and Mr. G. Smeal (Government research scholar), dealt with temperatures near the freezing point, and the second, by Mr. Smeal, dealt with temperatures up to 31·4° C. The discussions appear to have proved that the suggested coefficient, being so nearly unity, is not wanted, especially if the covering be thin muslin and be kept clean. The factor, A=0·00072, derived from the observations and careful computations, varies slightly according to wind force. In the event of any modification of the simple formula being accepted it might be in this sense, but we suggest that it would be more to the point if one formula were selected from among those which already exist, and be recommended for general adoption.

A useful paper on the wet-bulb thermometer and tropical colonisation, by Prof. J. W. Gregory, F.R.S., is published in the Journal of the Scottish Meteorological Society (vol. xvi., No. xxix.). The author points out that the view that the tropics are injurious to health is prevalent, but the explanations why this is so are very unsatisfactory. Heat is mostly regarded as one of the principal factors of tropical maladies, but it is now recognised that no locality with a *dry* climate has a temperature so high as to be injurious to health; in fact, the hottest districts in a country are often the healthiest. Healthiness of tropical localities does not depend upon diurnal or annual range of temperature, and moisture is not necessarily injurious; the latter is better for some constitutions, but heat and moisture combined may be very harmful. Experiments appear to indicate that "the industrial development of any locality where the wet-bulb temperature commonly exceeds 80° will be almost, and if it exceed 88°, quite impossible." But statistics supplied to the author by the Meteorological Office show that such high wet-bulb temperatures do occur in well-populated tropical localities. The author laments that the distribution of such temperatures is not well known, and refers to the collection of observations in Australia by Prof. W. A. Osborne, of Melbourne. The annual summary of the Australian Monthly Weather Report for 1910 (received by us in July, 1912) contains monthly wet-bulb isotherms from 9h. a.m. observations, with means of 80° in the north-west in December–February inclusive.

RECENT ADVANCES IN SCIENTIFIC STEEL METALLURGY.[1]

IT has already been pointed out that the year 1870 marked the commencement of the tungsten era, and 1880 that of the tungsten-chrome era. But the years 1899 to 1902 inaugurated what is destined to be the most remarkable epoch of the three, namely the vanadium era. During these years was carried out in the experimental steel works of Sheffield University a series of researches on the influence of the comparatively rare metal vanadium on plain carbon steel and on alloy steels. At that time (1899) vanadium was 60*s*. per lb. In 1912, owing to the large demand, the cost had fallen to 10*s*. per lb.

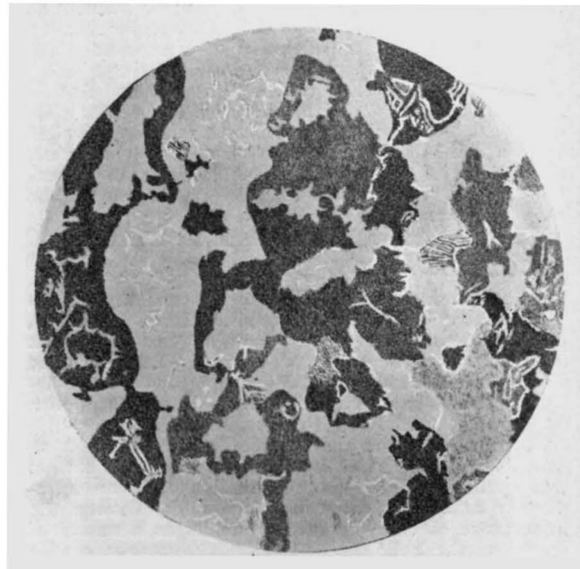
The first report, having reference mainly to cutting steels, was issued in June, 1900, and the second and third reports respectively in January and June, 1902. The results are briefly summarised in the two next paragraphs.

June 28, 1900.

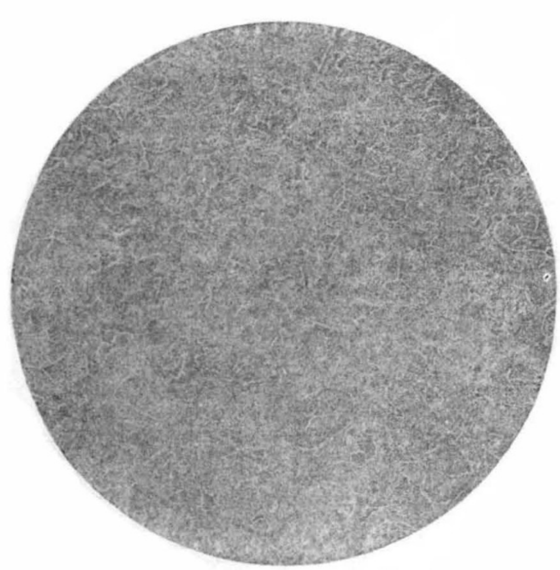
"The results of this preliminary investigation have profoundly impressed upon my mind the future before vanadium as a steel-making element, and even at this early stage of my knowledge of its effect, I venture to say that its action resembles that of tungsten, but that it is from ten to twenty times as powerful as the latter element."

January 14, 1902.

"It is already evident that as a steel-making element vanadium will place in the hands of metallurgists and engineers a very powerful weapon, because it is now demonstrated beyond doubt that the addition of a few tenths per cent. of vanadium raises the elastic limit of mild structural steel at least 50 per cent., without seriously impairing its ductility or presenting any difficulty in the hot or cold working of the steel."



(*a*) Carbon, 0·60 per cent. Vanadium, 0·71 per cent. Pale ground mass of slightly vanadiferous ferrite. Dark areas, troostitic vanadium pearlite. Less dark areas, sorbitic vanadium pearlite. White cell walls and masses, "B" iron cementite, resulting from thermal decomposition of laminated iron pearlite, a few areas of which still remain undecomposed.



(*b*) Carbon, 0·93 per cent. Vanadium 5·84 per cent. Ground mass of sorbitic vanadium pearlite, overlaid with a broken and irregular mesh-work of vanadiferous ferrite.

FIG. 6.—Magnified 450 diameters.

[1] Discourse delivered before the Royal Institution on Friday, January 24, by Prof. J. O. Arnold, F.R.S. Continued from p. 49.

Some of the results upon which these paragraphs were founded are tabulated below. Perhaps the most remarkable results in this series are:—

(1) A plain carbon steel containing about 1 per cent. of carbon has a yield point of 35 tons per square inch, a maximum stress of 60 tons per square inch, an elongation of 10 per cent. on 2 inches, and a reduction of area of 10 per cent. The addition to such steel of about 0·6 per cent. of vanadium raised the yield point from 35 to 65 tons, the maximum stress from 60 to 86 tons per square inch, still leaving an elongation of 7 and a reduction of area of 8 per cent.

(2) A steel containing 0·25 per cent. of carbon and 3·3 per cent. of nickel registered a yield point of 33 tons, a maximum stress of 42 tons per square inch, an elongation of 26 per cent. on 2 inches, and a reduction of area of 53 per cent.

A practically identical steel, but containing in addition about 0·25 per cent of vanadium, recorded a yield point of 50 against 33 tons, a maximum stress of 68 against 42 tons per square inch. The elongation was 17 per cent. on 2 inches, and the reduction of area 36 per cent.

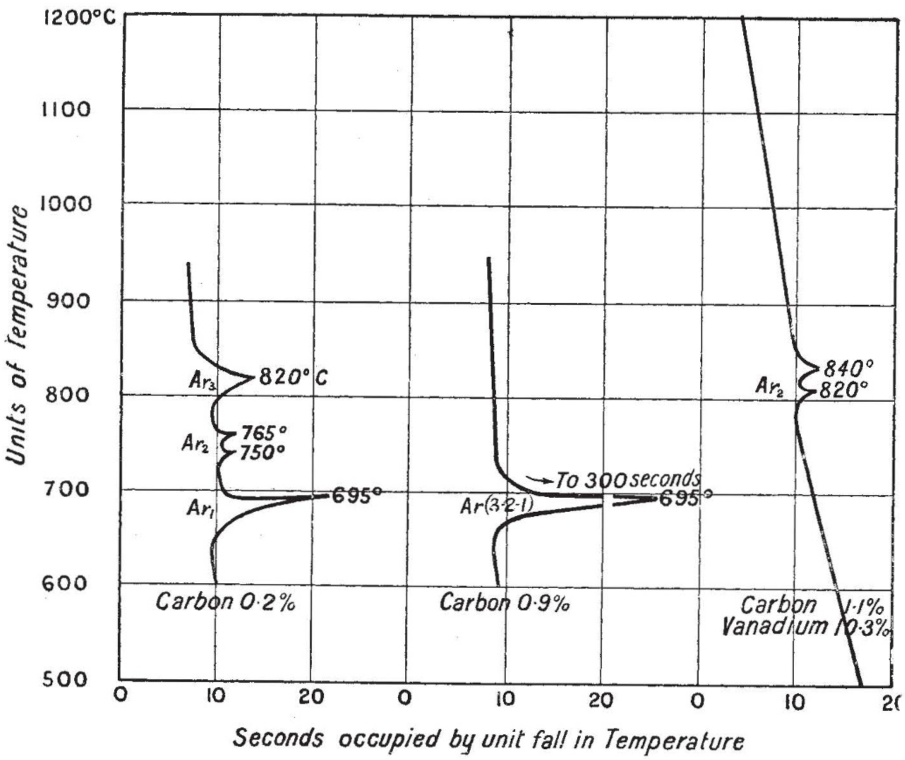


FIG. 7.

(3) A steel containing 0·25 per cent. of carbon and about 1 per cent. of chromium registered a yield point of 27 tons, and a maximum stress of 41 tons per square inch, together with an elongation of 36 per cent. on 2 inches, and a reduction of area of 55 per cent.

The addition of 0·25 per cent. of vanadium raised the yield point from 27 to 40, and the maximum stress from 41 to 55 tons per square inch. The elongation was lowered from 36 to 26, and the reduction of area from 55 to 53 per cent.

Thus vanadium differs from tungsten in having an almost magically beneficial effect, not only on cutting, but also on structural steels. In connection with vanadium steels it is an interesting fact that the series of copyrighted and published reports issued from Sheffield University during the years 1900 to 1902 were unconscious plagiarisms of a series of American patents issued during the years 1904 to 1908. This seems to constitute a remarkable problem in psychology.

A study of what may be called the pure science of vanadium steels made by the lecturer and Prof. A. A. Read, of the University of Wales, has yielded results of profound theoretical and probably practical importance. It was shown that vanadium does not seem to form a double carbide with iron. It gradually wrests the carbon from the carbide of iron until when about 5 per cent. of vanadium is present Fe_3C cannot exist, and only a vanadium carbide, V_4C_3, containing 15 per cent. of carbon is present, and this constituent is constant, at any rate in tool steels containing up to 14 per cent. of vanadium. The micrographic analysis of these alloys, as shown in Fig. 6 (*a*) and (*b*), has resulted in the discovery of three new constituents, viz. vanadium pearlite, vanadium hardenite, and vanadium cementite. Vanadium hardenite seems to have a hardness of 8 (topaz) as compared with the hardness 7 (quartz) of iron hardenite.

The recalescence results obtained are of great practical, as well as theoretical, interest. They strongly suggest the explanation of the curious thermo-mechanical behaviour of high-speed steels, and incidentally they appear provisionally to prove that the hardening is not due to allotropic change, but to the carbon change only. Fig. 7 shows (1) the inverse rate recalescence curve of a 0·2 per cent. plain carbon steel, which exhibits all Osmond's critical points, viz., Ar_3, Ar_2 (with a double peak) and Ar_1, the carbon change point; (2) the recalescence of a saturated steel containing 0·89 per cent. of carbon, in which all three points are merged into one very large evolution of heat at 695° C.; (3) the recalescence curve of a steel containing 1·1 per cent. of carbon, and 10·3 per cent. of vanadium. This curve was registered from 1210° to 505° C. It presents only the double-peaked point Ar_2. When the steel is quenched all along the above range it still remains quite soft to the file. To harden it it is necessary before quenching in water to heat the alloy above the A_1 or carbon change point, which takes place at a white heat, near 1400° C. The steel is then very hard.

Fig. 8 shows the transformation on heating up to a white heat (*a*) of annealed vanadium cementite into vanadium pearlite, (*b*) or sorbitic vanadium pearlite into amorphous and topaz-hard vanadium hardenite.

The advance in concrete cutting efficiency of turning tools from 1740 to 1912 was then dealt with. It should be noted that the best steel of this kind made in Sheffield in 1740 would be absolutely incapable of cutting at all under conditions under which the best modern high-speed steel would remove 700 cubic inches of metal before breaking down.

The advantages of this enormous increase in cutting power are manifold, and an obvious example is the relative rapidity with which huge naval guns may now be turned out.

In January, 1909, I had the honour of suggesting to a Royal Institution audience the coming of a new British steel which would have a cutting power four times as great as the best steel then on the market. The skilful application of vanadium by Sheffield steelmakers has practically fulfilled that forecast, and the world-wide sensation and publicity created by the announcement has left Great Britain supreme in this very important branch of scientific steel metallurgy. An aspect of iron and steel metallurgy already demanding attention is the diminishing quantity of the

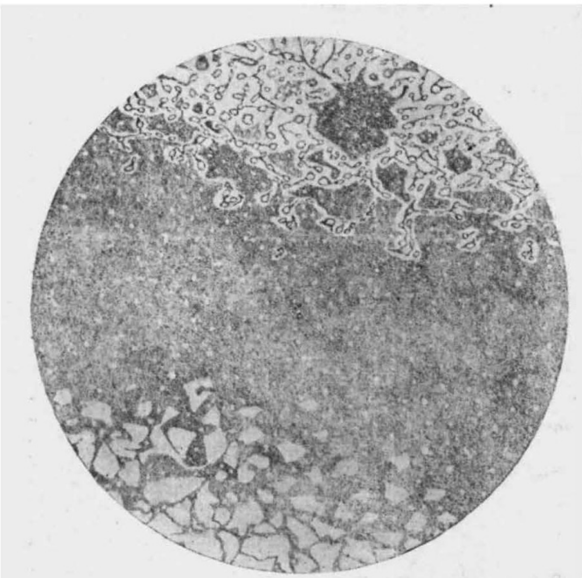


FIG. 8.—Carbon, 1·10 per cent. Vanadium, 13·45 per cent. Transformation stages of vanadium cementite and vanadiferous ferrite into vanadium hardenite. Upper area, mainly vanadiferous ferrite with vanadium cementite nodules, together with a little sorbitic vanadium pearlite. Middle area, ground mass of unsaturated vanadium pearlite, overlaid with undissolved nodules of vanadium cementite. Lower area, mainly structureless vanadium hardenite cells formed from a series of centres and surrounded by walls of the structure described for middle area Hardening temperature, near 1400° C. Magnified 450 diameters.

world's iron ore supply. To a great extent the latter could be strongly reinforced from the huge deposits of iron sands now lying useless if a simple, economical and direct process of reduction could be devised. That metallurgical science and art will do this eventually seems certain, and I hold an opinion, founded on practical data, that the solution of this hitherto baffling problem is nearer than most metallurgists suppose.

In conclusion, it may be pointed out that the skeleton history of early Sheffield steel metallurgy sketched in this discourse is in some important points in conflict with the somewhat disparaging historical outline written by Lord Macaulay, but in this particular connection there seems to be a modicum of truth in the answer of the schoolboy who, when asked to mention his favourite work of fiction, unhesitatingly replied, "Macaulay's History of England."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DURHAM.—ARMSTRONG COLLEGE.—The foundation-stone of the new building for the department of agriculture is to be laid on Saturday, April 5. Mr. C. Cochrane has promised the sum of 2,500*l.* towards the equipment of the department, and a Diesel engine has been offered to the college by Mr. G. E. Henderson. The appointment has been approved of Mr. G. D. H. Cole as deputy professor of philosophy, in the absence of Prof. Hoernlé, who is to deliver a course of lectures at Harvard University between October, 1913, and January, 1914.

THE Senate of the University of Dublin has approved the conferment of the honorary degree of doctor of science upon Prof. A. C. Seward, F.R.S., and Prof. the Hon. R. J. Strutt, F.R.S.

BY the will of Sir Alfred Jones, 227,100*l.* is left to charitable and educational institutions, and the scheme for carrying out the objects of the will has just been sanctioned by Vice-Chancellor Dudley Stewart-Smith. By the provisions of the will the Liverpool School of Tropical Medicine will receive 40,000*l.*, and a further 40,000*l.* when the annuities payable out of the estate cease. The 40,000*l.* now given is to form a fund to be called the "Sir Alfred Lewis Jones Bequest," and is to be devoted (*a*) to defraying the cost of a new wing or ward to the Liverpool Royal Infirmary for the reception of persons suffering from tropical diseases, to be called the "Sir Alfred Lewis Jones Tropical Ward"; (*b*) to the erection of new premises in Liverpool for the study of tropical medicine, to be permanently associated with the name of the testator; (*c*) to the erection and equipment of a laboratory in Sierra Leone, to be called the "Sir Alfred Lewis Jones Tropical Laboratory"; (*d*) the residue of the gift is to be used as a permanent endowment. 20,000*l.* is left for the promotion of technical education in British West Africa, and 1000*l.* to Liverpool University.

BY the will of Mr. John Fritz, the iron master, says *Science*, his residuary estate, amounting to about 30,000*l.*, is given to Lehigh University primarily as an endowment fund for the maintenance of the Fritz Engineering and Testing Laboratory. It is also announced that Mr. Charles L. Taylor, of Pittsburg, has given Lehigh University a gift for a large gymnasium and a stadium. From the same source we learn that by the will of the late Mr. C. C. Weld, of Newport, R. I., the residuary estate, valued at nearly 800,000*l.*, is, in case his daughter dies without issue, to be divided between the Massachusetts General Hospital and the Massachusetts Institute of Technology.

AT the opening of a new technical college and secondary school at Workington last week, Sir John Randles said he desired to commemorate the occasion by a gift of 1000*l.*, to provide a travel scholarship for a student of the college. The gift will yield some 50*l.* or 60*l.* each year to a student to assist him to become proficient in the metallurgy of iron and steel, which is associated with the local industry. The money is to be used by the student, within three years of its being awarded, in visiting some Colonial or foreign metallurgical centre, and may be recreative as well as useful. In this way Sir John Randles hopes some of the pleasure he has enjoyed in life by travel will be secured year by year to a Cumberland youth.

THE President of the Board of Education, Mr. J. A. Pease, spoke at a meeting of the National Union of Teachers at Sheffield on March 15, and referred to the