427. *The Isotopic Ratio in Hydrogen: A General Survey by Precise Density Comparisons upon Water from Various Sources. Part II.*

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THE methods described in an earlier paper (this vol., p. 1207; regarded as Part I) have been applied to a number of new samples and the results of the further survey are now given.

Through the courtesy of Mr. Rymill, Organising Secretary of the British Grahamsland Expedition, we have been able to examine two specimens of water from the polar regions which were kindly collected for us in the early spring of 1934 by the captain of a sealer in the Greenland Sea: one, A, was collected in lat. N. 73° 35′ and long. W. 6° 54′, a point about 140 miles N.N.E. of Jan Mayen Land, with air temperature — 8·5° and sea temperature — 1·7°; and the other, B, in lat. N. 78° 13′ and long. E. 10° 30′, a point about 35 miles off the west coast of Spitzbergen, with air temperature — 1° and sea temperature + 2·5°. The results of our determinations are as follows:—

	T_S.	T_{H_2O}.	$(T_S - T_{H_2O}) \times 10^3$.	$\Delta\gamma d$.
Polar water, A	20·344°	20·349°	+ 5°	+1·36
,, ,, ...	20·350	20·356	+ 6	
,, ,, ...	20·344	20·351	+ 7	
Polar water, B	20·344	20·365	+21	+4·2
,, ,, ...	20·344	20·362	+18	

There seems to be no reason to doubt the reality of these observed differences from the standard, and, if true, they are certainly interesting as affording the first example of a natural water occurring in bulk which has not been subject to abnormal evaporation and yet is substantially heavy. It will be observed that the more northerly water is much the heavier.

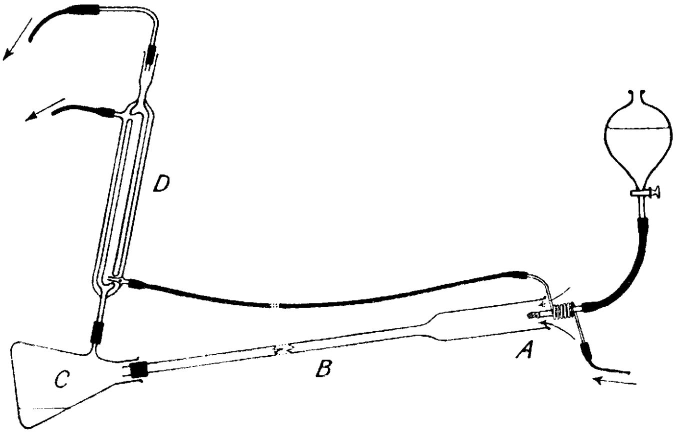
Another very interesting sample of natural water was kindly procured for us by Sir John Cadman on the suggestion of Mr. H. T. Tizard. It is described as "a deep-seated water from the Asmari Limestone, in the Lower Miocene strata of the Persian oilfields," and gave:

T_S.	T_{H_2O}.	$(T_S - T_{H_2O}) \times 10^3$.	$\Delta\gamma d$.
20·344°	20·352°	+ 8°	+1·9
20·344	20·354	+10	

Here again is a natural water which is distinctly heavy, though in this case evaporation may be the cause.

The only industrial sample included in this series was water obtained by burning permanent gas driven off from the charcoal absorbers of the Beckton benzole plant of the Gas Light & Coke Co., for which we are indebted to Mr. H. Hollings and Mr. R. H. Griffith of that company. This, after the usual purification, had a flotation temperature T_{H_2O} = 20·366°, differing from that of the standard by $+ 22 \times 10^3$, whence $\Delta\gamma d = + 4{\cdot}6$. Here, evidently, is another example of preferential adsorption of hydrocarbons containing heavy hydrogen.

The heaviness of the water of ox blood recorded in Part I seemed so remarkable that we have examined further samples as a check upon our results. Three new samples were obtained, on three different days, from the slaughter house of the Metropolitan Cattle Market. In two cases the whole blood was treated to obtain pure water, as in the earlier determinations. In the third case, the clear plasma was first separated centrifugally and then purified by the standard method. The results, given below, entirely confirm the earlier values. Alongside them are placed the values now obtained for samples of mixed ox bile obtained from the same source.



	T_S.	T_{H_2O}.	$(T_S - T_{H_2O}) \times 10^3$.	$\Delta\gamma d$.
Ox blood, sample 1	20·344°	20·354°	+10°	+2·10
,, ,, 2	20·344	20·356	+12	+2·52
,, ,, 3	20·344	20·355	+11	+2·31
Ox bile	20·344	20·351	+ 7	+1·47
,, ...	20·344	20·351	+ 7	

The remaining results of this series, which are tabulated below, relate to sugar and to the process of fermentation. The curiously high value previously recorded for water produced by combustion of cane sugar is confirmed by the figure now obtained for a fresh sample of sucrose from Trinidad. Beet molasses also gives water heavier than the normal, but the difference from the standard in this case is only about half that for cane sugar.

Through the courtesy of the Research Department of the Distillers Company Ltd., we have been able to examine the products of alcoholic fermentation in two distinct cases. In a laboratory fermentation conducted for us by Dr. H. B. Hutchinson, a pure beet molasses (" Vauxhall ") was diluted with water (17 l.), treated with yeast (200 g.), and fermented at about 30°, an air current being blown through the fermenting liquid. At the end of the fermentation there were about 21 l. of liquid containing 1066 g. of yeast with a content of 27% of dry matter. The second fermentation was a large-scale operation using mixed molasses and conducted in the ordinary way in a distillery, from which we had samples of the molasses, the spent wash left after fermentation and distillation, the alcohol, and the fusel oil. The molasses samples were burnt in the same manner as the sucrose.

Alcohol and fusel oil were each burnt on an asbestos wick carried in a copper tube and fed from a reservoir as shown at *A* in the fig. The products of combustion were drawn through a long air-cooled glass tube, *B*, of which the top surrounded the flame, and the bulk of the water was condensed in the flask *C*, the remainder being caught by the water-cooled surface condenser *D*.

	T_S.	T_{H_2O}.	$(T_S - T_{H_2O}) \times 10^3$.	Δ*yd*.
Cane sugar (Trinidad)	20·344°	20·380°	+36°	+7·56
Laboratory fermentation.				
"Vauxhall" beet molasses	20·350	20·364	+14	+2·94
	20·344	20·358	+14	
Yeast from the above	20·344	20·355	+11	+2·10
	20·344	20·353	+ 9	
Spent wash from ditto	20·344	20·347	+ 3	+0·63
Large-scale fermentation.				
Mixed molasses	20·344	20·369	+25	+5·25
Spent wash	20·344	20·352	+ 8	+1·58
	20·344	20·351	+ 7	
Alcohol	20·344	20·359	+15	+3·15
	20·344	20·359	+15	
Fusel oil	20·344	20·363	+19	+ 4·0

It is evident from these data that a substantial part of the heavy hydrogen present in the sucrose is found subsequently in the spent wash, although, from the circumstances of its production, this probably gains some heavy water from the steam used in the distillation. The air used for the combustion of sugar, alcohol, and fusel oil naturally contained some water vapour, and this evidently may affect the observed values for the hydrogen burnt. Since, however, it has been found that the water present as vapour in air is lighter than the standard, its presence does not affect the general conclusion that the hydrogen of sugar, molasses, alcohol, and fusel oil is relatively heavy. Perhaps the most significant observation is that the isotopic ratio in the hydrogen of the fusel oil is comparable with that in the original sucrose, while that in the hydrogen of the alcohol or of the resulting yeast is distinctly less.

Although in many cases the reasons for the observed differences in density are obscure, it appears fairly certain that they are real, and it is hoped that their further study will throw new light on the processes giving rise to them.

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