The Rusting of Iron.

DURING the past few months the study of the chemical changes involved in the rusting of iron has been coming to the fore. In 1888 Crum Brown pointed out that iron remained free from rust in an atmosphere of oxygen, carbon dioxide, and water vapour so long as liquid water was prevented from condensing on its surface. Whitney, in 1903, confirmed the opinion that liquid water alone had no effect on the metal at ordinary temperatures. No mention was made, however, of the purity of the iron used. Last year Dunstan, Jowett, and Goulding confirmed these results for polished iron plate (99.94 per cent. iron) in a series of carefully planned experiments. Since iron of such great purity as this is seldom used for commercial purposes, it seemed to me desirable to try the effect of water alone on different samples of varying qualities. Three such were chosen:—(1) cast iron from a piece of old piping; (2) wrought iron; (3) fairly pure iron (99.5 per cent.). The pieces were polished, and measured approximately 1 cm. long by 3 cm. broad and 0.2 cm. thick. They were dropped into flasks of boiling distilled water, and after five minutes the latter were closed with tightly-fitting india-rubber bungs, in the way indicated by Whitney. It was found that whilst the pure and wrought iron were unchanged, the cast iron invariably turned a shade darker in tint. The experiment was varied by employing thin glass tubes instead of flasks, and the surface of the metal was in some cases roughened with a coarse file. After the admission of the iron, the tubes were drawn out and finally sealed off. The results were invariably the same. I have kept these tubes for several months, but no further changes have taken place. This seems to indicate that, whilst neither warm nor cold water has any effect upon the purer forms of iron, they exert some slight action on the coarser cast iron.

Many and various are the theories which have been suggested from time to time to account for the process of rusting. Crum Brown pointed out that carbon dioxide was necessary. This dissolved in the water and attacked the iron, forming ferrous carbonate, FeCO_3 , or perhaps the soluble ferrous hydrogen carbonate, $\text{FeH}_2(\text{CO}_3)_2$. The hydrogen gas set free combined with any dissolved oxygen, forming water. The oxygen of the air would convert the ferrous hydrogen carbonate into rust, with the liberation of carbon dioxide. Thus a small amount of carbon dioxide in the presence of water and oxygen would be capable of converting an infinite amount of iron into rust.

During the present year Moody has confirmed this theory by showing that if elaborate precautions are taken to remove every trace of carbon dioxide, pure iron (99.98 per cent.) may be kept for an indefinite time in the presence of air and liquid water without undergoing the slightest visible change. He has also directed attention to the fact that when a piece of pure iron is introduced into a dilute solution of distilled hydrogen peroxide the latter is decomposed slowly, evolving a steady stream of oxygen, whilst the iron is unchanged. This again demonstrates the fact that oxygen and water alone have no action on pure iron.

I have repeated the experiments with hydrogen peroxide, using the different samples of iron already referred to. The peroxide was from Merck, and guaranteed to be pure. It was diluted to thirty times its volume with freshly-boiled distilled water. On introducing the iron, it was found that the pure sample remained perfectly bright, a slow stream of oxygen being evolved. After some hours an odd speck or two of rust appeared. No further alteration occurred even after the lapse of one or two weeks. The wrought iron decomposed the peroxide rather more rapidly, and the specks of rust were more numerous. The cast iron decomposed the peroxide with astonishing rapidity, and in a few minutes was covered with rust. This was, no doubt, due to catalytic action.

We thus see that the purer the iron the less is the action of the peroxide upon it. Had such pure iron as that used by Moody been employed, I have no doubt my result would have exactly coincided with his.

It is not impossible, therefore, that while carbon dioxide, oxygen, and water are essential for the rusting of pure iron, the last two alone may be sufficient to cause rust in the coarser forms, such as cast iron.

J. NEWTON FRIEND.

The Mixed Transformation of Lagrange's Equations. THE history of the formula

$$L = \mathcal{L} + \Sigma(\mathcal{Q}\theta) - \mathcal{R} - V \dots \dots (1)$$

is as follows. About twenty years ago I read two papers by Lord Rayleigh and Prof. W. M. Hicks in which certain problems relating to the motion of a cylinder in a liquid, which possesses cyclic irrotational motion, were solved. Both authors employed the old-fashioned method of calculating the forces due to the pressure of the liquid; but I at once perceived that some form of Lagrange's equations must exist which would enable the problems to be solved without introducing internal forces. I accordingly examined all the works on dynamics to which I had access, including Dr. Routh's treatises and Prof. J. J. Thomson's recently published papers in the Phil. Trans., 1886 and 1887, but without finding what I wanted. The necessary clue was at length obtained by means of a theorem of Lord Kelvin's published in the Proc. Roy. Soc. Edin., vol. vii., p. 668 (about 1872 or 1873), which enabled me to establish the formula in question.

Dr. Routh ("Rigid Dynamics," pp. 319 and 320, fourth edition) has given some rather formidable determinants, by means of which it is conceivable that (1) might be deduced by a more or less lengthy analytical process; but in their present form I have never been able to make any use of them. The procedure explained in §§ 418-420 could not apparently be employed when the velocities which are to be eliminated are either unknown or would be inconvenient to introduce.

A. B. BASSET.

Fledborough Hall, Berks, September 21.

Suspended Germination of Seeds.

SOME years ago it was reported that charlock seed had germinated upon the site of a Norman church in Kent. Is there any similar record of foxgloves awakening from a long sleep? Last February I removed an ancient wall circling the top of a very bare hill on a north country farm. We took out the large foundation stones. As the spring advanced, the site of the wall became carpeted with seedling foxgloves; if the cattle permit, a thick foxglove hedge will round the crown of the hill next year.

There were no foxglove plants within several hundred yards, and even had there been roots there would be no seed in February. The wall was formerly the fence of an oak wood, which was felled and turned into pasture forty years ago. The seeds were unquestionably as old as that date; but my own strong opinion is that they were right underneath the foundation stones of the wall, and had lain there ever since it was built. I examined the site very carefully, and also noted that disturbance of the neighbouring turf, outside the site, did not produce any foxglove crop. I believe that the oaks were planted and fenced by a man named Stephen Green between 1600 and 1610.

Another less pleasing instance occurred on the same farm. I took some cartloads of turf and loam—top-spit from an old pasture traditionally called the "Barley Field"—and spread it on another part of the grass; whereupon there came up thousands of corn-weeds, such as fumitory and sun spurge, which were previously unknown in the pastures.

H. B. P.

Optical Illusions on Electric Fan.

A REVOLVING electric fan with gilt blade is illuminated by the light from a window. When we look fixedly on the revolving face an irregular patch of greyish-purple colour appears on the yellowish ground. The patch shows an amoeba-like motion, and its size seems to increase with the speed of the fan. The border of the patch is coloured pale. In its centre a bright spot is often discerned. If we look at the fan after having closed or turned aside our eyes for a while the patch has disappeared, and it takes a few seconds before it reappears.

Several other experiments on illusion can be made conveniently by means of the fan. If the blade be covered with red papers and revolved slowly, a white paper looked at through the revolving face appears greenish, and a greenish one greyish.

T. TERADA.

Physical Laboratory, Tokyo, August 26.