The following tables, which condense these results, show that in each case there was a considerable decrease in the pressure of dissociation. From the standpoint of chemical dynamics, it might be very interesting to extend these observations. Unfortunately, these researches involve many delicate precautions which might be easily avoided by selecting compounds more suitable than lead nitrate for this class of work.

Temperatures. °C.	Partial pressure of excess of oxygen. mm.	Total pressure of all gaseous products. mm.	Real pressure of dissociation in presence of excess of oxygen. mm.	Pressure of dissociation for lead nitrate without excess of oxygen. mm.	Ratio between partial and total pressure.	Ratio between pressure without and with excess of oxygen.
357	425	583	158	514	7 : 10	10 : 3
357	425	592	167	514	7 : 10	10 : 3
357	467	586	119	514	8 : 10	10 : 2

Temperatures. °C.	Partial pressure of nitrogen peroxide in excess. mm.	Total pressure of all gaseous products. mm.	Real pressure of dissociation in presence of excess of nitrogen peroxide. mm.[1]	Pressure of dissociation for lead nitrate without excess of nitrogen peroxide. mm.	Ratio between partial and total pressure.	Ratio between pressure without and with excess of nitrogen peroxide.
357	630	780	150	514	8 : 10	10 : 3
357	640	790	150	514	8 : 10	10 : 3

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NEW YORK.

[CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.]

NEW METHOD OF DETERMINING COMPRESSIBILITY, WITH APPLICATION TO BROMINE, IODINE, CHLOROFORM, BROMOFORM, CARBON TETRACHLORIDE, PHOSPHORUS, WATER AND GLASS.[1]

BY THEODORE WILLIAM RICHARDS AND WILFRED NEWSOME STULL.

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IT HAS been suggested recently that since the volume of a solid or liquid must be determined in part by the internal pressures to

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[1] Indicated by the difference between total pressure of gaseous products and partial pressure of excess of nitrogen peroxide.

[2] This paper is an abbreviated statement of the chief points in an investigation printed as a monograph by the Carnegie Institution (Publication No. 7), entitled "New Method for Determining Compressibility."

which it is subjected by chemical affinity and cohesion, the compressibilities of substances are probably data of important chemical significance.[1]

In attempting to interpret this significance, the inquirer at once faces the fact that few pertinent compressibilities are accurately known. Only complex organic compounds have been much studied, and their behavior under pressure is affected by too many variables to be easily interpreted. No more than four elements have been studied at all, and none except mercury and copper have been investigated by more than a single investigator.

In order to fill this important gap in physiochemical knowledge, the following investigation was undertaken. Its publication will be followed promptly by similar more extended publications, in which the compressibilities of as many elements and simple compounds as possible will be treated.

The determination of compressibility is sometimes considered as one of the most difficult of physical processes. The difficulty is due chiefly to the fact that under pressure all the parts of any apparatus change in volume, and hence the contraction under pressure of the substance under examination is partly hidden. Perhaps it is this difficulty, added to a lack of realization of the significance of the data, which has deterred investigators from undertaking the problem more systematically.

Our experience gained with modifications of older methods led to the devising of a new method retaining all the advantages, and at the same time obviating all the disadvantages of previous procedure. The essential feature of this method is the comparison of the compressibility of the substance to be studied with a standard liquid, by noting the weighed quantities of mercury which must be added to the apparatus in order to supply the volumes lost under compression at successive pressures. Electrical contact was used to indicate when the desired extent of compression had been attained. Many errors were obviated by conducting first a series of compressions with pure mercury in the apparatus, and then another series with as much as possible of the mercury displaced by the substance to be studied.

Two forms of apparatus for containing the mercury—one for

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[1] Richards: *Proc. Am. Acad.*, **37**, 1 (1901), 399 (1902); **38**, 293 (1902); also *Ztschr. phys. Chem.*, **40**, 169, 597; **42**, 129 (1902).

solids and one for liquids—were devised. The first of these consisted simply of a wide, short test-tube, with a very well-ground hollow stopper terminating above in a fine funnel tube provided with a downward pointing platinum wire.

This *glass jacket* was filled with the liquid metal, and the change in volume for different pressures was measured very simply by placing the whole jacket under the liquid in the barrel of a Cailletet compression apparatus, adding successive weighed portions of mercury, and noting each time the pressure needed just to break and then again make the electrical connection between the meniscus and the platinum point. The electrical method of indication has often been used for similar purposes, especially by Barus and Amagat, but never in exactly this way. If the platinum wire is very finely pointed, the fine tube around it about 1.5 mm. in diameter and the mercury meniscus covered with perfectly clean water, the indications of this instrument are surprisingly constant and trustworthy. Even with a substance no more compressible than mercury, it is easy to be certain of the necessary pressure within one atmosphere—a very small fractional error in many hundred atmospheres. The pressure at which the connection was made was taken as the true point, rather than that at which the connection was broken, since there is sometimes a slight adhesion between the point and the mercury under the last-named circumstances. Often, however, the making and breaking occurred within an atmosphere's pressure of one another.

If the fine tube is larger than 1.5 mm., the sensibility of the instrument is reduced; if it is much less than 1.5 mm., drops of mercury are likely to be caught and held by the wire.

The most serious possible cause of error arises, however, from the faulty fitting of the ground stopper of the glass jacket. If a poorly ground stopper be used, the mercury during the process of compression is forced into the tiny interstices between stopper and tube—a complication which makes the compressibility of the liquid seem slightly greater than it is. This difficulty may be obviated wholly by always wetting the ground surfaces with a minute drop of water or some other liquid, thus displacing all the air, and preventing the ingress of mercury. The infinitesimal variations in the compression of this practically constant drop of lubricating liquid are quite too small to produce any perceptible effect, and successive trials always yield the same result.

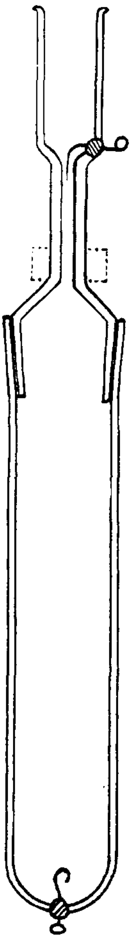

Fig. 1.

The stopper was firmly tied in place by means of stout string passed over a rubber shoulder. The latter, used to give needed elasticity, is indicated by dotted lines in Fig. 1. In order to conduct away the heat of compression and to make the lower electrical contact, mercury was poured around the lower two-thirds of the glass-jacket. The whole apparatus was immersed in a thermostat kept constant within 0.01°.

The upper platinum wire was connected with an insulated wire running through a capillary glass tube sealed into the uper movable part of the Cailletet apparatus, and the contact was detected with the help of a feeble cell and a delicate index galvanometer. The apparatus being tightly screwed into place, pressure was applied until the circuit was broken—a condition which showed that the mercury had been compressed until its meniscus had fallen below the platinum point. The heating effect of the compression was considerable, but the inner jacket being immersed in mercury, the heat was quickly conducted away to the large surrounding themostat. Constancy of pressure reading, indicating constancy of temperature, was always obtained in ten minutes.

The quantity of mercury in the glass jacket was usually so adjusted that the first constant pressure reading was between fifty and one hundred atmospheres, and this first reading was taken as the starting-point of the determination. Minute air bubbles were thus disarmed of possible injurious effect. As already suggested, a weighed quantity of mercury was now added through the funnel tube (A in

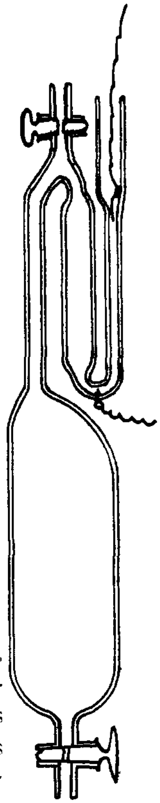

Fig. 2.

Fig. 2) and pressure again applied. The added pressure necessary to break the electrical circuit corresponded to the volume of the extra mercury introduced. This process was repeated until the highest pressure was reached, and thus were found the points on a curve which depicts the difference between the compressibilities of mercury and glass. Only in the most accurate work is it necessary to consider the compression of the small extra volumes of mercury introduced, since the omission of this correction causes an error of only 0.04 per cent for every hundred atmospheres.

If now there is introduced beneath the mercury the substance whose compressibility is to be determined, and a new curve is found in the same way, it is evident that the differences between these two curves represent the differences between the compression of the new substance and an equal volume of mercury.

With liquids which did not attack mercury, even a simpler device may be used. In this case a doubly bent tube must be attached above, in order to contain the mercury necessary for making electrical contact. The apparatus thus assumes the form shown in Fig. 2, the stop-cocks being affixed to facilitate filling. For the most accurate work it would be better to omit these stopcocks, and to fill the jacket by exhausting the air, because the stopcocks are liable to leak unless very well ground, and their presence introduces a slight uncertainty due to the small amount of liquid contained in their channels. In our experiments this small volume, amounting to only 0.002 of the whole, could be safely neglected. It is well not to heat the glass to a high temperature during the filling, because of its well-known volume lag. On the other hand, we have as yet been unable to detect any appreciable volume lag on compression. This is shown by the fact that series of experiments made by *taking out* mercury after the attainment of high pressure give results identical with those obtained by gradually *adding* mercury.

After being thoroughly cleaned this jacket was filled with mercury and the stop-cocks *m* and *n* were closed. The mercury was arranged at a level slightly above the lower point of the wire (3), and the funnel tube above was filled with pure water as before.

The jacket was placed in the Cailletet barrel, and the pressures corresponding to successive added portions of mercury were found in the way already described. Thus the mercury curve was determined.

The greater part of the mercury was now withdrawn, and the residue, filling the U-tube, at least, was weighed with the glass. Subsequently the liquid under investigation was drawn in, completely displacing the air; and finally the apparatus, after external drying, was weighed again. Thus was found the weight of the liquid to be compressed.

The jacket was now placed once more in the Cailletet barrel, and once more the pressures corresponding to successive added portions of mercury were found. These new readings define the curve of compression of the liquid and the residual mercury. The differences between the weights of mercury added, for any given change of pressure, as found on the two curves, give by simple calculation the differences between the compression of the given volume of liquid and the same volume of mercury, hence the compressibility is easily computed. Those who wish to carry out experiments by this method are advised to consult the original memoir for the full details, both of plotting and of calculation.

In the case of liquids which attack mercury, this latter apparatus could not be used; such liquids were enclosed hermetically in very thin, flat flexible glass bulbs, containing no other substance. The decrease of volume in these bulbs upon compression was determined as if they were homogeneous solids, by compressing them under mercury in the glass jacket first described. Allowance is easily made for the change in volume of the mercury and glass, if the containing apparatus has been properly tested full of mercury in the first place.

Since the bulbs were so thin as to collapse under a pressure of less than the quarter of an atmosphere, the pressure within them must have been essentially the same as that applied without. Some experience and art were needed in order to prevent these bulbs from being so thin in places as to be fractured by the bouyant pressure of the mercury; and a number of exasperating accidents occurred from this cause. It is perfectly possible, however, to make a glass bulb, containing several cubic centimeters, which will change under pressures by 5 per cent. of its volume and yet be strong enough to endure immersion in mercury. Our experiments were made with such bulbs. The diagram (Fig. 3) represents one of them. Their flattened sides were best produced by well-directed heating after the cylindrical shape had been first attained.

For the purpose of filling, the neck of the bulb was at first drawn down stoutly in the fashion indicated by the dotted lines in Fig. 3. After having been filled by means of a capillary funnel tube, the bulb was packed in ice and water. When the liquid within had contracted so much as to leave the narrowed part far above the meniscus, this narrow portion was drawn out to a very fine point, the bulb itself being shielded from the heat by asbestos. Upon warming the bulb through a degree or two this capillary point was at once filled with liquid, and was then sealed by fusion, usually without enclosing a visible trace of air, and always without enclosing a measurable trace. The weight of the glass in the bulb was always determined, either by subtracting the drawn-off tip from the total original weight, or else by weighing the glass fragments after the experiment. The weight of the enclosed liquid was obtained by weighing the sealed bulb, and subtracting from this the weight of the glass.

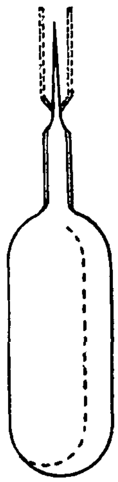

Fig. 3.

The bulb having been filled at 2° or 3° above zero the expansion of the liquid within caused the walls of the vessel to swell outward at 20°, and thus the possibility of compression of the bulb at ordinary temperatures was greatly increased. In the calculations the slight compressibility of the glass of this bulb was taken into account.

The full equation for the calculation of the results is as follows:

$$\beta = \left(\frac{(w - w')(1 - P_1\beta')}{13\ 546} + \frac{w''}{d}(P_1 - P_2)(\beta' - \beta'') \right) \frac{D}{W(P_1 - P_2)} + \beta'$$

when β, β', and β'' represent respectively the average compressibilities of the substance studied, mercury and glass;

w and w' represent respectively the two weights of mercury in the two series above corresponding to the given change of pressure $P_1 - P_2$;

w'' and W, respectively, the weights of the thin glass bulb and the substance studied;

d and D, the densities of glass and of the substance;

13.546, the density of mercury at 20°.

In special cases this equation may be abbreviated without sensible error. The original paper must be consulted in order to obtain a full explanation of the equation and its abbreviated forms.

For our knowledge of the pressures we had to depend chiefly upon the hydraulic dial gauge made and guaranteed by Schaeffer and Budenburg. In view of the extensive experience of these manufacturers and the fact that the gauge is vouched for by the Société Genevoise, it seemed hardly possible that we could improve upon the accuracy of their work. The gauge registers as far as a thousand atmospheres, and has only a very small temperature coëfficient, according to their testimony and our careful trial. We tested this by means of our new liquid manometer, described on page 410, keeping the latter constant in temperature and varying the temperature of the dial gauge. The temperature of the room used for the experiments varied ordinarily but little from 20°, hence no trouble could have arisen from change of temperature, even had the coëfficient been considerable.

Several other indications point to the accuracy of the gauge. For example, the great regularity to be seen in the various curves points toward consistency in the indications.

After the work was completed, the gauge was returned to Schaeffer and Budenberg in order to be thoroughly tested anew. Their report was very satisfactory; the error at 500 atmospheres was only 0.1 per cent.

Whatever may have been the error of the gauge, the results are accurate relatively to one another; moreover, they may be easily corrected at any future time with the help of our determinations of the difference between the compressibility of the mercury and water. We hope, in the near future, thus to apply, ourselves, any correction which may be necessary. Nevertheless, in view of the facts above stated, it seems certain that the possible inaccuracies of the gauge must be so small as to effect only the second differential coëfficient, and not the average value of the compressibility. Hence, even if the possible errors in the gauge were never found, the following results would be significant.

The substances whose compressibilities we have determined are bromine, iodine, chloroform, carbon tetrachloride, bromoform, phosphorus and water, while from the results we may also obtain the value for glass and a qualitative indication of the compressibility of liquid chlorine. In every case the temperature was 20°.

In the first place, relying upon Amagat's results for the compressibility of mercury at low pressures and the change of that of glass over a wide range of pressure, the compressibility of mercury and of our particular sample of glass was determined as far as 600 atmospheres. The details of these determinations are given in full in the monograph of the Carnegie Institution containing the complete account of the investigation, but they may be omitted here because their effect on the data for the other more compressible substances was small.

The substances bromine, iodine, chloroform, bromoform, carbon tetrachloride, phosphorus and water were all prepared in a state of sufficient purity. The bromine was, of course, sealed into a compressible bulb in the manner described; and the iodine was packed into a similar bulb under water, and special precautions, described in full in the complete account, were taken to correct the result for the changing solubility of iodine in water. Phosphorus was compressed under water in a small inverted test-tube. Water was experimented upon with both forms of apparatus, and since identical results were obtained with each, it is fair to assume that both served their purpose well. Moreover, the results with water agreed closely with those of the best previous experiments. In order to prove the non-existence of a permanent "set" in any of the solids concerned, observations were made by taking out mercury after the highest point had been reached, as well as by adding mercury in the usual way. No permanent alteration in volume was observed in any of the cases studied.

From extrapolation of the values for bromine and iodine, as well as from a comparison of bromoform and chloroform, an approximate estimate of the compressibility of liquid chlorine was made.

In expressing the results of our work, the doubt arises as to the best units to adopt. It is a matter of great regret that the scientific world has not agreed upon a less arbitrary unit of pressure than the atmosphere. The difficulty is now increased by the frequent technical use of this word to designate the pressure of a kilogram per square centimeter. The growing tendency toward the adoption of the c. g. s. system suggests the use of a consistent unit for this dimension also. Might not the pressure of a dyne per square centimeter be suitably called a *bar?* (Greek βαρος pressure, weight). This suggestion is made because the practical use of a unit is always much facilitated by a definite verbal designation. In this case the pressure of a megadyne per square centimeter would be called a *megabar*, a name no more cumbrous than atmosphere, and far more definite. This unit, though unnamed, has long been advocated by Ostwald as a more scientific one than the present standard.[1] The megabar is $\frac{000}{980.6} =$ 101.98 per cent. of a kilogram per square centimeter, or $\frac{101.98}{1033.2} = 98.703$ per cent. of an atmosphere, or the pressure measured by 75.015 centimeters of mercury at 0° C. at the sea-level, and 45° of latitude. This pressure is more nearly the average atmospheric pressure at the laboratories of the world than the arbitrary atmosphere usually taken. A megabar, acting through the volume of a cubic centimeter or milliliter, performs a megerg of work, or one-tenth of a joule.

In view of these circumstances, and as an incentive toward the adoption of the rational unit of pressure, the results below are expressed in terms of megabars. In order that those unfamiliar with this subject may see at once the significance of the figures below, it may be well to state that the first number, 45.2, given under the formula of water, signifies that under the pressure of a megabar (0.987 atmosphere) a liter of water is diminished in volume by 0.0000452 liter, or 0.0452 cubic centimeter.

COMPRESSIBILITIES AT 20.00° C.

The values given below are multiplied by 10^6 in order to economize space. Brackets signify partial extrapolation.

Range of pressure. Megabars.	I_2.	Br_2.	Cl_2.	CCl_4.	$CHCl_3$.	$CHBr_3$.	H_2O.	P_4.	Hg.
0–100	[13]	[62.5]	[116]	[90.0]	[93.2]	[50.1]	[45.2]	[21.3]	3.88
100–200	13	57.4	[108]	88.3	88.1	46.7	44.1	20.8	3.82
200–300	13	53.7	[100]	82.0	78.7	43.3	41.8	20.3	3.79
300–400	..	51.2	[89]	74.2	71.6	41.3	41.1	20.2	3.76
400–500	..	49.0	[83]	68.6	66.6	[40.3]	39.4	20.0	3.71

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[1] Grundriss: *Allgem. Chem.*, p. 54 (1899). Since writing the above statement we have heard that essentially the same suggestion was made although not formally adopted, at the International Congress of 1900. The word "barie" was suggested as the name of pressure of a dyne per square centimeter.

A glance at the above table shows that all the substances studied, like all those examined by Barus, show a decrease in compressibility with increasing pressure. This decrease is by no means a simple function, however. Leaving out of consideration the cases of chlorine and iodine, which cannot claim accuracy enough for serious consideration in a discussion of this kind, the other substances show the following percentage decrease in their compressibilities betwen 100 and 500 atmospheres: $CHCl_3$, 29; CCl_4, 26; Br, 21; $CHBr_3$, 20.6; H_2O, 13; Hg, 4. This order is arranged according to the magnitude of the compressibility, and it exhibits a steady decrease; hence one may infer that, other things being equal, the greater the compressibility the greater is its percentage decrease with increasing pressure. That other circumstances influence this relation is shown, however, by the fact that chloroform and carbon tetrachloride manifest different second differential quotients, although their first differential quotients are exactly identical at 150 atmospheres. Moreover, bromoform and water have almost the same compressibility, and yet the change of this compressibility with the pressure is noticeably different. Such differences as this must be referred to the specific natures of the component elements, and the internal pressure relations within each substance.

When the theorizer goes further than such a comparison as this, and attempts to determine the mathematical expressions for these curves, he is met by a serious obstacle. The departure from the perfectly linear equation $x = ay$ is not sufficiently greater than the possible error of the gauge to make its somewhat subtle nature clearly manifest. One should point out also the probability that the parabolic equations, proposed by Barus for the organic liquids studied by him, are subject to an even greater experimental uncertainty, so that it is safe to say that no data now known to us afford a satisfactory basis for the determination of the law underlying the change of compressibility with pressure. It is our hope, by more accurate experiments made upon larger quantities of material and with a more perfect gauge, to proceed further in this direction.

It has been mentioned already, in the early part of this paper, that the substances are warmed by compression. This heating effect causes a thermal expansion so great as to cause the first breaking of the galvanic current in the jacket to occur at a much higher pressure than the true pressure corresponding to isothermal compression. Since the substance itself is the measuring medium, it was thought possible that this instant self-heating effect might afford a means of avoiding the lag which any form of thermometer must involve, and thus give a truer measure of the adiabatic rise of temperature on compression than any method involving a thermometer.

The temperature to which the liquid was heated is easily calculated when the change of pressure between the adiabatic and isothermal condition is known. The state of the glass does not have as much effect as might have been supposed. In this way it was found that mercury is heated about 1° and water about 2° by being subjected to a sudden pressure of 500 atmospheres. The rapid cooling of the jacket probably introduces a large error; the results are given as preliminary examples of an application of the apparatus, rather than as a precise evaluation of the effect. With greater precautions a more exact result might be obtained; and we hope to test the method further.

The properties of a few pure substances serve as the most convenient and generally useful means of defining, by comparison, the properties of all substances and the various dimensions of energy. Thus specific gravities and specific heats usually serve as the means of determining densities and heat capacities; the temperature scale is defined by the triple or quadruple or other fixed points of a few elements or simple compounds, and subdivided by the tension-increase of hydrogen in constant volume; electromotive force is found, by comparison, with a Clark or Weston cell; electrical quantity is determined by the weight of a pure metal which it can deionize, and so forth. It seems to us desirable to define the measurement of high pressures also in an equally convenient way by reference to the compressibility of one or more easily obtained pure liquid substances. The problem has been considered as a difficult one, because the apparatus used for containing the material may be distorted by the strain of compression; but with the help of our glass jacket the result is very easily attained.

If glass were a definite substance, the figures given in the table of data concerning the compressibility of water alone or of mercury alone, would at once afford the desired intelligence. By plotting our data for water, for example, it is readily seen that in a glass jacket containing 18.75 milliliters of water and 1.9 millimeters of mercury at 20°, 100 megabars would correspond to 1.070 grams of added mercury, 200 megabars to 2.127 grams of added mercury, and so forth. The same proportion of change of volume to total volumes of water and mercury would exist in a jacket of any other size. Unfortunately, however, the compressibility of glass is not uniform enough in different samples to make such an inference more definite than within 0.3 per cent.

On the other hand, the *difference between the compression of water and mercury*, as found by a jacket of this kind, is perfectly definite and free from all uncertainty connected with the glass. This difference will serve at any time as a means of comparing any other gauge with that made by Schaeffer and Budenberg, thus enabling any one who has a less accurate gauge to correct its readings, or any one who has a more accurate gauge to correct ours.

The best method of making this comparison would be to make successive series of experiments first with mercury and afterwards with water in a given glass jacket, in a way described above, and then to plot the results and compare the differences with ours. The curves are so nearly straight lines that they may be drawn with great accuracy by bending a thin ruler, made of wood with an even grain, until all the points are covered.

From our preliminary experiments it seems probable that the sensitiveness of this manometer is very great. Under favorable conditions the method is able to detect $\frac{1}{20}$ atmosphere in 1000 atmospheres, or one part in 20,000.

It is our purpose to carry out the evaluation of this manometric method with much greater precision than has been heretofore possible, in an apparatus free from ground-glass joints. The present results in this direction must be considered as merely preliminary, but even these may serve an end hitherto unattainable.

In conclusion, it is a pleasure to express our great indebtedness to the Cyrus M. Warren Fund, of Harvard University, for assistance in the early part of this investigation, and to the Carnegie Institution for assistance in the latter part.

In this investigation the following additions to the knowledge of compressibility are made:

(1) The practical difficulties of many previously used methods have been demonstrated.

(2) New methods have been suggested which are applicable to nearly all solids and liquids. The feature which all these new methods possess in common is the comparison of each substance with mercury, by noting the pressures needed to compress the whole system, with small added quantities of mercury, to a fixed point, as determined by electrical indication. Solids attacking mercury were surrounded by water, and liquids attacking mercury were enclosed in very thin compressible glass bulbs.

(3) With the help of these methods the compressibility of bromine, iodine, chloroform, bromoform, carbon tetrachloride, phosphorus, water and glass were determined by reference to mercury, in most cases as far as 500 or 600 atmospheres. From some of these the compressibility of liquid chlorine was inferred.

(4) The word "megabar" is advocated as the most convenient name for the logical unit of pressure—the pressure of a megadyne per square centimeter. The megabar is 0.987 atmosphere.

(5) Expressing the pressure in terms of this unit the average compressibilities $\left(\frac{\Delta V/V}{\Delta p}\right)$ of the several substances between 100 and 200 atmospheres were found to be as follows:

Iodine	0.000013
Bromine	0.0000574
Chlorine	0.00011
Carbon tetrachloride	0.0000883
Chloroform	0.0000881
Bromoform	0.0000467
Water	0.0000441
Phosphorus	0.0000208
Glass	0.00000231
Mercury	0.00000382 (Amagat).

(6) The compressibilities of the substances named above are compared with regard to their relative decrease with increasing pressure.

(7) Approximate determinations of the heat of compression of water and mercury were made.

(8) A new manometer for calibrating high pressure gauges is proposed.

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June, 1903.