ground, the vegetable covering of the soil, and openness of situation. ALEXANDER BUCHAN

Edinburgh, April 9

THERE is one consideration which your correspondents, the secretary of the Scottish, and the president of the British Meteorological Societies have equally overlooked, and which may seriously affect the conclusions at which they arrive as to the suitability of Greenwich for a first-class meteorological station. Since the year 1846 the temperature observations at Greenwich have been made under conditions of exposure of thermometers which, whatever their merits or demerits, are not those usually adopted. In a paper published in the *Quarterly Journal of the Meteorological Society* (October, 1873) I have shown from the average of five years' daily comparisons that the effect of the method adopted at Greenwich upon the mean annual temperature is to obtain a result 0°·475 warmer than is obtained by the usual method. This quantity is almost identical with the excess which Mr. Eaton attributes to the local consumption of fuel, an explanation surely most inadequate. Thus the discrepancy pointed out by Mr. Eaton only serves to establish his opponent's case. Mr. Buchan on the other hand must be unaware that it is the eye observations alone, made from the revolving stand, that are relied upon for temperature results at Greenwich, and though his conclusion would seem to be correct it does not seem possible to sustain the argument by which he has arrived at it.

Orwell Dene, Nacton JOHN I. PLUMMER

Cast-Iron

I HAVE been struck by the statement I found in several books on physics that cast-iron expands when it gets cool. As some of these books are used as text-books in schools in this country, and as this statement is contrary to the experience of all practical men with whom I have conversed upon the subject, I think the following translation of an article which appeared in *Der Civil Ingenieur*, edited by K. R. Bornemann, in Freiberg, 1863, ix. Band, iv. Heft, p. 219, may not be uninteresting, explaining, as it seems to me fully, at least one of the facts on which the statement mentioned above appears to be based, viz., the fact that cold iron swims in liquid iron :— H. M.

"At a meeting of the Association of Saxon Engineers which took place in Freiberg in August last year (1862) Mr. H. Gruson, of Buckau, near Magdeburg, called the attention of the members to a phenomenon which had frequently been observed by him, but of which no proper explanation could be given at the time, viz., that pieces of cold cast-iron swim perfectly in molten iron. The question was raised, to what causes this may be due, and as from the physical point of view it was thought an interesting one, it was suggested that experiments should be made in order to obtain a proper explanation thereof.

"In consequence of this, M. Centner, Inspector of the Jacobi Iron-works, near Meisen, made such experiments, the result of which he communicated to the Association at a meeting on May 17, 1863. The following is an extract of Mr. Centner's report :— (Signed) W. TAUBERTH"

"Before anwering this question I made some experiments in order to ascertain whether this swimming is not caused by the specific weight of the body ; by there I found confirmed that cold cast-iron weighs $\frac{1}{27}$ more than an equal volume of molten iron, for if a piece of cold cast-iron of 28 lbs. be used to form a mould, and if this mould be filled with molten iron, the new piece of metal thus obtained will only weigh 27 lbs. This weight, of course, is also that of the liquid metal which was required to fill the mould, formed from a piece weighing 28 lbs.

"For this reason, in making moulds for cast-iron, a measure is used which is $\frac{1}{96}$ longer than the ordinary measure, if the piece of iron to be formed is to have the full size of the ordinary measure.

"Repeated experiments with a mass of molten iron of 2,000 lbs. gave me further proofs that the causes of this swimming must be other than the specific weight.

"For my experiments I used four bodies of cast-iron of different shapes, but of the same volume, viz. a plate of 6″ inches in the square and 1″ thick, a cube of $3\frac{1}{3}$″, a cylinder of 4″ diameter, and 3″ height, and a ball of 4″ diameter. Each of these four bodies measured 36″ cube and weighed 7 lbs.

"If the cause of the swimming were the specific weight, an equal part of the volume of all these bodies ought to remain above the surface of the liquid iron, but such is not the case at all. The volume above the surface of the liquid iron is different in each of the four bodies ; it is greatest with the plate and smallest with the ball. Thus it is dependent on the shape and position of the surface which rests on the liquid iron.

"In order to come to the real causes of this swimming, I must first remind the reader that in every hot liquid in an open vessel, in consequence of the more rapid cooling at the surface, a continuous current is originated, the interior hottest parts ascending and the exterior colder ones descending ; and thus a more or less visible movement or agitation is produced in the mass. Such currents occur in every mass of molten iron, and are there especially remarkable in consequence of a contemporaneous ascension and separation of slags, which, when they have arrived at the surface, are generally pushed towards the edges.

"If a solid piece of iron be put on the liquid mass the former gets at once heated at the expense of the latter ; the portions of water and of air which are contained in the solid piece get expanded and expelled with considerable force, thus forming a current in opposition to the ascending one above mentioned.

"This expulsion of air and water may even cause dangerous explosions, if the usual precaution is neglected to warm the solid piece somewhat, before it is brought into contact with the liquid mass.

"Now there is no doubt that these opposite forces alone are able to raise the heavier solid piece more or less according to the more or less favourable surface it presents.

"But besides this there is to be taken into consideration that the overweight of the solid piece of iron is diminished by the previous heating which when the solid piece comes into contact with the liquid, is at once augmented and that the proportion of heat of the molten iron to that of the solid piece must to some extent have an influence on the more or less deep immersion of the latter.

"A further cause, although a slight one, of this swimming of the solid piece is the cohesion of the liquid iron ; but at any rate this becomes of some importance in conjunction with the above-mentioned continuous ascending of slags which collect under the swimming body and retain partly the air expelled by the latter, helping in this way to keep it afloat.

"Solid cast-iron being $\frac{1}{28}$ heavier than an equal volume of molten iron, the overweight of each of the four bodies used for my experiments is consequently only $\frac{1}{4}$ lb., and in the present case it is therefore only this one *quarter of a pound* which the above-mentioned opposite forces have to lift within areas of 12″ to 36″ square in order to keep the body swimming.

"On increasing the size of the solid bodies, however, it will be easily understood that a limit to this swimming will soon be reached, and indeed I accidentally found this limit on my first trial in quadrupling the sizes of the four bodies so that each of them weighed 28 lbs. ; for all the bodies with the exception of the plate which was 12″ in the square and 1″ thick went to the bottom. The plate on being put gently on the liquid mass was just kept afloat, but its surface was a little below the surface of the molten iron. 1 lb. overweight therefore with a surface of 12″ in the square could scarcely be kept swimming.

"The behaviour of the other three bodies at the bottom was remarkable in consequence of a continuous vehement ebullition accompanied by the shooting out of long white brilliant flames, and these phenomena can only be attributed to the water and air expelled by the heat.

"These experiments with bodies of 28 lbs. weight show therefore that above this weight, without giving to the body a more favourable surface than 12″ in the square, these bodies do not what is properly called swim in the sense that part of the solid body is kept above the level of the liquid. For if the bodies, for instance the ball, the cube, and the cylinder on being moved, rise and fall a little alternately, this can no longer be called swimming, for it is just the transition from overweight to equilibrium.

"That the greater or lesser degree of density of the different sorts of iron will also exercise an influence cannot be doubted.

"Less fortunate but still interesting was an experiment which I made with four pieces of zinc of the same shapes as the pieces of iron on 200 lbs. of liquid zinc, when with the pieces of 7 lbs. each the same thing took place as with the cast-iron pieces of 28 lbs. each on liquid iron, viz., the plate was just kept afloat and the three other bodies went to the bottom.

"With zinc, therefore, this phenomenon of swimming does not occur with such heavy bodies as with iron, and this may be explained by the fact that with zinc, in consequence of the much smaller difference of temperature between the liquid and the