

contents in steel. Honda and Sekito,³ however, have obtained from their experiments that the value of this ratio is independent of the contents of carbon, and that the ratio is equal to 1.07.

This result of Honda and Sekito is contrary to the well-known fact of the diminution of volume change of quenched steel with decrease of carbon contents. From Honda and Sekito's data we can conclude that in quenched steel with carbon content 0.2 per cent, the volume of tetragonal elementary cell is 5 per cent larger than the volume of an elementary cell of a iron. This is entirely contradictory to results of Matsushita⁴ and Birnbaum,⁵ who investigated the changes of volume of steel with small contents of carbon during the process of tempering. Matsushita and Birnbaum were also unable to obtain a transition point near 100° for steels with carbon content 0.2 per cent.

Prof. Honda has kindly informed me by letter of certain details of his and Sekito's experiments. According to that letter "Sekito placed the specimen in a porcelain tube, one end closed, packed with charcoal powder, and heated it in an electric furnace." In such conditions, surface cementation might take place, and that would give equal values for the ratio of axes for tetragonal martensite in specimens of steel with different contents of carbon. In fact, the constant values for the ratio of axes obtained by Honda and Sekito probably mean that the content of carbon in the surface-layers was the same in all cases.

The broadening of the spectral lines in the case of martensite, Honda and Sekito explain by the presence of the carbon atoms in the lattice. The presence of a carbon atoms changes the dimensions of the cells which they occupy, and exerts an influence on the dimensions of the surrounding cells, giving an irregularity in the lattice.

We entirely agree that such irregularity of the lattice is very probable in the case of martensite.

Now Debye⁶ has shown that the heat movements of atoms in the lattice produce a decrease in the intensity of the spectral lines. In martensite, therefore, in this solid solution, the irregularities in the positions of the solvent atoms produced by the solute atoms give a continuous variation of the lattice parameter, and therefore also cause only a decrease in the intensity of the spectral lines, but not the broadening of them.

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Raman Effect in Gases.

SINCE the discovery of the Raman effect in scattered light, investigation has been extended to a large number of substances in the solid and liquid state. So far as I know, practically nothing has been done on gases, if we except an observation on ether vapour by Ramdas. Of course, the main difficulty in the case of gases consists in the extreme weakness of the scattered radiation.

Using a very luminous spectrograph (aperture of camera lens 1 : 2.7) I have obtained plates which show Raman spectra of different gases. The light source employed was a mercury arc, and the exposure time was 48 hours, using gases at atmospheric pressure. The length of the spectrum on the plate was 16 mm. from $\lambda 3650$ to $\lambda 5461$; wave-lengths were measured by comparison with a copper arc spectrum.

This research is being carried on, and will be extended to a larger number of gases, and, if possible,

³ K. Honda and S. Sekito. *Sc. Rep. Tôhoku Imp. Univers.*, 17.

⁴ Matsushita. *Sc. Rep. Tôhoku Univ.*, 7, 43-52; 1918.

⁵ Birnbaum. *Archiv. für Eisenhut.* Heft 1, Juli, 1928.

⁶ P. Debye. *An. d. Physik*, 43, p. 49; 1914.

with a more dispersive apparatus. But the results already obtained with carbon monoxide and carbon dioxide are perhaps worth a short notice.

Carbon monoxide shows two Raman lines at about $\lambda 4432, 4810$. They correspond evidently to the same quantum transition, excited by both $\lambda 4046$ and $\lambda 4358$ of mercury; the differences in frequency between the Raman lines and the exciting lines are found to be respectively 2154 and 2156 cm^{-1} (the agreement being better than is to be expected with the dispersion used), and this corresponds to an infra-red absorption band at 4.64μ . In fact, a double band, with the centre at 4.66μ , has been found in the absorption spectrum of carbon monoxide, so that there can be scarcely any doubt about the origin of the observed Raman lines.

The behaviour of carbon dioxide is quite different. The infra-red absorption spectrum consists mainly of three bands (each of which has a structure, depending on rotation states) at 2.7, 4.25, and 14.7μ . These are interpreted by C. Schaefer and Philipps as being the three fundamental oscillation frequencies of the tri-atomic molecule.

Now, in the Raman spectrum no lines were found corresponding to any of these absorption bands, though they would all have fallen in the region of spectrum photographed. I observed instead two doublets, at $\lambda 4639, 4616$ and $\lambda 4289, 4268$, excited respectively by $\lambda 4358$ and $\lambda 4046$. They correspond to transitions of 1284 and 1392 (± 10) cm^{-1} , which have not been observed in absorption even through very thick layers of the gas.

A rather surprising coincidence appears, however, if we calculate the differences in frequency between the two components of the double band at 2.7μ and the band at 4.25μ (which has a much smaller separation). We find the values 1279 and 1381 cm^{-1} , which agree within the limits of experimental error with the two frequencies given above.

One example is not enough to prove that this coincidence has a physical meaning, but it is a remarkable fact anyhow that none of the strong absorption bands of carbon dioxide appear in Raman effect. Investigation extended to other substances will show if really, for some types of molecules, not the infra-red absorption frequencies themselves, but only their combinations, appear as a Raman shift in the scattered radiation.

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An Apparently Anomalous Raman Effect in Water.

CARRELLI, Pringsheim, and Rosen (*Zeits. für Physik*, 51, 511; 1928) have shown that the Raman scattering by water molecules yields only one modified frequency, corresponding to an infra-red band at 2.90μ . This modified frequency has, at first appearance, two anomalous aspects: (1) the modified 'line' is really a broad band of approximately 500 cm^{-1} width, in contrast to the sharpness of Raman lines produced by organic liquids; (2) no infra-red band corresponds exactly with the centre of the observed scattered band, the nearest one being the strong 3.0μ infra-red band.

I believe that the Raman spectrum of water is not anomalous in either respect. In 1927 (*Phil. Mag.*, 3, 618; 1927) I presented an argument, based largely on an attempted correlation of the water bands below 3μ , in which it was pointed out that the strongest infra-red band, the one at 3μ , was probably double, being made up of an overtone of the 6.1μ band and a new fundamental. I tentatively assigned a wave-length value of 2.9μ to this fundamental, and believe