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# THE COMPRESSIBILITY MEASUREMENTS ON LIQUIDS

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## Introduction

In a high pressure apparatus, water, mercury, alcohols, glycerin, machine oils, and silicone oils, etc. are used as pressure transmitting liquids. It is desirable that in order to be used as the transmitting liquids, the liquids have the following properties,—(a) they are chemically stable, (b) the changes of their viscosities by temperature are small, (c) their melting points under pressures are below, and (d) their physical constants under a wide range of pressure and temperature have been elucidated. Water, mercury, alcohols, and glycerin, whose physical constants under pressures have been measured, have the faults for use due to their low melting points under high pressures or chemical stabilities. The viscosities of machine oils have wide difference according to their kinds, and change widely by temperature, and the compressibilities of the oils have not been reported in literature. Silicone oils are chemically stable, their flash points are about 315°C and the changes of their viscosity by temperature are smaller than those of machine oils, but their compressibilities have not been reported in literature except P. W. Bridgman's report[1] (published during the present measurements) in which, however, the differences of two neighbouring pressures observed are too wide, and the experimental temperatures have not been described. Therefore, in order to measure the compressibilities of machine oils and silicone oils, the authors have constructed the two apparatus for compressibility measurement on liquids, the one for lower pressure ranges and the other for higher, both of which are able to be employed under the pressures changing continuously. The former by which H. Teranishi has measured the results in Part I, has a modified type of E. P. Perman and W. D. Urry's apparatus employed in 1930[2], and can be used for viscous liquids, the latter, by which K. Inoue has measured the results in Part II with assistance of Mr. K. Ozawa, has a modified type of F. G. Keyes' reported in 1933[3], and can measure directly the volume change of the sample independent of that of mercury.

The compressibility $k$ of liquid is defined as the following equation[4],

$$k = -\frac{1}{V_1} \times \frac{V_2 - V_1}{P_2 - P_1}$$

where $V_1$ and $V_2$ are the volumes of liquid under the pressures $P_1$ and $P_2$ respectively.

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[1] P. W. Bridgman, *Proc. Am. Acad. Arts Sci.*, **77**, 115, 129 (1949)

[2] E. P. Perman and W. D. Urry, *Proc. Roy. Soc.*, **126**, 44 (1930)

[3] F. G. Keyes, *Proc. Am. Acad. Arts Sci.*, **68**, 505 (1933)

[4] Landolt-Börnstein, "*Physikalisch-chemische Tabellen,*" (5 Auflage) I, 94 (1923)

In this work, $P_1$ is always 1 atm[5] and so $k$ means the average compressibility under the pressure range from 1 to $P_2$ atm.

The distilled water, which had been boiled to remove the bubbles contained, was employed in the calibrating tests of both apparatus[6].

For the compressibility measurements of machine oils, three kinds of Mobil oils A, BB, and B (S. A. E. 30, 50, and 60 respectively) of Standard Vacuum Oil Co., N. Y., preceding the measurement on home products, were employed, after the bubbles contained had been removed by heating to 80°C for 1 hour.

For silicone oil, the samples of two groups (a) and (b) were employed. The oils of (a) were synthesized, separated, and purified in our laboratory by T. Ikegami and T. Izumitani in 1949[7] as described below. Methyl chlorosilanes, which were produced by the reaction of methyl chloride and sintered metallic silicon-cupper mixture at 285°C, were distillated by means of a Podbielniak's distillator and dimethyl dichlorosilane (B. P. 70.2°C) was separated. Then the latter was dissolved in the same volume of ethyl ether and an ether solution was hydrolized by being added dropwise to the same amount of water at 0°C. The products were distillated by means of a Podbielniak's distillator and the sample oils were separated at the conditions described below.

| *Molecular form* | *Molecular weight* | *Boiling point* |
|---|---|---|
| $[(CH_3)_2SiO]_4$ | 296 | 74.5 ~ 76.0°C (19~20 mm Hg) |
| $[(CH_3)_2SiO]_5$ | 370 | 92.0 ~ 100.5°C ( 20 mm Hg) |

Four oils of group (b) were high polymers of dimethylsiloxane* signed SS-I, -II, -III, and -IV respectively in order of their viscosities, and the following table shows their densities and viscosities at 20°C and the average molecular weights[8] which were determined by the measurements of viscosities of their toluene solutions.

| | *Average molecular weight* | *Density* (20°C) g/cc | *Viscosity* (20°C) c.s. |
|---|---|---|---|
| SS-I | 1130 | 0.940 | 10.4 |
| SS-II | 6800 | 0.961 | 100 |
| SS-III | 13900 | 0.971 | 272 |
| SS-IV | 43000 | 0.974 | 4530 |

# PART I

## Experimental Apparatus and Procedures

In the E. P. Perman and W. D. Urry method[2], the sample liquid is filled in a capillary glass piezometer which has a dilated part at one end. The dilated part is set in a steel

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5) L. B. Smith and F. G. Keyes, *Proc. Am. Acad. Arts Sci.*, **69**, 313 (1934)

6) E. H. Amagat, *Ann. Chim. Phys.*, (6) **29**, 68, 505 (1893)

7) R. Kiyama, T. Ikegami and T. Izumitani, *Unpublished*.

8) A. J. Barry, *J. App. Phys.*, **17**, 1020 (1946)

* Donated by Shin-etsu Chem. Ind. Co., Tokyo.

vessel and protected for destruction by pressure, and the other end of the piezometer is connected with a steel pipe. The volume changes of the sample liquid due to pressures are read from displacements of the head of the sample liquid which contacts in the capillary part with pressure transmitting mercury. By this method, when the sample liquid becomes viscous, the volume change of the sample would be inaccurate, because a part of the sample which adheres on the inner wall of the piezometer would be enclosed in the mercury part by displacements of the mercury head. To improve the flaw, in the authors' method, mercury is filled in a piezometer together with the sample liquid, and the volume changes due to pressures are read from displacements of the mercury head which contacts in the capillary part with pressure transmitting air. Besides, considering the simplicities of washing the piezometer and of sampling, and the certainties of removing fine bubbles on the inner wall of the piezometer and of the jointing of glass to steel, the authors have constructed the apparatus described below in detail.

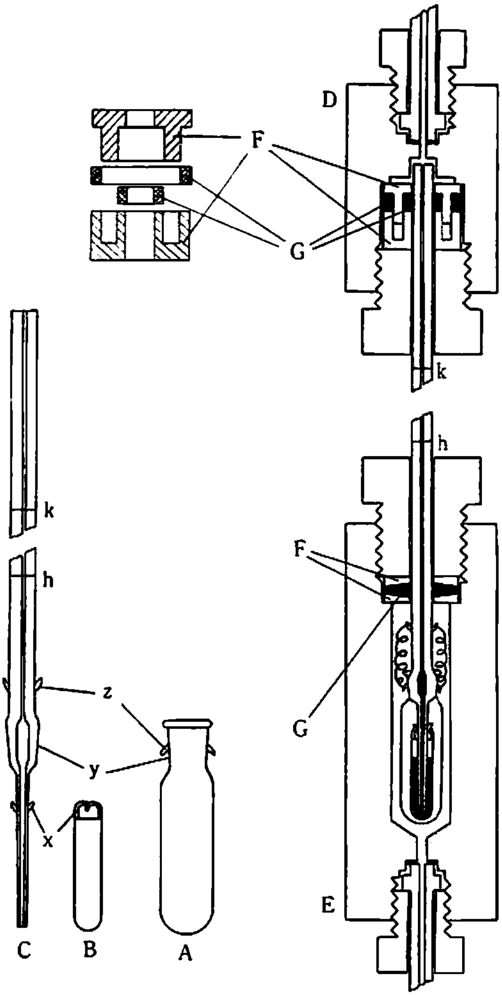

Fig. 1 The details of the piezometer and the glass-steel joints

The details of the piezometer and of the methods of glass-steel joints are shown in Fig. 1. The piezometer consists of a sample vessel A, a mercury vessel B, and a capillary glass C. A is about 6 cc and B is about 1.5 cc in capacity respectively, C is 0.8 cm and 0.087~0.113 cm in outer and inner diameters respectively, and 35 cm in length and the observable part in the experiments (between the marked lines, h and k) is 17 cm in length. After the capillary glass C is annealed at 500°C, and quenched if necessary, the capacities of the observable part and of the whole piezometer are measured by weighing the mercury stuffed in them. For sampling the piezometer, the vessel B is filled with the mercury, whose quantity has been precisely measured, and is hung from C by the projections x and then B and C are sunk into the vessel A which has been filled with the sample liquid, and the glass joint part y is fixed, and the projections z of A and C are fastened with spring wires. When the glass joint part y is fixed, the sample liquid is compressed and mercury in the vessel B rises inside the capillary glass C and the head of mercury comes to the observable part. The piezometer is then jointed to steel pipes at the upper and lower parts in steel vessels D and E respectively. Both joints are the self-tightening systems consisting of steel rings F and rubber rings G⁽⁹,¹⁰⁾. The lower joint is tightened first, and then the upper one by hand. Both joints are more tightened automatically by pressure elevations, and neither, of course, pressure leak nor destruction of glass are observed in these joints. The vessels D and E are fixed to an iron stand in a thermostat.

The pressure transmitting apparatus is shown in Fig. 2. V's are high-pressure valves, and by the air bomb R and the intensifier T the pressure is adjusted to a desired value. A pressure gauge P of Bourdon type has been graduated at 1/3kg/cm$^2$ from 0 to 100kg/cm$^2$ and tested by means of a dead weight tester. Each experimental temperature is kept constant within the fluctuation of ±0.01°C in a water thermostat.

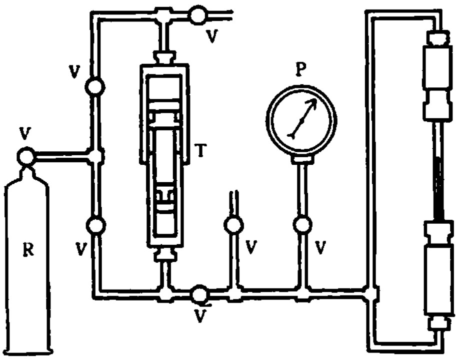

Fig. 2 The pressure transmitting part of the apparatus

The volume of the sample liquid at 1 atm is determined by reducing the volume of the mercury employed from the capacity of the piezometer and correcting the volume change caused by the pressure which is exerted by the height of mercury in the piezometer. The volume changes of the sample liquid due to applying pressures are determined by reducing the volume change of mercury⁵⁾ from the volume change corresponding to the displacement of the mercury head which can be read to 1/100 mm by means of a cathetometer.

## Results

### (1) Water

The results of compressibility measurements at 20°C are shown in Table 1. The compressibility values $k$ are the average values between 1 atm and the pressures listed in the first column. The results coincide with Amagat's data⁶⁾ within experimental errors.

Table 1
The compressibilities of water

| P<br>atm | $k \times 10^7$<br>20°C |
|---|---|
| 1 ~ 9.82 | 492 |
| 〃 15.83 | 491 |
| 〃 22.02 | 487 |
| 〃 28.36 | 485 |
| 〃 34.63 | 484 |
| 〃 40.92 | 481 |
| 〃 47.21 | 479 |
| 〃 53.50 | 476 |
| 〃 59.79 | 475 |
| 〃 66.08 | 474 |
| 〃 72.37 | 473 |
| 〃 78.66 | 473 |
| 〃 84.96 | 472 |
| 〃 91.25 | 471 |

### (2) Mobil oils

The results of measurements at 20°, 30°, and 40°C are shown in Table 2. In each sample, the compressibilities become larger as temperature becomes higher,

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9) R. Kiyama and K. Inoue, *This Journal*, 21, 74 (1951)

10) R. Kiyama, K. Suzuki and T. Ikegami, *ibid.*, 21, 54 (1951)

and at each temperature the compressibilities become smaller as the viscosities of oils become larger.

Table 2 The compressibilities of Mobil oils

| Mobil oil A | | | | Mobil oil BB | | | | Mobil oil B | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P atm | $k \times 10^7$ | | | P atm | $k \times 10^7$ | | | P atm | $k \times 10^7$ | | |
| | 20°C | 30°C | 40°C | | 20°C | 30°C | 40°C | | 20°C | 30°C | 40°C |
| 1~15.87 | 594 | 630 | 668 | 1~15.87 | 588 | 623 | 659 | 1~15.83 | 577 | 610 | 644 |
| 〃 22.08 | 588 | 625 | 659 | 〃 22.08 | 582 | 613 | 646 | 〃 22.04 | 575 | 600 | 632 |
| 〃 28.35 | 583 | 622 | 652 | 〃 28.35 | 578 | 608 | 638 | 〃 28.31 | 566 | 597 | 629 |
| 〃 34.64 | 578 | 618 | 649 | 〃 34.64 | 573 | 606 | 635 | 〃 34.60 | 563 | 595 | 623 |
| 〃 40.93 | 575 | 615 | 648 | 〃 40.93 | 570 | 603 | 633 | 〃 40.89 | 559 | 592 | 621 |
| 〃 47.21 | 572 | 613 | 646 | 〃 47.11 | 567 | 600 | 631 | 〃 47.17 | 557 | 588 | 619 |
| 〃 53.51 | 571 | 611 | 641 | 〃 53.51 | 565 | 599 | 628 | 〃 53.47 | 556 | 587 | 618 |
| 〃 59.80 | 571 | 609 | 640 | 〃 59.80 | 564 | 598 | 627 | 〃 59.76 | 555 | 586 | 617 |
| 〃 66.09 | 571 | 609 | 640 | 〃 66.09 | 564 | 597 | 626 | 〃 66.05 | 553 | 585 | 616 |
| 〃 72.36 | 570 | 608 | 640 | 〃 72.36 | 561 | 597 | 624 | 〃 72.32 | 548 | 585 | 614 |
| 〃 78.69 | 569 | 605 | 639 | 〃 78.93 | 560 | | | 〃 78.64 | 548 | 584 | 614 |

## (3) Silicone oils

The results of experiments at 20°, 30°, and 40°C are shown in Table 3. In each sample, as in the case of Mobil oils, the compressibilities become larger as temperature becomes higher, and at each temperature, the values become smaller as the molecular weights and viscosities become larger.

Table 3 The compressibilities of silicone oils

| $[(CH_3)_2SiO]_4$ | | | | $[(CH_3)_2SiO]_5$ | | | | SS-I | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P atm | $k \times 10^7$ | | | P atm | $k \times 10^7$ | | | P atm | $k \times 10^7$ | | |
| | 20°C | 30°C | 40°C | | 20°C | 30°C | 40°C | | 20°C | 30°C | 40°C |
| 1~ 9.81 | 1556 | 1717 | 1850 | 1~ 9.78 | 1348 | 1465 | 1580 | 1~ 9.86 | 1218 | 1290 | 1420 |
| 〃 15.82 | 1480 | 1634 | 1795 | 〃 15.79 | 1310 | 1433 | 1543 | 〃 15.87 | 1206 | 1266 | 1371 |
| 〃 22.01 | 1431 | 1591 | 1725 | 〃 21.98 | 1280 | 1401 | 1515 | 〃 22.06 | 1172 | 1251 | 1342 |
| 〃 28.35 | 1399 | 1551 | 1686 | 〃 28.32 | 1249 | 1376 | 1491 | 〃 28.40 | 1157 | 1232 | 1329 |
| 〃 34.62 | 1374 | 1517 | 1664 | 〃 34.59 | 1240 | 1362 | 1475 | 〃 34.67 | 1145 | 1222 | 1320 |
| 〃 40.91 | 1371 | 1511 | 1658 | 〃 40.88 | 1233 | 1339 | 1466 | 〃 40.96 | 1139 | 1216 | 1316 |
| 〃 47.20 | 1363 | 1489 | 1634 | 〃 47.17 | 1219 | 1326 | 1452 | 〃 47.25 | 1130 | 1208 | 1309 |
| 〃 53.49 | 1349 | 1485 | 1627 | 〃 53.46 | 1208 | 1323 | 1442 | 〃 53.54 | 1124 | 1200 | 1303 |
| 〃 59.78 | 1336 | 1481 | 1622 | 〃 59.75 | 1206 | 1315 | 1430 | 〃 59.83 | 1121 | 1197 | 1299 |
| 〃 66.07 | 1334 | 1475 | 1616 | 〃 66.04 | 1201 | 1310 | 1422 | 〃 66.12 | 1118 | 1191 | 1292 |
| 〃 72.36 | 1331 | 1467 | 1607 | 〃 72.33 | 1195 | 1304 | 1417 | 〃 72.41 | 1116 | 1185 | 1287 |
| 〃 78.65 | 1327 | 1465 | 1600 | 〃 78.62 | 1190 | 1300 | 1406 | 〃 78.70 | 1113 | 1184 | 1284 |
| 〃 84.95 | 1320 | 1450 | | 〃 84.92 | 1176 | 1295 | | 〃 85.00 | | 1179 | 1281 |
| | | | | 〃 91.21 | | 1290 | | | | | |

(Table 3 *continued*)

| SS-II | | | | SS-III | | | | SS-IV | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P | $k \times 10^7$ | | | P | $k \times 10^7$ | | | P | $k \times 10^7$ | | |
| atm | 20°C | 30°C | 40°C | atm | 20°C | 30°C | 40°C | atm | 20°C | 30°C | 40°C |
| 1～ 9.85 | 1190 | 1234 | 1335 | 1～ 9.90 | 1140 | 1231 | 1290 | 1～ 9.88 | 1130 | 1210 | 1252 |
| 〃 15.82 | 1152 | 1231 | 1319 | 〃 15.91 | 1128 | 1202 | 1275 | 〃 15.83 | 1120 | 1197 | 1242 |
| 〃 22.12 | 1141 | 1213 | 1302 | 〃 22.10 | 1116 | 1187 | 1266 | 〃 22.14 | 1100 | 1174 | 1217 |
| 〃 28.39 | 1127 | 1206 | 1277 | 〃 28.44 | 1107 | 1168 | 1251 | 〃 28.40 | 1086 | 1163 | 1205 |
| 〃 34.67 | 1118 | 1197 | 1269 | 〃 34.71 | 1098 | 1159 | 1242 | 〃 34.68 | 1082 | 1149 | 1197 |
| 〃 40.97 | 1111 | 1191 | 1260 | 〃 41.00 | 1094 | 1153 | 1236 | 〃 40.98 | 1079 | 1144 | 1191 |
| 〃 47.25 | 1106 | 1187 | 1258 | 〃 47.29 | 1090 | 1148 | 1232 | 〃 47.26 | 1075 | 1136 | 1189 |
| 〃 53.55 | 1102 | 1183 | 1255 | 〃 53.58 | 1087 | 1144 | 1231 | 〃 53.56 | 1073 | 1134 | 1187 |
| 〃 59.84 | 1098 | 1180 | 1252 | 〃 59.87 | 1085 | 1142 | 1230 | 〃 59.85 | 1070 | 1133 | 1185 |
| 〃 66.13 | 1097 | 1178 | 1250 | 〃 66.16 | 1084 | 1139 | 1227 | 〃 66.14 | 1068 | 1128 | 1183 |
| 〃 72.40 | 1096 | 1176 | 1249 | 〃 72.45 | 1083 | 1135 | 1225 | 〃 72.42 | 1066 | 1124 | 1181 |
| 〃 78.72 | 1092 | 1174 | 1244 | 〃 78.74 | 1081 | 1134 | 1221 | 〃 78.73 | 1061 | 1120 | 1180 |
| | | | | 〃 85.04 | 1077 | 1129 | 1217 | 〃 85.03 | 1059 | | |

Pressure is read by means of the pressure gauge graduated at $1/3\mathrm{kg/cm^2}$, and the volume change is measured, involving the error due to the temperature fluctuations, in accuracy of ±3/100 mm in the displacement of mercury head in the piezometer. The error in the measurement of the capacity of the piezometer and that due to the expansion by internal pressure[2] of the capillary part, which is exposed to atmospheric pressure, are negligible as compared with the error mentioned above.

The errors of the compressibility values which are calculated[11] from those concerning the measurements of temperature, pressure and volume, are about 2.0 and 0.19 % at 9.82 and 91.25 atm respectively for water, 4.4 and 0.28 % at 15.83 and 78.93 atm respectively for Mobil oils, and 3.6 and 0.10 % at 9.88 and 85.00 atm respectively for silicone oils.

## PART II

### Experimental Apparatus and Procedures

The piston displacement method is used in this experiment. The layout of the apparatus is shown in Fig. 3. The vessel C of the high pressure volumenometer is made of special steel and is 50 mm in external diameter, 180 mm in length and is applicable up to a few thousands atmospheres. It consists of a wide part which is 20 mm in internal diameter and 20 cc in volume, and a narrow cylinder part to be fitted to the piston P. The piston is made of special steel, and 8 mm in diameter, 80 mm in length, and is ground in the same way as the cylinder. A self-tightening packing[12] is used on the piston head H, and the steel rod S fixed to the piston head is observable and the displacement

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[11] R. Livingston, "*Physico Chemical Experiments*," p. 21 (1939) Macmillan Co.

[12] R. Kiyama, *This Journal*, **19**, 5 (1945)

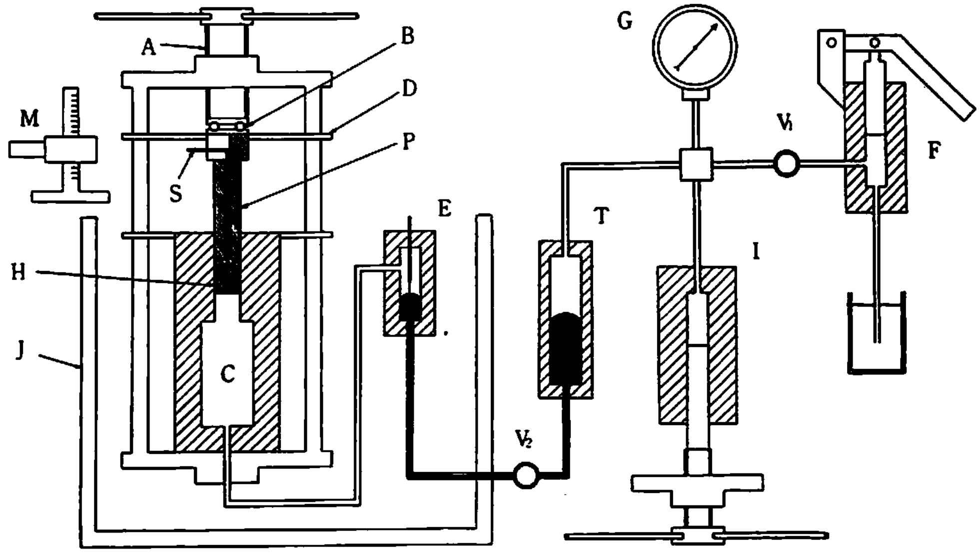

Fig. 3 The measurement apparatus

of the position of the rod is measured by the cathetometer M graduated at 0.01 mm, in order to measure the height of the piston head regardless of the change of the thickness of packing due to deformation by pressure. The piston is thrust by four handles fixed to the screwed rod A, and to prevent the rotation of the piston, the thrust bearing B and the steel plate D are used.

The mercury head contacting with the sample, is kept at constant level by the electrode E, which has the same mechanism as reported[13]. In the measurements on water and oils, a nickel and a hardened steel rods are used as a contacting lead wire respectively. To prevent the chemical change and the emulsification of the sample and mercury, the amount of the current is decreased as small as possible by using the vacuum tube circuit. The height of mercury head in E is controlled by means of the intensifier I, with which E is connected through the trap T by pressure transmitting oil. The intensifier consists of a piston and a cylinder, 10 mm in diameter, and pressure is applied to transmitting oil by the same handling as in the case of the volumenometer. F, G and V show a hand pump, a Bourdon type pressure gauge and a high pressure valve respectively. Every part, to which pressure is applied, is connected with each other by steel tubes, 8 mm in external and 1 mm in internal diameter.

As to the operation, the piston and the electrode are taken away, and the sample is filled in the volumenometer and the electrode vessel keeping the height of mercury head in the electrode vessel near the working point of the electrode by closing the valve $V_2$. After the electrode is set and $V_2$ is opened, the piston is fitted in the cylinder controlling the height of mercury head. Then $V_1$ is opened and the pressure transmitting oil, compressed preliminaryly by the hand pump, is led to the intensifier. Afterwards, $V_1$ is

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[13] R. Kiyama, *This Journal*, 19, 13 (1945)

closed, and pressure is applied by driving the screwed parts of the volumenometer and the intensifier at the same time in order to keep constant the height of mercury head. The compressibility measurements are started from 88 atm, because the self-tightening packing does not work under the lower pressure.

In the pressure measurements, three pressure gauges of Bourdon type, calibrated by a dead weight and a standard Bourdon type pressure gauges, are used. The maximum pressures of their gauges are 300, 1000 and 2000 kg/cm², and graduated at 1, 20 and 50 kg/cm² respectively. The first has the accuracy of one tenth of a graduation by the reflection of a mirror, and the latter two have that of one third.

The total volume of the volumenometer, the electrode vessel and their connecting tube is determined by weighing the mass of mercury which is filled in them. The measured volume under pressure is corrected with the volume change due to the deformation of the vessels to which the pressure is applied.

The sampling parts C and E are set in the thermostat J and the temperature is measured in accuracy of 0.05°C by means of a standard mercury thermometer. The pressure is applied slowly in order to keep the balance of temperature, and the volume is measured after making sure that the volume does not change at a given pressure.

## Results

### (1) Water

The compressibilities of water up to a pressure of 1500 atm at 20° and 30°C are

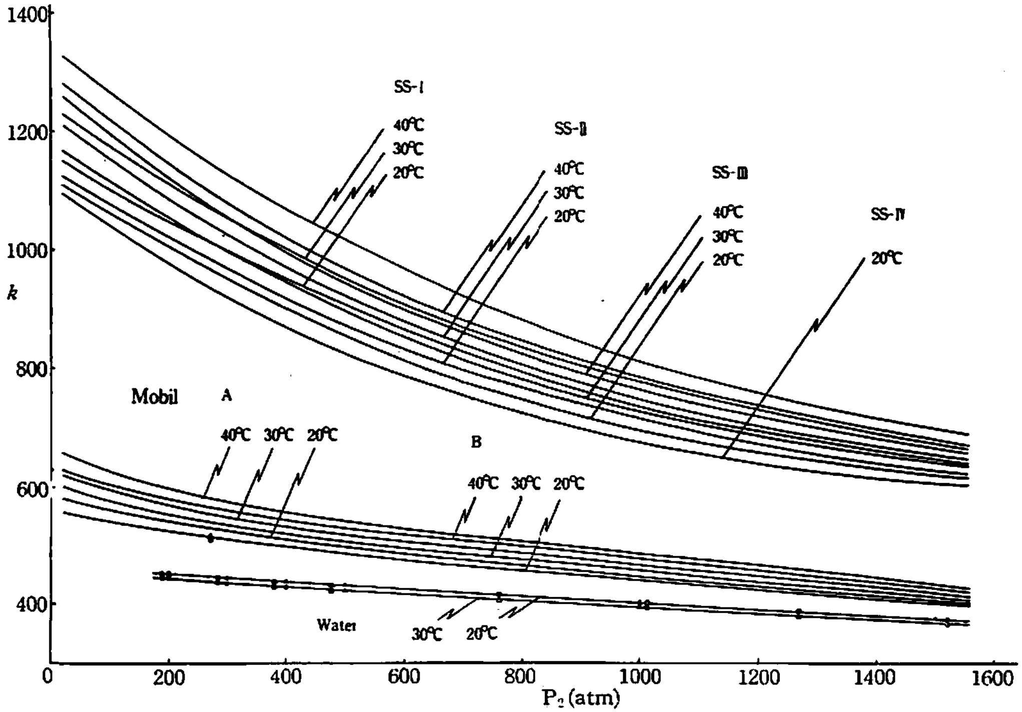

Fig. 4 The compressibility diagrams of water, Mobil oils and silicone oils
× Amagat ○ Authors

measured in order to certificate the apparatus, and compared with Amagat's data[6]. Amagat's values in Table 4 and Fig. 4 are calculated from his reported values to be compared with our data. The compressibility values $k$ are the average values from 1 atm to the pressures listed in the first column in tables.

Table 4 The compressibilities of water

| Authors |  |  | Amagat |  |  |
|---|---|---|---|---|---|
| P atm | $k \times 10^7$ |  | P atm | $k \times 10^7$ |  |
|  | 20°C | 30°C |  | 20°C | 30°C |
| 1 ~ 187 | 452 | 447 | 1 ~ 200 | 454 | 447 |
| 〃 284 | 445 | 438 | 〃 300 | 446 | 437 |
| 〃 380 | 438 | 430 | 〃 400 | 439 | 430 |
| 〃 477 | 432 | 424 | 〃 500 | 434 | 424 |
| 〃 761 | 417 | 406 | 〃 750 | — | — |
| 〃 1014 | 401 | 393 | 〃 1000 | 403 | 395 |
| 〃 1269 | 390 | 380 | 〃 1250 | — | — |
| 〃 1525 | 375 | 370 | 〃 1500 | 377 | — |

### (2) Mobil oils

In three kinds of Mobil oils, the compressibilities of Mobil A and B are measured from 88 atm up to 1500 atm at 20°, 30° and 40° C, and calculated the average compressibilities from 1 atm to the pressures listed, using the data of Part I. The results are shown in Table 5 and Fig. 4.

Table 5 The compressibilities of Mobil oils

| P atm | Mobil oil A |  |  | Mobil oil B |  |  |
|---|---|---|---|---|---|---|
|  | $k \times 10^7$ |  |  | $k \times 10^7$ |  |  |
|  | 20°C | 30°C | 40°C | 20°C | 30°C | 40°C |
| 1 ~ 187 | 545 | 574 | 600 | 529 | 557 | 583 |
| 〃 284 | 530 | 552 | 580 | 514 | 537 | 564 |
| 〃 380 | 516 | 539 | 563 | 503 | 526 | 548 |
| 〃 477 | 500 | 523 | 549 | 490 | 513 | 536 |
| 〃 761 | 470 | 490 | 512 | 460 | 477 | 505 |
| 〃 1014 | 445 | 466 | 485 | 440 | 458 | 477 |
| 〃 1269 | 425 | 441 | 458 | 418 | 434 | 451 |
| 〃 1525 | 407 | 420 | 431 | 404 | 414 | 424 |

### (3) Silicone oils

The compressibilities of SS-I, SS-II and SS-III at 20°, 30° and 40° C, and SS-IV at 20° C are measured from 88 atm up to 1500 atm and calculated the average compressibilities from 1 atm to the pressures listed, using the data of Part I. The results are shown in Table 6 and Fig. 4.

Table 6 The compressibilities of silicone oils

| P atm | $k \times 10^7$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SS - I | | | SS - II | | | SS - III | | | SS - IV |
| | 20°C | 30°C | 40°C | 20°C | 30°C | 40°C | 20°C | 30°C | 40°C | 20°C |
| 1~ 187 | 1057 | 1118 | 1198 | 1030 | 1094 | 1153 | 1010 | 1061 | 1130 | 990 |
| 〃 284 | 1006 | 1060 | 1134 | 979 | 1034 | 1085 | 963 | 1003 | 1062 | 930 |
| 〃 380 | 962 | 1010 | 1074 | 930 | 980 | 1030 | 908 | 951 | 1009 | 881 |
| 〃 477 | 915 | 961 | 1026 | 883 | 932 | 979 | 861 | 905 | 955 | 836 |
| 〃 761 | 804 | 847 | 896 | 780 | 818 | 859 | 759 | 793 | 837 | 736 |
| 〃 1014 | 732 | 771 | 810 | 713 | 748 | 781 | 692 | 726 | 758 | 674 |
| 〃 1269 | 680 | 715 | 745 | 663 | 692 | 725 | 650 | 675 | 705 | 632 |
| 〃 1525 | 642 | 666 | 695 | 625 | 649 | 676 | 616 | 638 | 661 | 605 |

The errors of compressibility values which are calculated[11] from those concerning the measurements of temperature, pressure and volume, are about 0.60 and 0.36 % at 187 and 1525 atm respectively for water, 0.58 and 0.36 % for Mobil oils and 0.41 and 0.37 % for silicone oils.

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