VELOCITY OF PROPAGATION OF SOUND THROUGH SEA WATER.

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VELOCITY OF PROPAGATION OF SOUND THROUGH SEA WATHER

THE development of the methods of sounding and ranging by means of echo has induced several countries to study the velocity of propagation of sound through sea water.

The value of the resulting depths or distances depends partially on the accuracy of the estimation of this velocity at the spot where they are taken.

Among the nations which have specially contributed to this study, the United States of America must be particularly mentioned.

The information which is given below has been extracted from the Special Publication N° 190 of the Coast & Geodetic Survey, entitled "*Velocity of sound in sea water*" by Commander N. H. HECK and Ensign JERRY H. SERVICE, Washington 1924., which summarises the data resulting from the experiments carried out during the cruise of the "*Guide*".

Further, tables based on the units of the metric system have been drawn up and are included in the publication.

METHOD OF OPERATION.

There is no evidence in existing Publications to show that any organisation, except the United States Coast & Geodetic Survey has made experimental determinations of the velocity for vertical transmissions to great depths.

From November 17th to December 29th, 1923, the Coast & Geodetic Survey steamer "*Guide*" was engaged on an oceanographic cruise from New London, Conn., to San San Diego, Calif., by way of Porto-Rico and

the Panama Canal. As the work included an investigation of Nares deep north of Porto-Rico, the deepest part of the Atlantic Ocean, and also the development of a hitherto unexplored deep in the Pacific off the coasts of Central America and Mexico, the range in depth and the number of deep soundings was exceptional. The actual range in depth was from 185 fathoms to 4617 fathoms.

The "*Guide*" was equipped with a sonic Depth finder, and was also equipped with standard apparatus for taking wire soundings, temperatures and water samples (for later determination of salinity) at any depth, and for taking specimens of the bottom. A definite scheme of soundings was laid out in advance. At every fourth or fifth sounding the depth was obtained by wire and the corresponding time interval for the transmission of sound was determined by the sonic depth finder. Temperatures and water samples were obtained at the surface, at the depth of 200 fathoms, and at the bottom. In one case in the Atlantic and one in the Pacific serial temperatures and water samples were obtained from surface to bottom. On arrival at San Diego, the water samples were turned over to the Scripps Institution for biological research, at La Jolla, Calif., for determination of salinities.

Intermediate soundings were taken by the sonic depth finder. The velocity of sound to be used in each case was not decided upon until the velocities obtained by simultaneous depth and time determinations had been studied and a rational basis for applying theoretical velocities had been developed.

Inasmuch as the piano-wire soundings, which were taken with special care in recognition of their importance in connection with the velocity of sound, were direct measurements of depth, and the observations with the sonic depth finder, taken with equal care, were direct measurements of time, it is evident that the work of the "*Guide*" made available a reliable series of measurements of the velocity of sound in sea water under a wide range of conditions. Owing to strong surface currents in a few places affecting the accuracy of the wire soundings, to faint echoes, to instrumental difficulties, and to other causes, a few of the determinations are less reliable than others, and such velocities are given less weight than those obtained under good conditions.

Early in the cruise of the "*Guide*" it became evident that the velocity increased with the depth in spite of the fact that the temperature fell and the salinity remained practically the same. This fact suggested that the velocity is a function not only of temperature and salinity but also of pressure.

THEORY.

The Newtonian equation for the velocity of sound in a given medium suggested itself as a logical and reliable foundation upon which to work

$$V = \frac{1}{\sqrt{\rho\,\rho}} = \sqrt{\frac{E}{\rho}}$$

E = elasticity of the medium or reciprocal (adiabatic) compressibility ρ or β, i. e.

$$E = \frac{\text{(increase of pressure applied to the medium).}}{\text{(resulting decrease in volume expressed as a fraction of the original volume)}}$$

the increase of pressure being for instance, measured in bars equal to 10^6 dynes per square centimeter.

ρ, the density of the medium, (specific weight) expressed in grammes per cm^3, or reciprocal specific volume v expressed in cm^3 per gramme.

It has seemed most satisfactory to make use in the application of Newton's equation of the specific-volume data tabulated in Dynamic Meteorology and Hydrography, part I, by V. Bjerknes and J. W. Sandström, published in 1910 by the Carnegie Institution of Washington. These specific volumes are based upon the very precise work of Knudsen, Ekman, and others. The specific volume, is of course, the reciprocal of the density and can therefore be used directly in the application of Newton's equation.

It is desirable to explain the form in which the specific volume tables (Tables H) of Bjerknes and Sandström have been compiled. Seven tables are required which are as follows:

Table 8H gives the specific volumes of sea water in cm^3/gm at 0°C. temperature and 35 $\frac{0}{00}$ (35 parts per thousand) salinity for every 10 decibars pressure from 0 to 10,000 decibars.

Table 9H is a table of salinity corrections to specific volume and has a range from salinity 0 $\frac{0}{00}$ (pure water) to salinity 39 $\frac{0}{00}$.

Table 10 H gives temperature corrections to specific volume and ranges from — 1° to 29° C.

Table 11H is a table of combined salinity-temperature corrections.

Table 12H is a table of combined salinity-pressure corrections.

Table 13H is a table of conbined temperature-pressure corrections.

Table 14H is a table of combined salinity-temperature-pressure corrections.

It should be understood that the corrections in Tables 9H and 10H

are first-order corrections and that the corrections in Tables 11H, 12H, 13H and 14H, are additional second-order corrections.

It was found advantageous to transform Newton's equation into a more convenient form that would be better adapted to Bjerknes and Sandström's tables. The definition of elasticity which has been given can be put into the form.

$$\text{Elasticity} = \frac{\textit{increase of pressure in dynes/cm}^2}{\left(\frac{\textit{resulting decrease in sp. vol. in cm}^3\textit{/gm}}{\textit{specific volume in cm}^3\textit{/gm.}}\right)}$$

Increase of pressure is taken as 10 decibars or 10^6 dynes/cm^2.
" Resulting decrease in sp. vol." may be designed by dv.
Specific volume may be designated by v.
The elasticity equation then becomes :

$$\text{Elasticity} = \frac{10^6}{\left(\frac{\text{dv}}{\text{v}}\right)} = \frac{10^6\ \text{v.}}{\text{dv}}$$

Furthermore, in order to have dv a whole number instead of a small decimal, it is found convenient to use 10^5 dv instead of dv, necessitating multiplying the numerator also by 10^5, which gives :

$$\text{Elasticity} = \frac{10^{11}\ \text{v.}}{(10^5\ \text{dv})}$$

Since density $= \frac{1}{\text{v}}$ we have from Newton's equation :

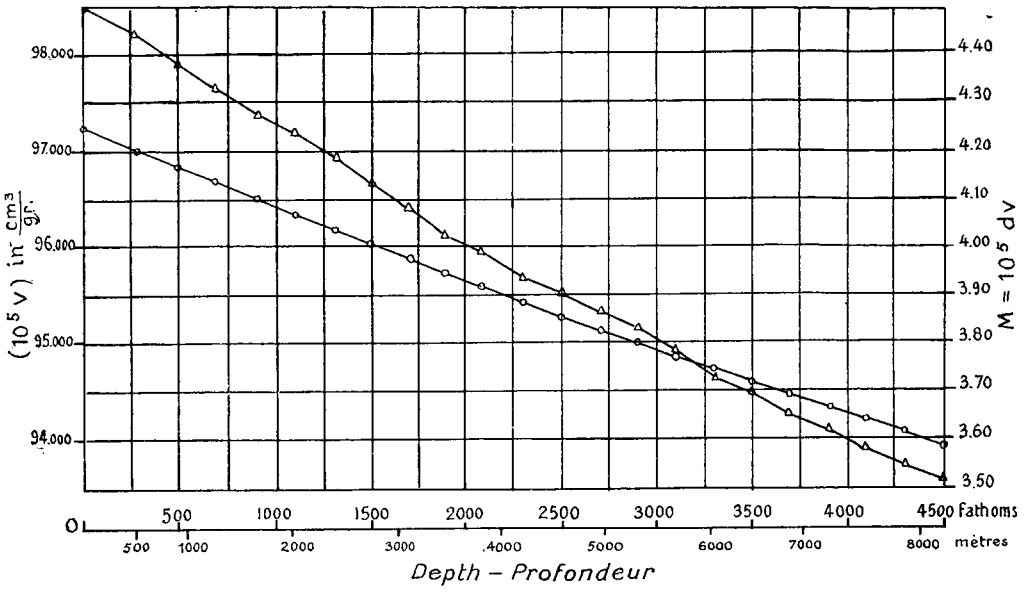
$$\text{V in cm/sec.} = \sqrt{\frac{10^{11}\ \text{v}}{(10^5\,\text{dv})} \div \frac{1}{\text{v}}} = \sqrt{\frac{10^{11}\ \text{v}^2}{10^5\ \text{dv}}} = 10^5\ \text{v}\ \sqrt{\frac{10}{(10^5\ \text{dv})}}$$

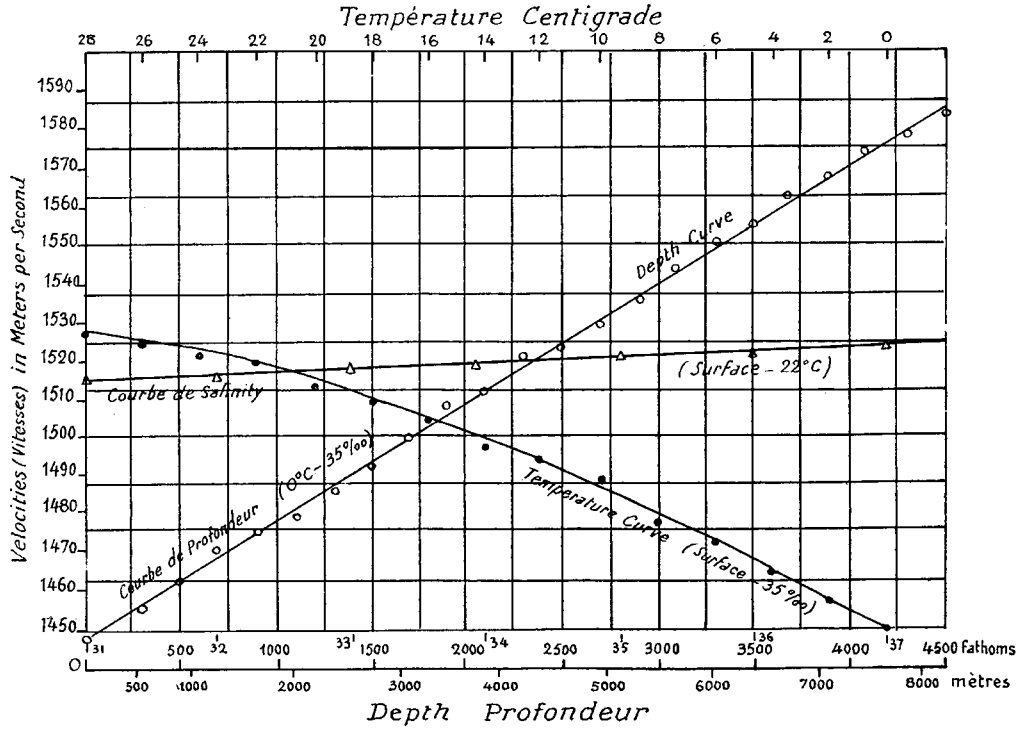
$$\text{V in m/sec.} = 10^3\ \text{v}\ \sqrt{\frac{10}{10^5\ \text{dv}}} \qquad (1)$$

$$\text{V in fathoms/sec.} = 5.468 \times 10^2\ \text{v}\ \sqrt{\frac{10}{(10^5\ \text{dv})}} \qquad (2)$$

METHOD OF PREPARING VELOCITY TABLES

In order that the velocity of sound may be obtained in accordance with equation (2) at any place, the water from the surface to the bottom is considered in 200-fathoms layers and the mean temperature and salinity for each layer is obtained from the best available source of information. The velocity for the entire depth is then taken as the mean of the various layer velocities.


98.000
97.000
96.000
95.000
94.000
(10⁵ v) in cm³/gr.
4.40
4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
3.50
M = 10⁵ dv
0
500
1000
1500
2000
2500
3000
3500
4000
4500 fathoms
500
1000
2000
3000
4000
5000
6000
7000
8000 mètres
Depth – Profondeur


Température Centigrade
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1590
1580
1570
1560
1550
1540
1530
1520
1510
1500
1490
1480
1470
1460
1450
Velocities (Vitesses) in Meters per Second
Depth Curve
(Surface - 22°C)
Courbe de Salinity
Courbe de Profondeur
(0°C - 35‰)
Temperature Curve
(Surface 35‰)
31
32
33
34
35
36
37
0
500
1000
1500
2000
2500
3000
3500
4000
4500 fathoms
500
1000
2000
3000
4000
5000
6000
7000
8000 mètres
Depth Profondeur

Accordingly, Velocity Table N° 13 (pages 93) gives the velocity for the possible range of temperature and salinity for the surface and for the depth corresponding to the middle of each 200-fathom layer.

CALCULATION OF V.

The formation of a table of values of v consisted simply of taking out from Table 8H in Bjerknes the "base specific volume" (for O° C. and 35 $\frac{0}{00}$ salinity) for the pressures corresponding to the depths at the middle of the 200-fathom layers and applying to these base specific volumes corrections for salinity and temperatures from Tables 9H to 14H, inclusive. The resulting corrected values of v are given in Table 1. (*see* page : 88).

CALCULATION OF dv AND OF THE MODULE $M = 10^5$ dv.

10^5 *dv*, which will hereafter be referred to as M is obtained from the tables in a somewhat similar manner, that is "base M" (for O° C. and 35 $\frac{0}{00}$) is taken out and then corrections are applied, but fortunately only two corrections are necessary. The base M is approximately the difference between successive values of the base specific volumes in Table 8H. A preliminary table (Table 2) of values of base M was first computed for every 100 decibars from 0 to 8,900 decibars. The method used in computing this table may be illustrated by computing one of the values, say base M for 8,300 decibars pressure.

TABLE 8 H.

Specific volumes in $\frac{cm^3}{gm} \times 10^5$

DECIBARS	0	10	20	30	40	50	60	70	80	90
8.200.....	93,989	93,986	93,982	93,979	93,975	93,971	93,968	93,964	93,961	93,957
8.300.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8.400.....	93,919	93,915	93,912	93,908	93,905	93,901	93,897	93,894	93,890	93,887
	70	71	70	71	70	70	71	70	71	70

Mean difference
Difference moyenne : 70,4.

The change per 10 decibars, which is the base M for 8,300 decibars, equals 70.4 divided by 20, or 3.52.

TABLE 2. — M (35, O,P)

M (35, O. P) = 10^5 dv at 35 0/00 salinity, O°C, and standard pressure.
à 35 0/00 de salinité, O°C, et pression normale.

where dv = decrease in specific volume in $\frac{cm^3}{gm}$ corresponding to 1 bar increase in pressure.

avec dv = diminution de volume spécifique en $\frac{cm^3}{gm}$ correspondant à un accroissement de pression de 1 bar.

PRESSURE PRESSION DÉCIBARS	M (35, O,P)	PRESSURE PRESSION DÉCIBARS	M (35, O,P)	PRESSURE PRESSION DÉCIBARS	M (35, O,P)	PRESSURE PRESSION DÉCIBARS	M (35, O,P)
0	4.50	2,500	4.17	5,000	3.87	7,500	3.60½
100	4.50	2,600	4.15	5,100	3.85	7,600	3.59
200	4.50	2,700	4.14	5,200	3.83½	7,700	3.58
300	4.49	2,800	4.13½	5,300	3.83½	7,800	3.57½
400	4.46½	2,900	4.12	5,400	3.82½	7,900	3.56½
500	4.44½	3,000	4.10½	5,500	3.80½	8,000	3.55
600	4.43	3,100	4.09½	5,600	3.80	8,100	3.54½
700	4.41½	3,200	4.08½	5,700	3.79	8,200	3.53½
800	4.40½	3,300	4.05½	5,800	3.77½	8,300	3.52
900	4.39½	3,400	4.06½	5,900	3.77	8,400	3.52½
1,000	4.37½	3,500	4.04½	6,000	3.76	8,500	3.51½
1,100	4.36	3,600	4.00	6,100	3.73½	8,600	3.50
1,200	4.35	3,700	4.00	6,200	3.73	7,800	3.48½
1,300	4,33	3,800	4.00	6,300	3.72½	8,800	3.47½
1,400	4.31½	3,900	4.00	6,400	3.71	8,900	3.47
1,500	4.30	4,000	4.00	6,500	3.70½		
1,600	4.29	4,100	3.99½	6,600	3.69		
1,700	4.27½	4,200	3.95	6,700	3.68½		
1,800	4.26	4,300	3.93½	6,800	3.68		
1,900	4.25	4,400	3.94½	6,900	3.65		
2,000	4.24	4,500	3.92	7,000	3.65		
2,100	4.22½	4,600	3.91	7,100	3.65		
2,200	4.20½	4,700	3.89½	7,200	3.62½		
2,300	4.19	4,800	3.88	7,300	3.62		
2,400	4.18½	4,900	3.88	7,400	3.61½		

The final table of M (Table 5) (see page: 91) is then blocked out in the same manner as Table 1 and base values of M are inserted in their proper places.

Corrections computed from Tables 12H and 13H were necessary in order to obtain the values of M for other temperatures and salinities. The corrections in Tables 9H, 10H and 11H do not change presssure with and therefore do not affect M, and the correction from Table 14H is negligible in so far as M is concerned. The salinity and temperature corrections used in the computations of Table 5 are tabulated in Tables 3 and 4, respectively.

TABLE 3

Salinity corrections to M.
Corrections à faire subir à M pour la salinité.

SALINITY ‰	DEPTHS where applicable. PROFONDEURS où la correction est applicable		Correction	SALINITY ‰	DEPTHS where applicable. PROFONDEURS où la correction est applicable		Correction
	Fathoms Brasses	Meters Mètres			Fathoms Brasses	Meters Mètres	
31.....	0–1300	0–2380	+0.06	34.....	0–2500	0–4570	+0.01½
	1500–2300	2740–4200	+ .05½		2700–3500	4940–6400	+ .01
	2500–2700	4570–4940	+ .05		3700–4700	6770–8600	+ .00½
32.....	0–1100	0–2000	+ .04½	36.....	0–2500	0–4570	— .01½
	1300–2700	2380–4940	+ .04		2700–3500	4940–6400	— .01
					3700–4700	6770–8000	— .00½
33.....	0–1300	0–2380	+ .03	37.....	0–1300	0–2380	— .03
	1500–3900	2740–7130	+ .02½		1500–3900	2740–7130	— .02½
	4100–4700	7500–8600	+ .02		4100–4700	7500–8000	— .02

TABLE 4

Temperature corrections to M
Corrections à faire subir à M pour la température

Temperature (Centigrade)	Depths where applicable. Profondeurs où la correction est applicable		Correction	Temperature (Centigrade)	Depths where applicable. Profondeurs où la correction est applicable		Correction
	Fathoms Brasses	Meters Mètres			Fathoms Brasses	Meters Mètres	
1	1900–3300	3480–6040	—0.02	12	0–300	0– 550	—0.25
	3500–4700	6400–8600	—0.01½		500	910	— .24
					700	1280	— .24
					900	1650	— .23
2	0–1100	0–2000	— .05	14	0– 300	0– 550	— .27
	1300–2300	2380–4200	— .04½		500	910	— .26
	2500–3300	4570–6040	— .04		700	1280	— .25
	3500–4100	6400–7500	— .03½				
	4300–4700	7860–8600	— .03				
3	1900–2700	3480–4940	— .05½	16	0– 500	0– 910	— .30
					700	1280	— .29
4	0–1100	0–2000	— .09½	18	0– 300	0– 550	— .33
	1300–1700	2380–3110	— .09		500	910	— .32
					700	1280	— .31
6	0–1300	0–2380	— .13				
8	0– 500	0– 910	— .17½	20	0– 100	0– 180	— .35
	700–1100	1280–2000	— .17		300	550	— .34
					500	910	— .34
					700	1280	— .33
10	0– 300	0– 550	— .22	22	0	0	— .38
	500	910	— .21½		100	180	— .37
	700	1280	— .21		300	550	— .36
	900	1650	— .20		500	910	— .36
					700	1280	— .35

The salinity corrections tabulated in Table 3 were computed from Table 12H as the rate of change per bar of the values in that table at the salinity and pressure in question. The method used in computing these values may be illustrated by computing one of the values, say the correction for $31\frac{0}{00}$ salinity applicable between depths 0 and 1, 300 fathoms (pressures 0 and 2,400 decibars).

TABLE 12 H.

$10^5 \times$ Salinity-pressure correction in $\frac{cm^3}{gm}$ to specific volume

Correction à faire subir au volume spécifique en raison de la salinité et de la pression, exprimée en $\frac{cm^3}{gm}$ et multipliée par 10^5

SALINITY 31	DECIBARS
0	0
- 13	2.300
- 14	2.400
- 14	2.500
- 15	2.600

From an inspection of the table one may fairly assume that the exact pressure to which — 14 belongs is very approximately 2,450 decibars. Since the correction for 0 decibars is 0, the mean change per bar in the salinity-pressure correction is — 14 divided by 245, or -0.06. Since this tends to make the specific volume less at the higher pressure, it is additive to *M*. Hence the salinity correction, as tabulated in Table 3, to the base *M* at $31\frac{0}{00}$ salinity between 0 and 1,300 fathoms is + 0.06.

The temperature corrections tabulated in Table 4 were computed from Table 13H, in an exactly similar manner, as the rate of change per bar of the values in that table at the temperature and pressure in question.

The values of velocity in Table 13 (see page 93) were then computed directly by means of equations (1) and (2) from the values of *v* and *M* in Tables 1 and 5 respectively.

The curves on Plate 2 show how the two quantities from which V is computed, v and *M*, respectively, vary with the depth. The curves on Plate 3 show how velocity varies with depth, temperature, and salinity, respectively.

ADIABATIC CORRECTIONS OF VELOCITY

The values of velocity in Table 13 were computed using values of M experimentally determined under isothermal conditions. Granting that the condensations and rarefactions of the sea water during the transmission of sound take place under adiabatic conditions, then the velocities in Table 13 theoretically need to be increased by small corrections, which were neglected in computing that table.

The theory underlying the computation will now be given. The symbols used were as follows:

βa is the adiabatic compressibility (pressure rate of change of specific volume) of the sea water. In cm^3/gm per $dyne/cm^2$;

β is the isothermal compressibility;

C_v is the specific heat at constant volume, in ergs per gram per degree centigrade;

C_p is the specific heat at constant pressure;

α is the thermal coefficient of expansion (temperature rate of change of specific volume), in cm^3/gm per degree centigrade;

T is the absolute temperature on the centigrade scale.

It is shown in works on thermodynamics that

$$\frac{\beta a}{\beta} = \frac{Cv}{Cp}$$

$$\text{and that } Cp - Cv = \frac{\alpha^2 T}{\beta}$$

$$\text{whence } Cv = Cp - \frac{\alpha^2 T}{\beta}$$

$$\text{and } \frac{\beta a}{\beta} = \frac{Cv}{Cp} = 1 - \frac{\alpha^2}{\beta}\,\frac{T}{Cp}$$

In other words, the adiabatic compressibility, which probably obtains during sound transmission, is less than the isothermal compressibility, which is what Ekman measured and Bjerknes used in his tables, by a fraction equal to $\frac{\alpha^2 T}{\beta\ Cp}$. Now the elasticity is very nearly equal to the reciprocal of the compressibility, so that the adiabatic elasticity will be greater than the isothermal elasticity by the same fraction. And since the velocity is proportional to the square root of the elasticity, the velocity computed from adiabatic compressibility will be greater than the velocity computed from isothermal compressibility by approximately one-half this fraction. Tables are given herewith of $10^5\,\alpha$, $10^5\,\beta$, $\frac{Cp}{4.18}$, $\frac{\alpha^2 T}{\beta\ Cp}$

and of the adiabatic corrections to the velocities under the various conditions. Since the unit of pressure used for β was the bar, or 10^6 dynes/cm^2, a unit of energy in *Cp* equal to 10^6 ergs, or 1 decijoule, was necessary.

TABLE 6 — $10^5\alpha$

$$\alpha = \left(\frac{dv}{dt}\right)_p =$$

temperature rate of change of specific volume, in $\frac{\text{cm3}}{\text{gm}}$ per degree centigrade, of sea water of salinity 35.

Vitesse de variation du volume spécifique de l'eau de mer de salinité 35 en fonction de la température, exprimée en $\frac{\text{cm3}}{\text{gm}}$ par degré centigrade.

DEPTH PROFONDEUR		TEMPÉRATURE (CENTIGRADE)				
Fathoms Brasses	Meters Mètres	0	5	10	15	20
Surface	*Surface*	5	11	16	21	25
1.100	2.000	10	15	19		
2,100	3,840	15	19			
3,300	6,040	19				
4,300	7.860	22				

The above values were computed by means of Tables 10*H* & 13*H*.

Les valeurs ci-dessus ont été calculées au moyen des tables 10*H* et 10*H*.

TABLE 7 — $10^5\beta$

$$\beta = \left(\frac{dv}{dp}\right)_T =$$

isothermal pressure rate of change of specific volume, in $\frac{cm3}{gm}$ per bar, of sea water of salinity 35.

vitesse de variation du volume spécifique de l'eau de mer de salinité 35, en fonction de la pression isotherme, exprimée en $\frac{cm3}{gm}$ par bar.

DEPTH PROFONDEUR		TEMPÉRATURE (CENTIGRADE)				
Fathoms Brasses	Meters Mètres	0	5	10	15	20
Surface	*Surface*	4.5	4.4	4.3	4.2	4.2
1,100	2,000	4.2	4.2	4.0		
2,100	3,840	4,0	3.9			
3,300	6,040	3.7				
4,300	7,860	3.6				

The above values were taken directly from Table 5 with two significant figures.

Les valeurs ci-dessus ont été extraites de la Table 5 avec deux chiffres significatifs.

TABLE 8 — $\frac{C_p}{4.18}$

C_p = specific heat at constant pressure, in decijoules per gram per degree centigrade, of sea water of salinity 35 0/00.

chaleur spécifique à pression constante de l'eau de mer de salinité 35 0/00, exprimée en décijoules par gramme et par degré centigrade.

DEPTH / PROFONDEUR		TEMPÉRATURE (CENTIGRADE)				
Fathoms / Brasses	Meters / Mètres	0	5	10	15	20
Surface	*Surface*	9.3	9.3	9.3	9.3	9.3
1,100	2,000	9.1	9.1	9.1		
2,100	3,840	9.0	9.0			
3,300	6,040	8.9				
4,300	7,860	8.8				

TABLE 9 — $\frac{\alpha^2 T}{\beta C_p}$

DEPTH / PROFONDEUR		TEMPÉRATURE (CENTIGRADE)				
Fathoms / Brasses	Meters / Mètres	0	5	10	15	20
Surface	*Surface*	0.0004	0.002	0.004	0.008	0.111
1,100	2,000	.0017	.004	.0067		
2,100	3,840	.004	.007			
3,300	6,040	.007				
4,300	7,860	.010				

TABLE 10

Adiabatic correction to velocity, in fathoms per second. Corrections are also given in meters per second (lower line).

Correction adiabatique à faire subir à la vitesse, exprimée en brasses. La correction est aussi donnée en mètres par seconde (ligne inférieure).

DEPTH PROFONDEUR		TEMPÉRATURE (CENTIGRADE)				
Fathoms Brasses	Meters Mètres	0	5	10	15	20
Surface	*Surface*	0.2	0.8	1.6	3.2	4.4
		0.3	1.5	3.0	6.0	8.3
1,100	2,000	0.7	1.6	2.7		
		1.3	3.0	4.9		
2,100	3,840	1.6	2.8			
		3.0	5.1			
3,300	6,040	2.8				
		5.1				
4,300	7,860	4.0				
		7.3				

The authors are somewhat in doubt as to the advisability of applying this correction. The maximum effect is about 0.5 of 1 per cent and the average effect all through the tables is only about 0.2 or 0.3 of 1 per cent. Furthermore, in practice the depth obtained by wire under good conditions is accepted as the standard. It will be shown that the depth computed from the time interval measured with the sonic depth finder and the mean velocity obtained from Table 13 and known physical conditions agrees as closely as can be expected with the corresponding wire depth.

ACCURACY OF VELOCITY TABLE N° 13

The accuracy of the velocities tabulated in Table 13 is controlled by the accuracy of the values of M. Judging from the records of the experimental work of Ekman, which is the ultimate source of the values of this quantity, no value of M will be in error by more than 1 per cent. Since M appears under the radical in the velocity equation this

would indicate that no value of velocity will be in error by more than 0.5 of 1 per cent, which would amount to about 7 m. per sec., or 4 fathoms per sec.

It is believed that the velocities of Table 13 are of the highest degree of accuracy possible with compressibility data available at the present time and that they are adequate for acoustic-sounding purposes. It is realised, however, that the accuracy depends upon whether the values of M used in the table are the true values. Further study is being given by one of the authors to the possibility of obtaining directly from the results of Ekman's compressibility experiments more precise values of M.

COMPARISONS OF COMPUTED VELOCITIES WITH DIRECTLY MEASURED VELOCITIES

The results of the observations of comparisons made during the oceanographic cruise of the "*Guide*" are given in detail in Tables 11 and 12 of the Special Publication N° 198 of the U. S. Coast and Geodetic Survey.

It is seen from Table 12 that the average percentage difference between V measured and V computed for the entire 44 determinations is 0.2 of 1 per cent. Further it has been computed that the probable error of a single value is 1.2 per cent, which indicates that the average percentage difference may properly be taken as a guide in estimating the accuracy of the method.

SOURCES OF ERROR

The agreement between V measured and V computed seems to be remarkably good when it is considered how many elements enter into a comparison of these two quantities and what sources of errors there are in the determination of each of these elements.

Errors in the determination of V measured include errors in the determination of depth of wire sounding, and errors in the measurement of the time interval with the sonic depth finder.

The accuracy of the determination of depth by wire sounding depends upon the skill in handling the vessel, and the wire was kept as nearly vertical as possible during every sounding. In only a few cases were the currents strong enough seriously to affect the accuracy of the wire measurement.

The question of the accuracy of time-interval determination is the maintenance of period of disk rotation at exactly 10 seconds, which the tuning fork governor usually accomplishes. The depth finder used was of the first type developed by Doctor HAYES and had some operating defects that have been remedied in later types. One of these was the difficulty of reducing the loudness, as heard in the phones, of the original oscillator sound so as to be comparable with that of the echo. When the oscillator is operated at full power it is often extremely difficult to hear the echo and synchronize it with the original sound. The strength of echo also varies with the character of the bottom, so that in some cases the echo was faint at moderate depths and strong at great depths. Precision of synchronism depends very largely on the distinctness and strength of the echo. The personal equation of the observer affects to a certain extent the determination of a time interval with the sonic depth finder. The indications are that this is small for a skilled observer, but by no means negligible, and that it may be slightly different for two equally skilled observers. It lies chiefly in the synchronizing of outgoing signals and returning echoes. In the studies so far made it seems to be important chiefly in depths less than 500 fathoms. It is therefore advisable in a given region of moderate depths to take the personal equation into account.

The analysis of all the results indicates that a satisfactory degree of consistency is obtained. One one occasion a special effort was made to determine the ultimate possibilities under exceptionally favorable conditions. For five soundings in depths ranging from 535 to 702 fathoms the maximum difference of any value Vm from the mean was 1.5 fathoms per sec.

The accuracy of the determination of V computed depends not only upon the fundamental corrections of the method but also upon the reliability of the adopted values of temperature and salinity. The fundamental correctness of the method has been fully discussed, and it has been brought out that there is a possibility of small errors in the tables themselves and in the method of deriving M from the tables. The reliability of the adopted values of temperature and salinity depends on whether they have been actually measured or interpolated between such measurements as in the case of the "*Guide*", or whether they have been derived from less reliable sources.

During the cruise of the "*Guide*" depths were determined at 150 positions by the sonic depth finder alone, using computed velocities. Some of these determinations were in the vicinity of previous wire soundings obtained by various Coast Survey vessels and the agreement was found to be very satisfactory.

This vessel during a cruise of 6,500 miles encountered a temperature range of 28 degrees (0° to 28° C.), a salinity range of 5.5 $\frac{0}{00}$ (31 to 36.5 $\frac{0}{00}$), a depth range from 185 to 4,617 fathoms, and used computed velocitires ranging from 810 to 841 fathoms per sec.

It would obviously be of advantage to have tables expressing velocity as a function of depth alone. It has been clearly brought out that such tables can not be of universal application, but it is probable that they can be prepared for regions of considerable extent provided that the physical conditions of the sea water are approximately the same throughout the region.

While future expeditions can scarcely expect to have a wider range, they can do much more to provide control for acoustic sounding by determining physical conditions and making velocity measurements on all the oceans, and especially by fixing more accurately the places where physical conditions change.

BIBLIOGRAPHY

1897. — Adolph LINDENKOHL. — Das spezifische gewicht des Meerwassers im Nordöst Pacifischen Ozean in Zusammenhange mit Temperatur und Strömungzustanden. — Dr A. PETERMANN'S Geogr. Mitteilungen. — Heft XII.

1899. — Adolph LINDENKOHL. — Physiographische Probleme, Salzgehalt und temperatur des Pasifischen Ozeans betreffend. — Dr. A. PETERMANN'S, Mitteilungen aus Justus Perthes, Geogr. Anstalt, herausgegeben by Prof. Dr. A. SUPAN, 45 Band, Gotha, Justus Perthes.

1901-1904. — Martin KNUDSEN. — Hydrographic Tables. Copenhagen.

1902. — Atlantischer Ozean. Ein Atlas von 39 Karten, die physicalischen verhältnisse und die verkehrsstrassen dastellend, mit einer erläuternden einleitung und als beilage zum segelhandbuch fur den Atlantischen Ozean. — 2. Aufl. Hrsg. von der direktion Hamburg, L. FRIEDERICHSEN & C°.

1904. — H. SIEVEKING & Dr A. BEHM. — Akustische untersuchungen. — Annalen der Physik, pp. 793-814.

1908-1910 — V. W. ECKMAN. — Publications de circonstances nos. 43 et 49 du Conseil permanent International pour l'exploration de la mer. — Copenhagen.

1910. — G. SCHOTT & F. SCHU. — Die Warme verteilung in der tiefen des stillen ozeans. — Berlin.

1910. — V. BJERKNES and J. W. SANDSTROM. — Dynamic Meteorology and Hydrography. — Part I. — published by the Carnegie Institution of Washington.

1912. — V. BJERKNES. — Dynamisches Meteorologie und Hydrographie, I. TEIL, Braunschweig.

1912. — A. H. CLARK. — A study of the salinity of the surface water in the North Pacific Ocean and in the adjacent inclosed seas. — Smithsonian miscellaneous collections Vol. 60, N° 13, Dec. 4.

1914-15. — W. S. BRUCE, A. KING, D. W. WILTON. — The temperatures, specific gravities and salinities of the Weddell Sea & the North & South Atlantic Ocean. — Transactions of the Royal Society of Edinburgh, Vol. II, Part, I, p. 71.

1917. — H. B. BIGELOW. — Exploration of the United States C. & G. S. Steamer "*Bache*" in the Western Atlantic, January-March 1914, under the direction of the U. S. Bureau of Fisheries "*Oceanography*". App. *V* to the Report of the U. S. Commission of Fisheries for 1915. Bureau of Fisheries Document N° 833.

1920. — Ing. Hyd. MARTI. — Note sur la vitesse de propagation du son dans l'eau de mer. Annales Hydrographiques, Paris, 3e série, 1919-1920 pp. 165-179.

1921. — Ing. Hyd. MARTI. — Les sondages en mer par le son. — La Nature, 20-8-21. — pp. 125-127.

1922. — La vitesse du son dans l'eau de mer. — La Nature, 14-10-22.

1923. — A. B. WOOD & Captain HAROLD BROWNE. — Report N° 79 of the XIII th International Congress of Navigation, London 1923. Report on the propagation of sound carried out in 1921-22 on behalf of the Admiralty Department of Scientific Research).

1923. — E. B. STEPHENSON. — Velocity of sound in sea water. — Physical Review, vol. 21, pp. 182-185, Feb. 1923.

1923. — A. B. WOOD & H. E. BROWNE. — A Radio Acoustic method of locating positions at sea ; application to navigation and to hydrographical survey. — Proc. Phys. Soc. London, vol 35, part 3, pp. 183-194, 15-IV.

1923. — A TROLLIER. — Les signaux sous-marins par ondes ultra-sonores. La Nature, 1923.

1924. — H. C. HAYES. — Measuring Ocean depths by acoustical methods. — Journal of the Franklin Institute, March 1924. — Vol. 197, pp. 323-354.

1924. — F. E. SMITH. — Modern navigational devices. — Engineering, vol 117, pp. 299-300, March 17, 1924.

1924. — Acoustical methods for depth sounding. — Nature, vol. 113, pp. 463-465, March, 29.

1924. — Dr H. MAURER. — Uber echolotungen der Nordamerikanische Marine. — Annalen der Hydrographie und Maritimen Meteorologie, Apr. 1924. — pp. 75-87.

1924. — A. SCHUMACHER. — Hydrographische Bemerkungen und Hilfsmittel fur akustischen Tiefenmessung. — Annalen der Hydro graphie und Maritimen Meteorologie, Ap. 1924, pp. 87-95.

1924. — Prof. Mario TENANI. — Stato attuale del problema dello scandaglio acustico. — Rivista Marittima, Rome. — Nov. 1924, pp. 319-382.

1924. — E. A. ECKARDT. — Accurate determination of the speed of sound in sea water. — Physic. Rev. October 1924.

1924. — N. H. HECK, E. A. ECKARHDT, M. KEISER. — Radio acoustic method of position finding in Hydrographic Surveys, Special Publication N° 107. — U. S. C. & G. S.

1925. — International Hydrographic Bureau. — Echo Sounding. (Special publication, N° 4, March 1925 and Hydrographic Review).

Should any reader be aware of other publications which might be included in the above bibliographical information, it is requested that he will be kind enough to advise the International Hydrographic Bureau, giving full particulars; if suitable, such complementary data will be published for the benefit of the readers of the "*Hydrographic Review*".

TABLE 1. — $10^5 v$

v { Specific volume of sea-water expressed in / Volume spécifique de l'eau de mer exprimé en } { cm^3 / gm }

DEPTH PROFONDEUR		PRESSURE Pression DECIBARS	SALINITY (0/00).	TEMPERATURE (Centigrade)											
Fathoms brasses	Meters mètres			0	2	4	6	8	10	12	14	16	18	20	22
Surface & 100	*Surface* & 183	.....	31	97,570	97,581	97,596	97,616	97,641	97,670	97,703	97,740	97,781	97,824	97,873	97,923
		.....	32	97,493	97,504	97,520	97,540	97,566	97,595	97,629	97,666	97,707	97,751	97,799	97,850
			33	97,417	97,429	97,445	97,466	97,492	97,521	97,555	97,593	97,634	97,679	97,727	97,778
			34	97,340	97,352	97,369	97,391	97,417	97,447	97,481	97,519	97,561	97,605	97,654	97,705
			35	97,264	97,277	97,294	97,316	97,343	97,373	97,408	97,446	97,488	97,533	97,582	97,633
			36	97,188	97,201	97,219	97,241	97,269	97,299	97,335	97,373	97,415	97,460	97,510	97,561
			37	97,112	97,126	97,144	97,167	97,195	97,226	97,261	97,300	97,342	97,388	97,437	97,489
300.....	549.....	554	31	97,317	97,331	97,349	97,371	97,398	97,429	97,464	97,503	97,545	97,589	97,639	97,690
			32	97,241	97,255	97,274	97,296	97,324	97,355	97,391	97,430	97,472	97,517	97,566	97,618
			33	97,166	97,181	97,200	97,223	97,251	97,282	97,318	97,358	97,400	97,446	97,495	97,547
			34	97,090	97,105	97,125	97,149	97,177	97,209	97,245	97,285	97,328	97,373	97,423	97,475
			35	97,015	97,031	97,051	97,075	97,104	97,136	97,173	97,213	97,256	97,302	97,352	97,404
			36	96,940	96,956	96,977	97,001	97,031	97,063	97,101	97,141	97,184	97,230	97,281	97,333
			37	96,865	96,882	96,903	96,928	96,958	96,991	97,028	97,069	97,112	97,159	97,209	97,262
500.....	914.....	923	31	97,154	97,170	97,189	97,213	97,242	97,274	97,310	97,350	97,393	97,438	97,489	97 540
			32	97,078	97,094	97,114	97,138	97,167	97,200	97,237	97,277	97,320	97,366	97,416	97,468
			33	97,003	97,020	97,040	97,065	97,094	97,126	97,163	97,204	97,247	97,294	97,344	97,396
			34	96,928	96,945	96,966	96,992	97,021	97,054	97,091	97,132	97,177	97,223	97,274	97,326
			35	96,853	96,871	96,892	96,918	96,948	96,981	97,019	97,060	97,104	97,151	97,202	97,254
			36	96,778	96,796	96,818	96,844	96,875	96,908	96,947	96,988	97,032	97,079	97,131	97,183
			37	96,704	96,723	96,745	96,772	96,803	96,837	96,875	96,917	96,960	97,008	97,059	97,112
700.....	1280.....	1293...	31	96,989	97,006	97,027	97,053	97,084	97,117	97,154	97,195	97,240	97,285	97,337	.....
			32	96,914	96,931	96,953	96,979	97,010	97,044	97,082	97,123	97,168	97,214	97,265	.....
			33	96,840	96,858	96,878	96,905	96,936	96,969	97,007	97,049	97,095	97,142	97,193	.....
			34	96,765	96,783	96,806	96,834	96,865	96,899	96,937	96,979	97,025	97,071	97,124	.....
			35	96,691	96,710	96,733	96,761	96,793	96,827	96,866	96,908	96,954	97,001	97,053	.....
			36	96,617	96,636	96,660	96,688	96,721	96,755	96,795	96,837	96,883	96,930	96,983	.....
			37	96,543	96,563	96,587	96,616	96,649	96,684	96,722	96,765	96,811	96,859	96,911	.....
900.....	1646.....	1665...	31	96,827	96,846	96,869	96,897	96,929	96,963	97,002	.....	.....	.....	.....	.....
			32	96,753	96,772	96,796	96,823	96,857	96,891	96,931	.....	.....	.....	.....	.....
			33	96,679	96,699	96,723	96,751	96,784	96,819	96,859	.....	.....	.....	.....	.....
			34	96,605	96,625	96,650	96,679	96,712	96,749	96,787	.....	.....	.....	.....	.....
			35	96,531	96,552	96,577	96,606	96,640	96,675	96,716	.....	.....	.....	.....	.....
			36	96,457	96,478	96,504	96,533	96,568	96,603	96,645	.....	.....	.....	.....	.....
			37	96,384	96,406	96,432	96,462	96,497	97,532	96,573	.....	.....	.....	.....	.....

TABLE 1 — 10^5 v (continued) (suite)

Depth Profondeur		Pressure Pression	Temperature (Centigrade)					Salinity	Temperature (Centigrade)				Pressure Pression	Depth Profondeur	
Fathoms brasses	Meters mètres	Decibars	0	2	4	6	8	(0/00)	0	1	2	3	Decibars	Meters mètres	Fathoms brasses
1100	2012	2036	96,667	96,688	96,713	96,741	96,773	31	96,041	96,055	96,069	96,085	3527	3475	1900
			96,593	96,614	96,639	96,668	96,701	32	95,969	95,983	95,996	96,013			
			96,520	96,542	96,567	95,596	96,630	33	95,898	95,913	95,926	95,943			
			96,446	96,468	96,494	96,524	96,557	34	95,826	95,840	95,854	95,871			
			96,373	96,396	96,422	96,452	96,486	35	95,755	95,770	95,784	95,801			
			96,300	96,323	96,350	96,380	96,415	36	95,684	95,699	95,713	95,731			
			96,227	96,251	96,278	96,309	96,343	37	95,613	95,629	95,643	95,661			
1300	2377	2406	96,509	96,532	96,558	96,588	.....	31	95,890	95,905	95,920	95,936	3902	3840	2100
			96,436	96,459	96,485	96,516	.....	32	95,819	95,834	95,848	95,865			
			96,363	96,387	96,413	96,444	.....	33	95,748	95,764	95,778	95,795			
			96,290	96,314	96,341	96,373	.....	34	95,677	95,692	95,707	95,724			
			96,217	96,242	96,269	96,301	.....	35	95,606	95,622	95,637	95,654			
			96,144	96,169	96,197	96,229	.....	36	95,535	95,551	95,566	95,584			
			96,072	96,098	96,126	96,159	.....	37	95,465	95,482	95,497	95,515			
1500	2743	2780	96,351	96,376	96,404	.....	.....	31	95,738	95,754	95,769	95,787	4275	4206	2300
			96,278	96,302	96,332	.....	.....	32	95,667	95,683	95,697	95,716			
			96,206	96,231	96,260	.....	.....	33	95,597	95,614	95,628	95,647			
			96,133	96,158	96,188	.....	.....	34	95,526	95,542	95,557	95,576			
			96,061	96,087	96,117	.....	.....	35	95,456	95,473	95,488	95,507			
			95,989	96,015	96,046	.....	.....	36	95,386	95,403	95,418	95,438			
			95,917	95,944	95,975	.....	.....	37	95,316	95,334	95,349	95,369			
1700	3109	3154	96,195	96,222	96,251	.....	.....	31	95,588	95,606	95,621	95,639	4652	4572	2500
			96,122	96,148	96,179	.....	.....	32	95,518	95,535	95,551	95,569			
			96,051	96,078	96,108	.....	.....	33	95,448	95,466	95,481	95,501			
			95,978	96,005	96,036	.....	.....	34	95,378	95,395	95,411	95,430			
			95,907	95,935	95,966	.....	.....	35	95,308	95,326	95,342	95,361			
			95,836	95,864	95,896	.....	.....	36	95,238	95,256	95,272	95,292			
			95,764	95,793	95,825	.....	.....	37	95,169	95,188	95,203	95,223			

TABLE 1 — 10^5 v (continued) (suite)

DEPTH PROFONDEUR		PRESSURE PRESSION	TEMPERATURE (Centigrade)				SALINITY (0/00)	TEMPERATURE (Centigrade)			PRESSURE PRESSION	DEPTH PROFONDEUR	
Fathoms brasses	Meters mètres	Decibars	0	1	2	3		0	1	2	Decibars	Meters mètres	Fathoms brasse
2700	4938	5026	95,442	95,460	95,476	95,494	31	.....	.....	.....	7308	7132	3900
			95,371	95,388	95,405	95,423	32	.....	.....	.....			
			95,302	95,320	95,336	95,356	33	94,443	94,465	94,486			
			95,232	95,249	95,266	95,285	34	94,376	94,397	94,418			
			95,163	95,181	95,198	95,217	35	94,309	94,331	94,352			
			95,094	95,112	95,129	95,149	36	94,242	94,264	94,285			
			95,025	95,044	95,060	95,080	37	94,176	94,199	94,219			
2990	5303	5404	95,155	95,174	95,191	.....	33	94,305	94,328	94,349	7688	7498	4100
			95,086	95,104	95,122	.....	34	94,238	94,260	94,281			
			95,017	95,036	95,054	.....	35	94,172	94,195	94,216			
			94,948	94,967	94,985	.....	36	94,106	94,129	94,150			
			94,879	94,899	94,916	.....	37	94,040	04,064	94,084			
3100	5669	5780	95,011	95,031	95,048	.....	33	94,167	94,190	94 212	8070	7864	4300
			94,942	94,961	94,979	.....	34	94,101	94,123	94,145			
			94,874	94,894	94,912	.....	35	94,035	94,058	94,080			
			94,806	94,826	94,844	.....	36	93,969	93,992	94,014			
			94,737	94,758	94,776	.....	37	93,903	93,927	93,948			
3300	6035	6167	94,866	94,886	94,904	.....	33	94,033	94,057	94,079	8451	8229	4500
			94,797	94,816	94,835	.....	34	93,966	93,989	94,011			
			94,729	94,749	94,768	.....	35	93,901	93,925	93,947			
			94,661	94,681	94,700	.....	36	93,836	93,860	93,882			
			94,593	94,614	94,633	.....	37	93,770	93,795	93,816			
3500	6401	6547	94,723	94,744	94,762	.....	33	93,897	93,921	93,944	8834	8595	4700
			94,654	94,674	94,693	.....	34	93,831	93,854	93,877			
			94,587	94,608	94,627	.....	35	93,766	93,790	93,813			
			94,520	94,541	94,560	.....	36	93,701	93,725	93,748			
			94,452	94,474	94,493	.....	37	93,636	93,661	93,683			
3700	6766	6927	94,582	94,604	94,624	.....	33	.....	.....	.....			
			94,514	94,535	94,555	.....	34	.....	.....	.....			
			94,447	94,469	94,489	.....	35	.....	.....	.....			
			94,380	94,402	94,422	.....	36	.....	.....	.....			
			94,313	94,336	94,355	.....	37	.....	.....	.....			

TABLE 5 — $M = 10^5\,dv$

$dv =$ { decrease in specific volume in $\frac{cm3}{gm}$ corresponding to 1 bar in pressure.

diminution du volume spécifique, exprimée en $\frac{cm3}{gm}$ correspondant à un accroissement de pression de 1 bar.

Depth Profondeur		Salinity (0/00)	Temperature (Centigrade)											
Fathoms brasses	Meters mètres		0	2	4	6	8	10	12	14	16	18	20	22
Surface & 100	*Surface* & 183	31	4.56	4.51	4.47	4.43	4.39	4.34	4.31	4.29	4.26	4 23	4.21	5.18
		32	4.55	4.50	4.46	4 42	4.38	4.33	4.30	4.28	4.25	4.22	4.20	4.17
		33	4.53	4.48	4.44	4.40	4.36	4.31	4 28	4.26	4.23	4.20	4.18	4.15
		34	4 52	4 47	4 43	4 39	4 35	4 30	4 27	4 25	4 22	4 19	4 17	4 14
		35	4.50	4.45	4.41	4.37	4.33	4.28	4.25	4.23	4.20	4.17	4.15	4.12
		36	4.49	4.44	4.40	4.36	4.32	4.27	4.24	4.22	4.19	4.16	4.14	4.11
		37	4.47	4 42	4.38	4.34	4.30	4.25	4.22	4.20	4.17	4.14	4.12	4.09
300	549.....	31	4.50	4.45	4.41	4.37	4.33	4.28	4.25	4.23	4.20	4.17	4.16	4.14
		32	4.48	4.43	4.39	4.35	4.31	4.26	4.23	4.21	4.18	4.15	4.14	4.12
		33	4.47	4.42	4.38	4.34	4.30	4 25	4.22	4.20	4.17	4.14	4.13	4.11
		34	4.45	4.40	4.36	4.32	4.28	4.23	4.20	4.18	4.15	4.12	4.11	4.09
		35	4.44	4.39	4.35	4.31	4.27	4.22	4.19	4.17	4.14	4 11	4 10	4.08
		36	4.42	4.37	4.33	4.29	4.25	4.20	4.17	4.15	4.12	4.09	4.08	4.06
		37	4.41	4.36	4.32	4.28	4.24	4.19	4.16	4.14	4.11	4.08	4.07	4.05
500	914.....	31	4.45	4.40	4.36	4.32	4.28	4.24	4.21	4.19	4.15	4.13	4.11	4.09
		32	4.44	4.39	4.35	4.31	4.27	4.23	4.20	4.18	4.14	4.12	4.10	4.08
		33	4.42	4.37	4.33	4.29	4.25	4.21	4.18	4.16	4.12	4.10	4.08	4.06
		34	4.41	4.36	4.32	4.28	4.24	4.20	4.17	4.15	4.11	4.09	4.07	4.05
		35	4.39	4.34	4.30	4.26	4.22	4.18	4.15	4.13	4.09	4 07	4.05	4.03
		36	4.38	4.33	4.29	4.25	4.21	4.17	4.14	4.12	4.08	4.06	4.04	4.02
		37	4.36	4.31	4.27	4.23	4.19	4.15	4.12	4.10	4.06	4.04	4.02	4.00
700	1280.....	31	4.39	4.34	4.30	4.26	4.22	4.18	4.15	4.14	4.10	4.08	4.06	.....
		32	4.38	4.33	4.29	4.25	4.21	4.17	4.14	4.13	4.09	4.07	4.05	.....
		33	4.36	4.31	4.27	4.23	4.19	4.15	4.12	4.11	4.07	4.05	4.03	.....
		34	4.35	4.30	4.26	4.22	4.18	4.14	4.11	4.10	4.06	4.04	4.02	.....
		35	4.33	4.28	4.24	4.20	4.16	4.12	4.09	4.08	4.04	4.02	4.00	.....
		36	4.32	4.27	4.23	4.19	4.15	4.11	4.08	4.07	4.03	4.01	3.99	.....
		37	4.30	4.25	4.21	4.17	4.13	4.09	4.06	4.05	4.01	3.99	3.97	.....
900	1646.....	31	4 34	4.29	4.25	4.21	4 17	4.14	4 11	.....	.....	.....	.....	.....
		32	4.33	4.28	4.24	4.20	4.16	4.13	4.10	.....	.....	.....	.....	.....
		33	4.31	4.26	4.22	4.18	4.14	4.11	4.08	.....	.....	.....	.....	.....
		34	4.30	4.25	4.21	4 17	4.13	4.10	5.07	.....	.....	.....	.....	.....
		35	4.28	4.23	4.19	4.15	4.11	4.08	4.05	.....	.....	.....	.....	.....
		36	4.27	4.22	4.18	4.14	4.10	4.07	4.04	.....	.....	.....	.....	.....
		37	4.25	4.20	4.16	4.12	4.08	4.05	4.02	.....	.....	.....	.....	.....

Depth Profondeur		Temperature (Centigrade)					Salinity (0/00)	Temperature (Centigrade)				Depth Profondeur	
Fathoms brasses	Meters mètres	0	2	4	6	8		0	1	2	3	Fathoms brasses	Meters mètres
1100	2012	4 30	4 25	4 21	4 17	4 13	31	4.09	4.07	4.05	4.04	1900	3475
		4.28	4.23	4.19	4.15	4.11	32	4.07	4.05	4.03	4.02		
		4.27	4.22	4.18	4.14	4.10	33	4.06	4.04	4.02	4.01		
		4.25	4.20	4.16	4.12	4.08	34	4 05	4.03	4.01	4.00		
		4.24	4.19	4.15	4.11	4.07	35	4.03	4.01	3.99	3.98		
		4.22	4.17	4.13	4.09	4.05	36	4.02	4.00	3.98	3.97		
		4.21	4.16	4.12	4.08	4.04	37	4.01	3.99	3.97	3.96		
1300	2377	4.25	4.21	4.16	4.12	.....	31	4.06	4.04	3 02	4.01	2100	3840
		4.23	4.19	4.14	4.10	.....	32	4.04	4.02	4.00	3.99		
		4.22	4.18	4.13	4.09	.....	33	4.03	4.01	3.99	3.98		
		4.20	4.16	4.11	4.07	.....	34	4.02	4.00	3.98	3.97		
		4.19	4.15	4.10	4.06	.....	35	4.00	3.98	3.96	3.95		
		4.17	4.13	4.08	4.04	.....	36	3.98	3.97	3.95	3.94		
		4.16	4.12	4.07	4.03	.....	37	3.98	3.96	3.94	3.93		
1500	2743	4.20	4.16	4.11	.....	.....	31	4.00	3.98	3.96	3.95	2300	4206
		4.18	4.14	4.09	.....	.....	32	3.98	3.96	3.94	3.93		
		4.17	4.13	4.08	.....	.....	33	3.97	3.95	3.93	3.92		
		4.15	4.11	4.06	.....	.....	34	3.96	3.94	3.92	3.91		
		4.14	4.10	4.05	.....	.....	35	3.94	3.92	3.90	3.89		
		4.12	4.08	4.03	.....	.....	36	3.93	3.91	3.89	3.88		
		4.11	4.07	4.02	.....	.....	37	3.92	3.90	3.88	3.87		
1700	3109	4.15	4.11	4.06	.....	.....	31	3.96	3.94	3.92	3.91	2500	4572
		4.14	4.10	4.05	.....	.....	32	3.95	3.93	3.91	3.90		
		4.12	4.08	4.03	.....	.....	33	3.94	3.92	3.90	3.89		
		4.11	4.07	4.02	.....	.....	34	3.93	3.91	3.89	3.88		
		4.09	4.05	4.00	.....	.....	35	3.91	3.89	3.87	3.86		
		4.08	4.04	3.99	.....	.....	36	3.90	3.88	3.86	3.85		
		4.06	4.02	3.97	.....	.....	37	3.89	3.87	3.85	3.84		

Depth Profondeur		Temperature (Centigrade)				Salinity (0/00)	Temperartue (Centigrade)			Depth Profondeur	
Fathoms brasses	Meters mètres	0	1	2	3		0	1	2	Fathoms brasses	Meters mètres
2700	4938	3 92	3 90	3 88	3 87	31	.....	.....	.....	3900	7132
		3 91	3 89	3 87	3 86	32	.....	.....	.....		
		3 89	3 87	3 85	3 84	33	3 65	3 64	3 62		
		3 88	3 86	3 84	3 83	34	3 63	3 62	3 60		
		3 87	3 85	3 83	3 82	35	3 62	3 61	3 59		
		3 86	3 84	3 82	3 81	36	3 61	3 60	3 58		
		3 84	3 82	3 80	3 79	37	3 60	3 59	3 57		
2900	5303	3 85	3 83	3 81	.....	33	3 60	3 59	3 57	4100	7498
		3 84	3 82	3 80	.....	34	3 59	3 58	3 56		
		3 83	3 81	3 79	.....	35	3 58	3 57	3 55		
		3 82	3 80	3 78	.....	36	3 57	3 56	3 54		
		3 80	3 78	3 76	.....	37	3 56	3 55	3 53		
3100	5669	3 80	3.78	3.76	.....	33	3.57	3.56	3.54	4300	7864
		3.79	3.77	3.75	.....	34	3.56	3.55	3.53		
		3.78	3.76	3.74	.....	35	3.55	3.54	3.52		
		3.77	3.75	3.73	.....	36	3.54	3.53	3.51		
		3.75	3.73	3.71	.....	37	3.53	3.52	3.50		
3300	6035	3.76	3.74	3.72	.....	33	3.54	3.53	3.51	4500	8229
		3.74	3.72	3.70	.....	34	3.53	3.52	3.50		
		3.73	3.71	3.69	.....	35	3.52	3.51	3.49		
		3.72	3.70	3.68	.....	36	3.51	3.50	3.48		
		3.71	3.69	3.67	.....	37	3.50	3.49	3.47		
3500	6401	3.72	2.71	3.69	.....	33	3.49	3.48	3.46	4700	8595
		3.71	3.70	3.68	.....	34	3.48	3.47	3.45		
		3.70	3.69	3.67	.....	35	3.47	3.46	3.44		
		3.69	3.68	3.66	.....	36	3.46	3.45	3.43		
		3.67	3.66	3.64	.....	37	3.45	3.44	3.42		
3700	6766	3.68	3.67	3.65	.....	33	.....	.....	.....		
		3.66	3.65	3.63	.....	34	.....	.....	.....		
		3.65	3.64	3.62	.....	35	.....	.....	.....		
		3.64	3.63	3.61	.....	36	.....	.....	.....		
		3.63	3.62	3.60	.....	37	.....	.....	.....		

TABLE 13

Velocity of Sound in Sea water in fathoms per second.
Velocities are also given in meters per second (lower line).

Vitesse du son dans l'eau de mer, exprimée en brasses par seconde.
Les vitesses sont aussi données en mètres par seconde (ligne inférieure).

DEPTH PROFONDEUR		SALINITY (0/00)	TEMPERATURE (Centigrade)											
Fathoms Brasses	Meters Mètres		0	2	4	6	8	10	12	14	16	18	20	22
Surface & 100	*Surface* & 183	31	790 1,445	795 1,453	798 1,459	802 1,466	806 1,474	811 1,482	814 1,488	816 1,492	819 1,498	822 1,504	825 1,508	828 1,515
		32	791 1,446	795 1,454	799 1,461	803 1,467	806 1,474	811 1,483	814 1,489	816 1,493	820 1,499	823 1,505	825 1,509	829 1,516
		33	792 1,448	796 1,455	800 1,462	804 1,469	807 1,476	812 1,485	815 1,491	817 1,495	821 1,501	824 1,507	826 1,511	830 1,518
		34	792 1,449	796 1,456	800 1,463	804 1,471	808 1,477	813 1,486	816 1,492	818 1,496	821 1,502	825 1,508	827 1,513	831 1,519
		35	793 1,450	797 1,458	801 1,465	805 1,472	809 1,479	814 1,489	817 1,494	819 1,498	822 1,504	826 1,510	828 1,514	832 1,521
		36	793 1,451	798 1 459	802 1,466	806 1,473	809 1,480	815 1,490	818 1,495	820 1,499	823 1,505	826 1,511	829 1,515	833 1,522
		37	794 1,452	799 1,461	803 1,468	807 1,475	810 1,482	815 1,491	918 1,497	821 1,501	825 1,507	827 1,513	830 1,518	834 1,525
300	549	31	793 1,450	798 1,459	802 1,467	805 1,472	809 1,480	814 1,489	817 1,494	820 1,500	823 1,505	827 1,512	828 1,514	830 1,518
		32	794 1,452	799 1,461	803 1,468	806 1,474	810 1,481	815 1,491	818 1,496	821 1,502	824 1,507	827 1,513	829 1,516	831 1,520
		33	795 1,454	799 1,462	803 1,469	807 1,476	811 1,483	816 1,492	819 1,498	822 1,503	825 1,509	828 1,514	829 1,517	832 1,522
		34	796 1,455	801 1,464	804 1,470	808 1,478	812 1,485	817 1,494	820 1,499	823 1,505	826 1,510	829 1,516	830 1,518	833 1,523
		35	796 1,456	801 1,465	805 1,472	809 1,479	813 1,487	818 1,496	820 1,500	823 1,506	826 1,511	830 1,518	831 1,520	834 1,525
		36	797 1,458	802 1,466	806 1,474	809 1,480	814 1,488	819 14,98	822 1,503	824 1,507	827 1,512	831 1,520	832 1,522	835 1,527
		37	798 1,459	902 1,467	806 1,475	810 1,481	814 1,489	820 1,500	823 1,505	825 1,509	828 1,514	832 1,522	833 1,523	836 1,529
500	914	31	796 1,456	801 1,465	804 1,470	809 1,479	913 1,487	817 1,494	820 1,500	822 1,503	827 1,512	829 1,516	832 1,521	834 1,525
		32	797 1,458	802 1,467	805 1,472	809 1,480	814 1,488	818 1,496	821 1,502	823 1,505	827 1,513	830 1,518	832 1,522	835 1,527
		33	798 1,459	803 1,468	806 1,474	810 1,481	814 1,489	819 1,497	822 1,503	824 1,507	828 1,514	831 1,520	833 1,523	836 1,529
		34	798 1,460	803 1,469	807 1,476	810 1,483	815 1,491	819 1,498	922 1,504	825 1,509	829 1,516	832 1,521	834 1,525	837 1,531
		35	799 1,461	804 1,470	808 1,478	812 1,485	816 1,492	820 1,500	823 1,505	826 1,511	830 1,518	832 1,522	835 1,527	838 1,532
		36	800 1,463	804 1,471	809 1,480	813 1,486	817 1,494	821 1,502	824 1,507	827 1,512	831 1,520	833 1,523	836 1,529	838 1,533
		37	801 1,465	805 1,472	810 1,481	813 1,487	818 1,496	822 1,503	825 1,509	828 1,514	832 1,522	834 1,525	837 1,531	839 1,534

Depth Profondeur		Salinity (0/00)	Temperature (Centigrade)											
Fathoms brasses	Meters mètres		0	2	4	6	8	10	12	14	16	18	20	22
700	1280	31	801	805	809	813	817	821	825	826	830	833	835	.....
			1,465	1,473	1,479	1,487	1,494	1,502	1,508	1,510	1,518	1,523	1,527	.....
		32	801	806	809	814	818	822	825	826	831	833	836	.....
			1,466	1,474	1,480	1,488	1,496	1,503	1,509	1,511	1,520	1,524	1,529	.....
		33	802	807	810	814	819	823	826	827	832	835	837	.....
			1,467	1,475	1,481	1,489	1,497	1,505	1,511	1,512	1,522	1,527	1,531	.....
		34	803	807	811	815	819	824	827	828	833	835	838	.....
			1,469	1,476	1,483	1,491	1,498	1,507	1,512	1,514	1,523	1,529	1,532	.....
		35	804	808	812	816	820	825	828	829	834	837	839	.....
			1,470	1,478	1,485	1,492	1,500	1,509	1.514	1,516	1,525	1,530	1,534	.....
		36	804	809	813	817	821	826	829	830	835	837	840	.....
			1,471	1,480	1,487	1,494	1,502	1,511	1,516	1,518	1,527	1,532	1,536	.....
		37	805	810	814	818	822	827	830	831	836	839	841	.....
			1,472	1,481	1,489	1,496	1,503	1,512	1,518	1,520	1,529	1,534	1,538	.....

Depth Profondeur		Temperature (Centigrade)							Salinity (0/00)	Temperature (Centigrade)				Depth Profondeur	
Fathoms brasses	Meters mètres	0	2	4	6	8	10	12		0	1	2	3	Fathoms brasses	Meters mètres
900	1646	803	808	812	816	820	824	827	31	821	823	825	826	1900	3475
		1,469	1,478	1,485	1,492	1,500	1,507	1,512		1,502	1 506	1,509	1,511		
		804	809	813	817	821	825	828	32	822	825	827	827		
		1,470	1,479	1,487	1,494	1,502	1,508	1,514		1,503	1,508	1 5,12	1,512		
		805	809	814	818	822	825	829	33	823	825	827	828		
		1,472	1,480	1,489	1,496	1,503	1,509	1,516		1,505	1,509	1,513	1,514		
		805	810	815	819	823	826	830	34	824	826	828	829		
		1,473	1,481	1,490	1,498	1,505	1,511	1,518		1,507	1,511	1,514	1,516		
		806	811	815	820	824	827	831	35	825	827	829	830		
		1,475	1,483	1,491	1,499	1,507	1,512	1,520		1,508	1,512	1,516	1,518		
		807	812	816	820	825	828	832	36	825	827	829	831		
		1,477	1,485	1,493	1,500	1,509	1,514	1,522		1,509	1,513	1,517	1,519		
		809	813	818	821	826	829	833	37	826	828	830	831		
		1,479	1,487	1,495	1,502	1,511	1,516	1,523		1,511	1,514	1,518	1,520		
1100	2012	806	811	815	819	823	.....	.....	31	823	825	827	828	2100	3840
		1,474	1,483	1,491	1,498	1,505	.....	.....		1,505	1,509	1,512	1,514		
		807	812	816	820	824	.....	.....	32	824	826	828	829		
		1,476	1,485	1,492	1,500	1,507	.....	.....		1.507	1,511	1 514	1,516		
		808	813	817	821	825	.....	. .....	33	825	827	829	830		
		1,478	1,487	1,494	1 502	1,509	.....	.....		1,508	1,512	1,516	1 518		
		809	814	818	822	826	.....	. .....	34	825	827	830	831		
		1 479	1,488	1,496	1,503	1,511	.....	.....		1,509	1,513	1,518	1,520		
		809	814	819	823	827	.....	.....	35	826	828	831	832		
		1.480	1,489	1 498	1,505	1,512	.....	.....		1,511	1,514	15,19	15,22		
		810	815	820	824	828	.....	.....	36	827	829	831	833		
		1,481	1,491	1,499	1,507	1,514	.....	.....		1,512	1,516	1,520	1,523		
		811	816	820	825	828	.....	.....	37	827	829	832	833		
		1,483	1,492	1,500	1,509	1,515	.....	.....		1,513	1,517	1,522	1,524		

Depth Profondeur		Temperature (Centigrade)							Salinity (0/00)	Temperature (Centigrade)				Depth Profondeur	
Fathoms Brasses	Meters Mètres	0	2	4	6	8	10	12		0	1	2	3	Fathoms Brasses	Meters Mètres
1300	2377	809	814	819	822	.....	.....	.....	31	828	830	832	833	2300	4206
		1,480	1,488	1,498	1,504	.....	.....	.....		1,514	1,518	1,522	1,523		
		810	814	820	824	.....	.....	.....	32	829	831	833	834		
		1,481	1,489	1,499	1,506	.....	.....	.....		1,516	1,520	1,523	1,525		
		811	815	820	825	.....	.....	.....	33	829	832	834	835		
		1,483	1,491	1,500	1,508	.....	.....	.....		1,517	1,521	1,525	1,527		
		812	816	821	826	.....	.....	.....	34	830	832	835	836		
		1,485	1,492	1,502	1,510	.....	.....	.....		1,518	1,522	1,527	15,29		
		813	817	822	827	.....	.....	.....	35	831	833	836	837		
		1,487	1,494	1,503	1,512	.....	.....	.....		1,520	1,523	1,529	1,531		
		814	818	823	828	.....	.....	.....	36	832	834	837	838		
		1,488	1,496	1,505	1,514	.....	.....	.....		1,521	1,525	1,530	1,532		
		814	818	823	828	.....	.....	.....	37	832	834	837	838		
		1,489	1,497	1,506	1,515	.....	.....	.....		1,522	1,526	1,531	15,33		
1500	2743	813	817	822	.....	.....	.....	.....	31	830	833	835	836	2500	4572
		1,487	1,494	1,503	.....	.....	.....	.....		1,518	1,523	1,527	1,529		
		814	818	823	.....	.....	.....	.....	32	831	833	836	837		
		1,489	1,496	1,505	.....	.....	.....	.....		1,519	1,524	1,528	1,531		
		815	819	824	.....	.....	.....	.....	33	831	834	836	838		
		1,491	1,498	1,507	.....	.....	.....	.....		1,520	1,525	1,529	1,532		
		816	820	825	.....	.....	.....	.....	34	832	834	837	838		
		1,492	1,500	1,509	.....	.....	.....	.....		1,522	1,526	1,531	1,533		
		816	821	826	.....	.....	.....	.....	35	833	835	838	839		
		1,493	1,503	1,511	.....	.....	.....	.....		1,523	1,527	1,532	15,34		
		817	822	827	.....	.....	.....	.....	36	834	836	839	839		
		1,494	1,503	1,512	.....	.....	.....	.....		1,525	1,529	1,534	1,535		
		8 17	823	828	.....	.....	.....	.....	37	825	837	839	840		
		1,495	1,505	1,514	.....	.....	.....	.....		1,527	1,531	1,535	1,536		
1700	3109	816	820	826	.....	.....	.....	.....	31	833	836	838	839	2700	4938
		1,492	1,500	1,511	.....	.....	.....	.....		1,523	1,529	1,533	1,534		
		817	821	827	.....	.....	.....	.....	32	834	837	839	840		
		1,494	1,502	1,512	.....	.....	.....	.....		1,525	1,531	1,534	1,536		
		818	822	828	.....	.....	.....	.....	33	835	838	840	841		
		1,496	1,503	1,514	.....	.....	.....	.....		1,527	1,532	1,536	1,538		
		819	823	828	.....	.....	.....	.....	34	836	838	840	842		
		1,498	1,505	1,515	.....	.....	.....	.....		1,528	1,533	1,537	1,540		
		820	824	829	.....	.....	.....	.....	35	836	838	841	843		
		1,500	1,507	1 516	.....	.....	.....	.....		1,529	1,534	1,538	1,541		
		821	825	830	.....	.....	.....	.....	36	837	839	842	843		
		1,502	1,509	1,518	.....	.....	.....	.....		1,531	1,535	1,540	1,542		
		822	826	831	.....	.....	.....	.....	37	838	841	843	844		
		1,503	1,511	1,520	.....	.....	.....	.....		1,533	1,537	1,542	1,544		

Salinity 0/00	Depth Profondeur		Temperature (Centigrade)			Depth Profondeur		Temperature (Centigrade)			Depth Profondeur		Temperature (Centigrade)		
	Fathoms brasses	Meters mètres	0	1	2	Fathoms brasses	Meters mètres	0	1	2	Fathoms brasses	Meters mètres	0	1	
33	2900	5303	838 1,532	841 1,538	843 1,542	3700	6766	852 1,558	854 1,562	856 1,566	4500	8229	864 1,580	866 1,584	868 1,587
34			839 1,534	842 1,539	844 1,543			854 1,561	856 1,564	858 1,568			865 1,582	867 1,585	869 1,589
35			839 1,535	842 1,540	844 1,544			855 1,563	856 1,566	858 1,570			866 1,583	867 1,586	870 1,591
36			840 1,537	843 1,542	845 1,545			855 1,564	857 1,567	859 1,571			866 1,584	867 1,587	876 1,592
37			842 1,539	844 1,543	846 1,547			856 1,565	858 1,569	860 1,573			867 1,586	868 1,588	871 1,593
33	3100	5669	843 1,541	845 1,545	848 1,551	3900	7132	855 1,564	856 1,566	859 1,571	4700	8595	869 1,589	871 1,593	873 1,596
34			843 1,542	845 1,546	848 1,552			856 1,566	857 1,567	860 1,573			869 1,590	872 1,594	874 1,598
35			844 1,543	846 1,547	849 1,553			857 1,567	858 1,569	861 1,575			870 1,591	872 1,595	875 1,600
36			844 1,544	847 1,549	850 1,554			857 1,568	859 1,571	862 1,576			871 1,593	873 1,596	875 1,601
37			845 1,545	848 1,551	851 1,556			858 1,569	860 1,573	862 1,577			872 1,595	873 1,597	876 1,602
33	3300	6035	846 1,547	848 1,552	851 1,556	4100	7498	860 1,572	861 1,574	863 1,578			…… ……	…… ……	…… ……
34			847 1,549	850 1,554	852 1,558			860 1,573	861 1,575	864 1,580			…… ……	…… ……	…… ……
35			848 1,551	851 1,555	853 1,560			861 1,574	862 1,576	865 1,582			…… ……	…… ……	…… ……
36			849 1,552	851 1,556	854 1,561			861 1,575	863 1,578	866 1,583			…… ……	…… ……	…… ……
37			849 1,553	851 1,557	854 1,562			862 1,576	863 1,579	866 1,584			…… ……	…… ……	…… ……
33	3500	6401	849 1,553	851 1 556	853 1,560	4300	7864	862 1,576	863 1,578	866 1 583			…… ……	…… ……	…… ……
34			850 1 554	851 1 557	854 1,561			862 1,577	863 1,579	866 1,584			…… ……	…… ……	…… ……
35			850 1,555	852 1,558	854 1,562			863 1,578	864 1 580	867 1,586			…… ……	…… ……	…… ……
36			851 1,556	852 1,559	855 1,564			863 1,579	865 1,582	868 1,587			…… ……	…… ……	…… ……
37			852 1,558	854 1,561	856 1,565			864 1,580	866 1,584	868 1,588			…… ……	…… ……	…… ……

TABLE (A)

[1 fathom = 1,828768 mètres]

Correspondance des Echelles des brasses et des mètres

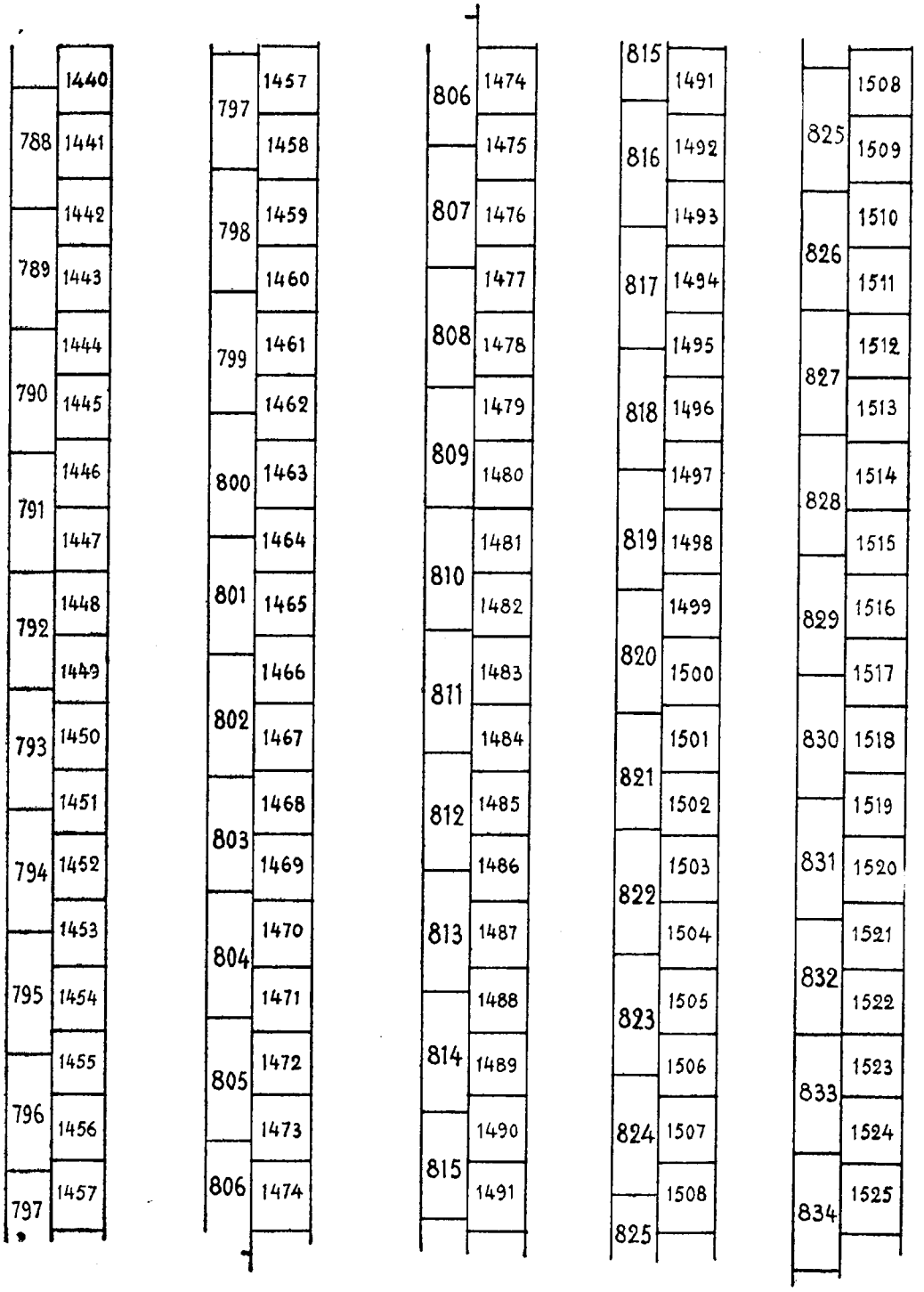
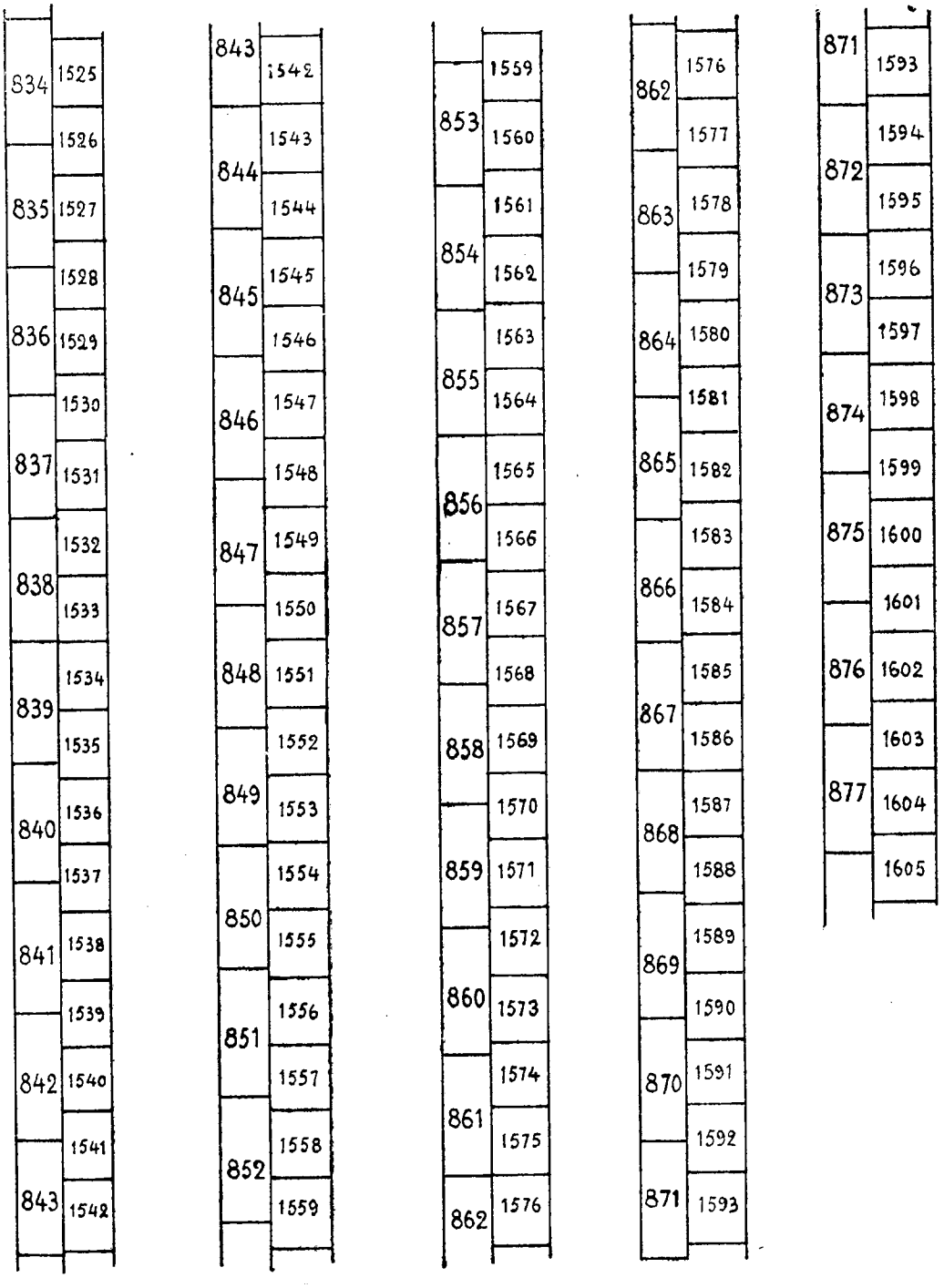


TABLE (A)

[1 fathom = 1.828768 metres]

Scales of Correspondence of fathoms and meters.



CONVERSION TABLE Fathoms in Meters (B·)

TABLEAU DE CONVERSION des brasses en mètres

Fathoms Brasses	00	10	20	30	40	50	60	70	80	90
	m	m	m	m	m	m	m	m	m	m
100	183	201	220	238	256	274	293	311	329	348
200	366	384	402	421	439	457	476	494	512	530
300	549	567	585	604	622	640	658	677	695	713
400	732	750	768	786	805	823	841	860	878	896
500	914	933	951	969	988	1006	1024	1042	1061	1079
600	1097	1116	1134	1152	1170	1189	1207	1225	1244	1262
700	1280	1298	1317	1335	1353	1372	1390	1408	1426	1445
800	1463	1481	1500	1518	1536	1554	1573	1591	1609	1628
900	1646	1664	1683	1701	1719	1737	1756	1774	1792	1810
1000	1829	1847	1865	1884	1902	1920	1939	1957	1975	1993
1100	2012	2030	2048	2067	2085	2103	2121	2140	2158	2176
1200	2195	2213	2231	2249	2268	2286	2304	2323	2341	2359
1300	2377	2396	2414	2432	2451	2469	2487	2505	2524	2542
1400	2560	2579	2597	2615	2633	2652	2670	2688	2707	2725
1500	2743	2761	2780	2798	2816	2835	2853	2871	2889	2908
1600	2926	2944	2963	2981	2999	3017	3036	3054	3072	3091
1700	3109	3127	3145	3164	3182	3200	3219	3237	3255	3274
1800	3292	3310	3328	3347	3365	3383	3402	3420	3438	3456
1900	3475	3493	3511	3530	3548	3566	3584	3603	3621	3639
2000	3658	3676	3694	3712	3731	3749	3767	3786	3804	3822
2100	3840	3859	3877	3895	3914	3932	3950	3968	3987	4005
2200	4023	4042	4060	4078	4096	4115	4133	4151	4170	4188
2300	4206	4224	4243	4261	4276	4298	4316	4334	4352	4371
2400	4389	4407	4425	4444	4462	4480	4499	4517	4535	4553
2500	4572	4590	4609	4627	4645	4663	4682	4700	4718	4737
2600	4755	4773	4791	4810	4828	4846	4865	4883	4901	4919
2700	4938	4956	4974	4993	5011	5029	5047	5066	5084	5102
2800	5121	5139	5157	5175	5194	5212	5230	5249	5267	5285
2900	5303	5322	5340	5358	5377	5395	5413	5431	5450	5468
3000	5486	5505	5523	5541	5559	5578	5596	5614	5633	5651
3100	5669	5687	5706	5724	5742	5761	5779	5797	5815	5834
3200	5852	5870	5889	5907	5925	5944	5962	5980	5998	6017
3300	6035	6053	6072	6090	6108	6126	6145	6163	6181	6200
3400	6218	6236	6254	6273	6291	6309	6328	6346	6364	6382
3500	6401	6419	6437	6456	6474	6492	6510	6529	6547	6565
3600	6584	6602	6620	6638	6657	6675	6693	6712	6730	6478
3700	6766	6785	6803	6821	6840	6858	6876	6894	6913	6931
3800	6949	6968	6986	7004	7022	7041	7059	7077	7096	7114
3900	7132	7150	7169	7187	7205	7224	7242	7260	7279	7297
4000	7315	7333	7352	7370	7388	7407	7425	7443	7461	7480
4100	7498	7516	7535	7553	7571	7589	7608	7626	7644	7663
4200	7681	7699	7717	7736	7754	7772	7791	7809	7827	7845
4300	7864	7882	7900	7919	7937	7955	7973	7992	8010	8028
4400	8047	8065	8083	8101	8120	8138	8156	8175	8193	8211
4500	8229	8248	8266	8284	8303	8321	8339	8357	8376	8394
4600	8412	8431	8449	8467	8485	8504	8522	8540	8559	8577
4700	8595	8614	8632	8650	8668	8687	8705	8723	8742	8760
4800	8778	8796	8315	8833	8851	8870	8888	8906	8924	8943
4900	8961	8979	8998	9016	9034	9052	9071	9089	9107	9126
5000	9144	9162	9180	9199	9217	9235	9254	9272	9290	9308
5100	9327	9345	9363	9382	9400	9418	9436	9455	9473	9491
5200	9510	9528	9546	9564	9583	9601	9619	9638	9656	9674
5300	9692	9711	9729	9747	9766	9784	9802	9820	9839	9857
5400	9875	9894	9912	9930	9949	9967	9985	10003	10022	10040

Prop. p.

Diff. 18

F.	M.
1	2
2	4
3	5
4	7
5	9
6	11
7	13
8	15
9	16

Diff. 19

F.	M.
1	2
2	4
3	6
4	8
5	10
6	11
7	13
8	15
9	17