observatory for their kind cooperation for the actual observations.

(1) Copenhagen Met. Inst. Comm. Mag., No. 15 (1936), 22.

(2) H. Herbert Howe, Terr. Mag., Vol. 43 (1938), 167~168.

(3) Memoir of the Kakioka Magnetic Observatory, Vol. 6, No. 1, 64.

(4) Common International Comparisons of May Standards, IATME : The Circular Letter, No. 216 of Dec. 17, 1952

(5) Transaction of Edinburgh Meeting 1936, 260~261.

(6) Reduction formulae for QHM 50, 51 and 52, Official letter of May 24, 1952 from Comm. I.C.M.S.

(7) Final values of the Intercomparison observations made at Cheltenham Mag. Obs. Official Letter of Mar. 24, 1954.

(8) Official Letter of Aug. 24, 1954 from the Comm. on Comparisons of Mag. standards, IATME.