and 50° on it are, respectively, 32° , 50° , 86° , 104° and 122° on the Fahrenheit scale.

The mean coefficients of dilatation of the different liquids are the mean increase of unit of their volume at the Centigrade zero, in fractions of this unit, due to the experimental increase of temperature above zero, per atmosphere of pressure under the experimental number of atmospheres to which the liquids were subjected.

COMPRESSIBILITY OF THE GASES OXYGEN, HYDROGEN, NITROGEN AND AIR, UP TO THE PRESSURE OF 3,000 ATMOSPHERES.*

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Translated by Chief Engineer ISHERWOOD, U.S.N.

The experiments on these gases were made according to the method I followed in my previous investigations of the compressibility of liquids within the same limits of pressure; but, in the present case, the difficulty was much greater, owing to the smallness of the volume of the gases when strongly compressed. Nevertheless, after numerous trials, I obtained perfectly regular and concordant results by employing, for the gauging of the platinum wire tubes, the same process of reading by electrical contacts which served afterwards to estimate in the same tubes the successive volumes of the compressed gases. In this manner I obtained for the same gas, with different tubes, graphic curves, which almost absolutely coincided with each other.

My results, given further on, and they are solely the apparent results, differ notably numerically from those obtained by Natterer. The differences within the limits common to our researches are very irregularly distributed, and amount to several hundreds of atmospheres. My experiments for the same reduction of the volume of the

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gas, give in general much greater pressures than his, but the differences can easily be accounted for by the probable and even inevitable causes of error in the method followed by him.

The following results relate solely to great pressures; the pressures below 1,000 atmospheres will be investigated in part by means of an apparatus permitting the use of temperatures vastly higher than I have been able to command with the apparatus imposed by the very great pressures, and with which I have been able to operate between only 0° C. and 50° C.

The following table gives for the pressures, in the first column, the volumes of the gaseous mass at 15° Centigrade relatively to its volume as unity at the same temperature and under the pressure of one atmosphere :

Pressures in Atmospheres.	Air.	Nitrogen.	Oxygen.	Hydrogen.
750	0'002200	0'002262		
1,000	0'001974	0'002032	0'001735	0'001688
1,500	0'001709	0'001763	0'001492	0'001344
2,000	0'001566	0'001613	0'001373	0'001161
2,500	0'001469	0'001515	0'001294	0'001047
3,000	0'001401	0'001446	0'001235	0'000964

The comparison of the compressibility of strongly compressed gases with each other, and with that of the liquids, is interesting, and to facilitate it I have calculated for differences of 500 atmospheres of pressure the coefficients of compressibility of the gases, as habitually defined for liquids. In the following table are the results obtained:

Limits of Pressure in Atmospheres.	Air.	Nitrogen.	Oxygen.	Hydrogen.
Between 750 and 1,000, . . .	0'000411	0'000407		
Between 1,000 and 1,500, . . .	0'000268	0'000265	0'000258	0'000408
Between 1,500 and 2,000, . . .	0'000167	0'000170	0'000160	0'000272
Between 2,000 and 2,500, . . .	0'000123	0'000122	0'000115	0'000197
Between 2,500 and 3,000, . . .	0'000093	0'000091	0'000091	0'000158

We see that, under very great pressures, the gases oxygen, nitrogen and air, have nearly the same compress-

sibility; and that it is of the order of magnitude of the compressibility of the liquids; at 3,000 atmospheres it is sensibly equal to that of alcohol under normal pressure.

The compressibility of hydrogen is very much greater—nearly double—and at 3,000 atmospheres it is almost equal to that of ether under normal pressure.

There may be easily foreseen that these compressibilities should, as in the case of the liquids, increase with the temperature, which is shown, as regards hydrogen, by the following table:

Limits of Pressure in Atmospheres.	COEFFICIENTS.		
	At Zero.	At 15°4°.	At 47°3°.
Between 1,000 and 1,500,	0'000	0'000408	0'000416
Between 1,500 and 2,000,	0'000263	0'000272	0'000280
Between 2,000 and 2,500,	0'000196	0'000197	0'000208
Between 2,500 and 3,000,	0'000156	0'000158	0'000158

The apparent densities are easily deduced from the first table; and admitting, provisionally, for the compressibility of glass the number generally adopted, we obtain the following results for the pressure of 3,000 atmospheres:

DENSITIES OF THE GASES UNDER THE PRESSURE OF 3,000 ATMOSPHERES,
RELATIVELY TO WATER.

	<i>Apparent.</i>	<i>Real.</i>
Oxygen,	1'0972	1'1054
Air,	0'8752	0'8817
Nitrogen,	0'8231	0'8293
Hydrogen,	0'0880	0'8887

The curves obtained by laying off the pressures as abscissas on an axis, and the products $p v$ as corresponding ordinates perpendicular to the axis, are nearly straight lines, but they all have a slight concavity towards the axis. I shall return to this important point as regards the limited volumes after I shall have determined the variation of the volume of the envelopes.