



## XXVI. Some properties of red vulcanized fibre

F.H. Parker B.Sc.

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destroyed. This procedure gives an exponential law of absorption for homogeneous rays; but in experiments this law should certainly be regarded not as the result of homogeneity but of extreme heterogeneity and of scattering.

If  $p$  is the greatest distance from the nucleus for which a  $\beta$  particle is caught and if  $N$  is the number of atoms in a c.c., the mean free path of a particle is  $1/N\pi p^2$ , and the absorption coefficient  $\lambda$  is  $N\pi p^2$ . For lead  $N = 4 \times 10^{23}$ , and for rays of velocity  $\cdot 9 c$  (that is fairly hard  $\beta$  rays),  $p_{\text{crit.}} = 1.35 \times 10^{-11}$ . This gives  $\lambda = 20 \text{ cm.}^{-1}$ . If the effect of radiation is to be included,  $p$  should be taken about three times as great, and this multiplies  $\lambda$  by about 10. This calculation neglects all scattering by the nuclei of those particles which are not absorbed, and also the effect of the electrons in the atoms. These should still further increase the coefficient. For rays of this type the experimental value is somewhere between  $100 \text{ cm.}^{-1}$  and  $500 \text{ cm.}^{-1}$ .

When caught the  $\beta$  particle emits a stream of radiation. This may be supposed to be the secondary X ray. Our calculation suggests that this will be on the scale of  $10^{-11} \text{ cm.}$ , a value very much smaller than is indicated by other methods.

My thanks are due to Sir J. J. Thomson and to Professor Rutherford for the interest they have taken in this work and for their advice.

Dec. 4, 1912.

## XXVI. *Some Properties of Red Vulcanized Fibre.*

By F. H. PARKER, *B.Sc., Woolwich Polytechnic* \*.

THE attention of the author was drawn to the fact that vulcanized fibre is one of the few materials, if not the only material suitable for the pistons of compressing engines in the plant for the liquefaction of air, and as, in order to prevent jamming, allowance has to be made for the expansion of the fibre, it seemed desirable to make some measurements on the change of volume due to absorption of water, as no data appeared to be available.

The results were rather of an unexpected character and seem of some interest.

The specimens examined were cut from two sheets, 1.9 cm. and 1.35 cm. thick respectively.

\* Communicated by the Author.

They were made into approximately rectangular prisms and the lengths of the three edges measured with a metal millimetre scale, the fractions of a millimetre being estimated by eye. They were next weighed on a delicate balance. They were now placed in a beaker of water and allowed to remain in for one or more days, when they were taken out, and after wiping with a cloth, re-measured and weighed. It was soon seen, however, that the specimens swelled most near the edges, making the measurement of their three dimensions of little value for the purpose of calculating the volume, and consequently these measurements were given up and the volume deduced by weighing in water as well as in air. The results obtained for some of the specimens are given in the following tables and diagrams. It will be seen that the two dimensions in the plane of the sheets, called the length and breadth, have only altered slightly, while the third dimension at right angles to the plane of the sheet has increased by about 30 per cent.

Further, the final volume of the specimens was considerably less than the initial volume plus the volume of the water absorbed. [It was assumed in the calculations that the water was at the temperature of maximum density, the correction for the actual temperature, approximately  $16^{\circ}\text{C}.$ , being quite immaterial as far as the nature of the results go.]

In order to ascertain if temperature had any influence on the amount of water absorbed or on the change of volume, a bath was maintained at a temperature of approximately  $60^{\circ}\text{C}.$ , and two specimens were placed in it and readings taken in a similar way to those for the specimens in the water at room temperature. The effect of the higher temperature was clearly to cause both the water to be absorbed more rapidly and the final volume to be attained more rapidly, the maximum amount of water absorbed as well as the change of volume both being smaller.

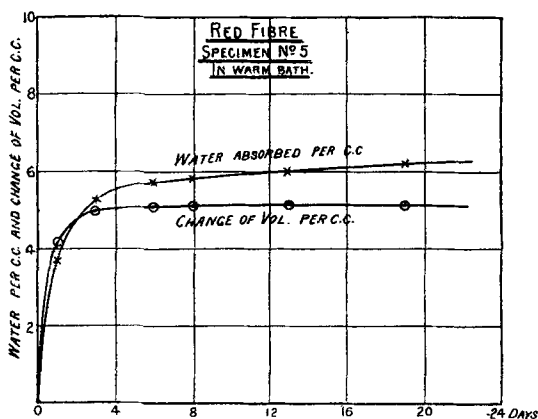
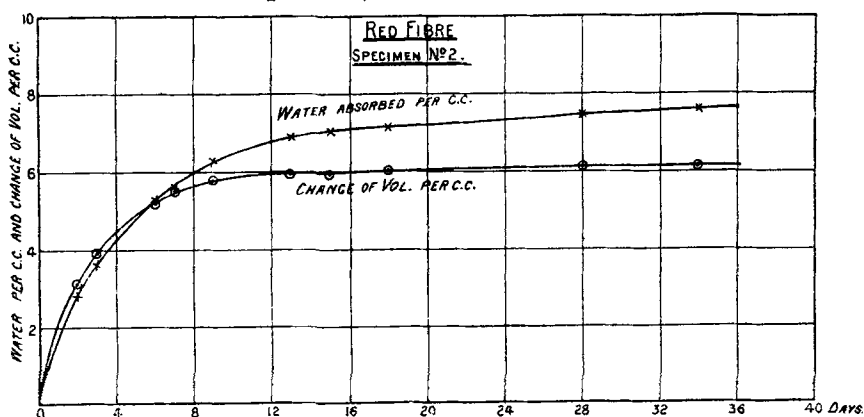
For the sake of comparison, observations were made at room temperature on two specimens of wood, one American bass and the other white deal. Here the changes of dimensions were all small and, as far as the measurements show, approximately of the same order as that for the two dimensions in the plane of the fibre, while the volume of the water absorbed was at least as large as in the case of the fibre, but did not appear to have reached its maximum amount when the observations were discontinued.

## Specimen No. 2.

	Weight (1).	Weight in water (2).	Volume from (1) & (2).	Volume by measurement from (3), (4), (5).	Weight of water absorbed.	Length (3).	Breadth (4).	Thickness (5).	Change of volume per c.c.	Water absorbed per c.c.
June 4th .....	16.98	...	...	13.986	...	5.6	1.85	1.35	...	...
June 6th .....	20.95	...	...	18.41	3.97	5.7	1.9	1.7	.31	.28 gr.
June 7th .....	22.105	...	...	19.49	5.12	5.7	1.9	1.8	.39	.36
June 10th .....	24.37	...	...	21.3	7.39	5.75	1.95	1.9	.52	.53
June 11th .....	24.86	3.18	21.68	21.39	7.88	5.77	1.95	1.9	.53 .55	.56
June 13th .....	25.85	3.77	22.08	21.37	8.87	5.77	1.95	1.9	.53 .58	.63
June 17th .....	26.61	4.34	22.27	22.50	9.73	5.8	1.97	1.92	.59	.69
June 19th .....	26.84	4.53	22.31	22.29	9.86	5.8	1.97	1.95	.59	.70
June 22nd .....	27.06	4.69	22.37	22.01	10.08	5.82	1.91	1.98	.60	.71
July 2nd .....	27.50	4.98	22.52	22.27	10.52	5.8	1.97	1.95	.61	.75
July 8th .....	27.70	5.15	22.55	21.45	10.72	5.79	1.94	1.91	.61	.76

## Specimen No. 5.

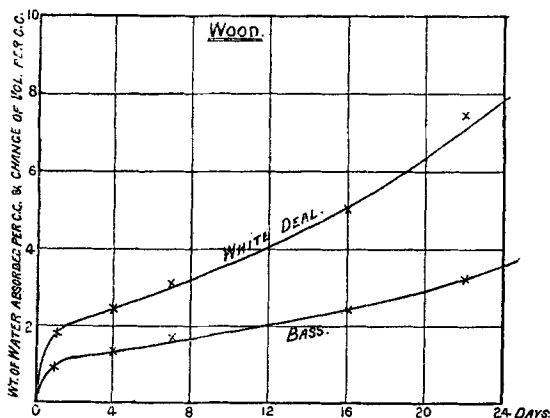
	Weight (1).	Weight in water (2).	Volume from (1) & (2).	Volume by measurement from (3), (4), (5).	Weight of water absorbed.	Length (3).	Breadth (4).	Thickness (5).	Change of volume per c.c.	Water absorbed per c.c.
June 19th .....	17.32	4.16	13.16	13.07	...	4.0	1.72	1.9	...	...
June 20th .....	22.23	3.45	18.78	18.82	4.91	4.12	1.85	2.47	.42	.37
June 22nd .....	24.37	4.63	19.74	18.82	7.05	4.1	1.8	2.55	.50	.53
June 25th .....	24.88	5.06	19.82	20.28	7.56	4.17	1.87	2.60	.51	.57
June 27th .....	24.92	5.03	19.89	19.58	7.60	4.12	1.85	2.57	.51	.58
July 2nd .....	25.25	5.31	19.94	20.07	7.93	4.15	1.86	2.60	.51	.60
July 8th .....	25.57	5.67	19.90	19.91	8.25	4.14	1.85	2.60	.51	.62
			In warm bath.							



Bass wood.	Weight (1).	Weight of water absorbed.	Length (3).	Breadth (4).	Thickness (5).	Water absorbed per c c.
June 6th .....	3.735	...	4.05	2.0	1.25	...
June 7th .....	4.70	0.96	4.10	2.0	1.30	.095
June 10th .....	5.15	1.39	4.0	2.0	1.32	.13
June 13th .....	5.53	1.77	4.05	2.0	1.3	.17
June 22nd ...	6.25	2.49	4.1	1.97	1.3	.24
July 8th .....	6.95	3.19	4.05	1.97	1.3	.31
White deal.						
June 6th .....	3.79	...	2.85	1.85	1.9	...
June 7th .....	4.93	1.14	2.87	1.90	1.92	.18
June 10th .....	5.31	1.52	2.90	1.90	1.92	.24
June 13th .....	5.78	1.99	2.90	1.92	1.90	.31
June 22nd ...	6.92	3.13	2.90	1.95	1.94	.50
July 8th .....	8.45	4.66	2.90	1.95	1.92	.74

The first specimen of fibre immersed, after being in for 9 days, was taken out and found at the end of 9 days to have yielded up 90 per cent. of its absorbed water.

The explanation of the enormous change in one dimension did not perhaps appear clear. In order to account for this thin sections were examined under the microscope, when it was seen that the structure was very heterogeneous. When



we attempt to split the fibre it yields easily in the plane of the sheet with a more or less flaky appearance, but it is very difficult to split in a direction perpendicular to the sheet. This agrees with the character of the sections in the plane of the sheet and perpendicular to it as seen in the microscope. The sections in the plane of the sheet showed a mass of long fibres or cells separated by a considerable amount of matrix or intercellular space, while the sections perpendicular to the sheet were of a very much denser character and showed only a few fibres longitudinally. (The sections perpendicular to the plane of the sheet were also much harder to cut than those in the plane of the sheet.) In the manufacture of the sheets great pressure is applied when the walls of the fibres or cells are in a partly gelatinous state, and hence the number of fibres or cells per centimetre perpendicular to the plane of the sheet is immensely greater than the number in the plane of the sheet, and consequently when water is absorbed the amount of swelling perpendicular to the plane of the sheet is much greater than in the plane of the sheet.