about forty-five in each group, will be allowed to come to London for the six weeks' course of training. They will receive their travelling expenses, namely, second-class railway fare, and 30s. a week while in London. The results of the teachers' examination will not be published. Each candidate will be informed of the position in which he would have been placed had he been examined as an ordinary candidate for honours. If he wish his success recorded, it will be done in the ordinary way. The Biology course will commence on the 14th June, and the course on Experimental Physics on the 5th July. It must be understood that no teachers, except such as come up under the foregoing rules, will have travelling allowances under § lxviii. of the Science Directory. No persons are eligible to receive the allowances granted in this minute except those who have been engaged in science teaching under the Science and Art Department during the session 1870-71.

It appears from Mr. Glaisher's Meteorological Tables, that while December 25 was the severest day of the recent frost in the neighbourhood of London, it was still more intense in other localities on January 1, falling as low as 4.9° at Wolverhampton, 5.0° at Hull, 6.7° at Bradford, 7.0° at Leeds, and 9.7° at Leicester, the minimum at Blackheath on that day being as high as 19.2°, although at Twickenham, as reported by Mr. Hall last week, the thermometer fell as low as 6.3°. As on Christmas Day the severest cold was again in the Midland and North Midland counties, and we have once more to record the phenomenon to which we have had occasion to allude more than once recently, that the frost was considerably more intense in England than in Scotland. For the week ending January 7, no lower temperature was recorded at any of the Scotch stations than 21.0°, at Dundee; the mean temperature for all the English stations was 29.6°, while for all the Scotch stations it was 35.5°, or more than 6° higher. From the 20th of December to the 13th of January, when the frost finally broke up, the temperature in London was only even slightly above the mean of the last fifty years on three days.

THE Rev. Mr. Gribble, F.R.S., reports from Constantinople that after a fine morning the disc of the sun in the late eclipse was obscured for some time, so that it was not well seen until 3^h 26^m mean time, when there was only about one-eighth of the disc clear. A large solar spot then became uncovered; clouds coming on again, this was all that was seen clearly. At 3^h 26^m the light was considerable.

THE *Scottish Naturalist*, to which we referred some weeks since as a new periodical proposed to be issued under the auspices of the Perthshire Society of Natural Science, has made a good beginning. Opening with a short programme of future operations, in which the editor, Dr. Buchanan White, wisely states his intention of restricting the contributions to papers and notes especially bearing on Scottish Natural History; we then have an article by Dr. Lauder Lindsay "On Natural Science Chairs in our Universities," to which we may possibly take occasion again to refer. The writer deals with a bold hand with the evils which are said to prevail more especially in the election of Professors in our northern Universities. He refers to the manner in which these appointments are stated often to be regulated by political influence or religious belief rather than by possession of qualifications to teach Natural Science, and is especially severe on the system of personal canvass and the "testimonial nuisance." Mr. J. A. Harker contributes a paper "On the Work and Influence of Local Natural History Societies;" Mr. George Norman a List of the Noctuæ occurring in Morayshire; the editor some hints on Sugar'ng, how, when, and where to do it; and an anonymous contributor, a paper "On the Mollusca of the North-east of Scotland," illustrated with a map. Some shorter articles and notes with reports of proceedings of Scottish Natural History Societies, make up the number, which we commend to the notice of all interested in natural history across the Border.

HENDERSON'S PATENT PROCESS FOR REFINING CAST-IRON

AN article was furnished a short time ago, and published in NATURE (No. 57, p. 94), respecting a new process for the production of steel by the partial decarburisation of cast-iron, invented by the writer. It was then stated that a description of a new process for refining cast-iron would soon follow.

This process supplies a more effective and economical process than the English finery or the German reverberatory furnace processes for refining cast-iron. It is very simple, and does not require any fuel, labour, or expensive apparatus; and there is no loss of weight of iron, as the impurities go off in vapour. The cost of refining is less than one-twentieth of that of the English and German processes; and its effect is more thorough than is possible by those systems.

The agents used are fluorine and oxygen combined. The fluorine is derived from any fluoride, and the oxygen from any substance containing or capable of evolving oxygen, which is adapted to use in the manufacture of wrought-iron and steel. Fluorspar and pure rich iron ores are the most available and economical substances for producing these agents, and are applied finely powdered and mixed, and placed in receptacles, preferably, so as to act from the under side upwards upon cast-iron in its molten state.

The most economical mode of application of this process is to treat the cast-iron in the condition in which it flows from the blast furnaces, with fluorspar and iron ore, applied in the "chills" or pig moulds used at blast furnaces, by being spread over the bottom of the moulds.

The iron, when tapped from the blast furnace, flows into the mould thus prepared; the heat of the iron causes fluorine and oxygen to be liberated, and, by reason of the affinities of these substances for silicon and phosphorus, these impurities are removed in the form of *vapour*. The reactions in the "chills" are similar to those of the boiling puddling process, and last about five minutes. The metal during this period is covered with jets of flame and smoke. The resulting metal, with respect to silicon and phosphorus, is as pure as wrought-iron.

It is preferable to use iron ores containing the largest amount of oxygen and the least of silica and phosphorus. These conditions exist in "washed iron sands," and the red hematites of Cumberland and Lancashire. When using the hematite ores, varieties that are the easiest to reduce to powder are preferred; and the ordinary edge running apparatus, with cast-iron rollers revolving in a pan, is an excellent one for the purpose.

The fluorspar and fine ore are passed through a sieve of not less than four hundred meshes to the square inch, and afterwards mixed so thoroughly as to appear to be one substance, in the proportion of one part of fluorspar to two parts by weight of iron ore, and are spread one-fourth to three-eighths of an inch deep over the "chills," then the iron is run upon them so as to form slabs one inch thick.

The former article gave analyses of refined cast-iron produced in the reverberatory furnace. It will be seen by comparing the analysis of the refined metal of this process with the analysis of that of the reverberatory furnace process, that they are analogous, except that the latter contains no silicates or graphite. The refined metal of the pig-mould process saves the fuel and time taken for refining by the reverberatory furnace process, and shortens the time of producing steel or wrought-iron by that process fully forty minutes. When using the refined metal of this process two workmen can take charge of five ordinary boiling puddling furnaces making steel, and six furnaces making wrought-iron, as the only labour necessary is "balling" and removing it from the furnace. When high carburised steel is made, "balling" is not required, as

the metal will be fluid enough to run from the furnace into ingot-moulds. The economy of the process consists in the saving of the labour of eight workmen making steel, and two workmen making wrought-iron; and in the superior quality of the result, as compared with puddling the refined metal. The time occupied by the conversion of the refined metal into steel or wrought-iron by the process without puddling is about the same as that usually taken in puddling pig-iron.

Ordinary coke pig-iron, smelted near Pittsburgh from a mixture of hematite ore and mill cinder, has been treated by this process. The refined metal was afterwards puddled and rolled into "muck" bars, and once heated and rolled into merchant bar-iron. The pig, refined cast, and wrought-iron, have been analysed by an analytical chemist in this city. These analyses are annexed, also analyses of refined cast-iron by the English finery and German reverberatory furnace process, and of the highest standard qualities of English, French, Swedish, and Russian wrought-iron, are given for comparison, taken from Percy's "Iron Metallurgy" and Ure's Dictionary:

Pittsburgh Coke Pig-iron.	Patent Refined Cast-iron.	Bar-iron.
Carbon (combined)	0.2040	0.3613
do (graphite)	2.7685	2.5066
Silicon	2.3096	none
Slags (silicates)	0.3623	0.2983
Phosphorus	0.4196	0.1029
Sulphur	0.1298	0.1269

English Finery Process. Refined Cast-iron.	German Reverberatory Furnace Process. Pig-iron.	Refined Cast iron.
Carbon	3.07	—
Silicon	0.63	4.66
Phosphorus	0.73	0.56
Sulphur	0.16	0.04
Silica } Alumina }	0.44	0.62

English Wrought-iron. Low Moor Stamp.	French. Petin, Gaudet, & Co.	Swedish. Hoop L.	Russian. CCND
Carbon	0.016	0.087	0.272
Silicon	0.122	0.115	0.062
Sulphur	0.104	0.220	0.234
Phosphorus	0.106	0.034	—

On comparing the analysis of the refined cast-iron of the patent process with those of the English and German processes, it will be seen that while the refined iron of the new process contains *no silicon*, that of the English and German processes contains 0.63 and 0.62 per cent. respectively; and compared as regards phosphorus, the German process reduces it from 0.56 to 0.50 per cent., or about 0.06 per cent., and the new process reduces it 0.32 per cent., or over five times as much phosphorus is removed by the new process as by the other processes. The slags or silicates are 0.15 per cent. less than in the refined iron of the English finery process. The analysis of the patent refined cast-iron, compared with that of the above English wrought-iron, shows that whilst the wrought-iron contains 0.122 per cent. of silicon, the refined metal contains none, and compared as regards phosphorus they are about the same.

The analysis of the puddled wrought-iron, made from the refined cast-iron by once heating and rolling the puddled or "muck" bar, shows a purer quality of iron than the most celebrated makers of Europe produced from the purest ores with charcoal.

The economy of using the refined metal in saving cost of labour, fuel, &c., for the puddling process, has been fully demonstrated by numerous trials. When all the advantages of the process are realised, about one-half of the cost of converting cast-iron into wrought-iron can be saved; and there is an improvement in the quality equal to the difference between ordinary forge pig-iron and charcoal iron.

These advantages are:—

1. Better quality, which is due to the purity of the refined metal; as good qualities of wrought-iron are produced from it as from pig-iron made from the best ores smelted with charcoal.

2. The refined metal being as pure as wrought-iron, with respect to silicon and phosphorus, requires merely decarbonising, with less skill to work it, and greater certainty of the quality of the product.

3. Large saving in cost of production, owing to the shortening of the time of puddling, which is caused by the removal of a large part of the impurities by the refining process. White refined iron is decarbonised in twelve to fifteen minutes, and a "heat" or charge of five hundred pounds is puddled in fifty-five minutes, including time of charging, melting the iron, and stirring or puddling or "balling" and removing it from the furnace; grey forge iron requires sixty-five minutes, and foundry iron about seventy minutes. Seven "heats" or charges to a "turn" or a day's labour, are of easier accomplishment than five charges are from the pig-iron from which it was produced; the five charges now require ten hours to convert pig-iron into wrought-iron. It is possible to obtain, with the patent refined metal, by employing three sets of workmen in twenty-four hours, instead of two sets as is now customary, twenty-one charges in twenty-four hours instead of ten charges; and allowing sufficient time for repairs, the production of any ironwork may be doubled, without additional investment of capital and without additional cost of repairs.

4. Saving of fuel per ton of iron produced, amounting to one-half, caused by increased production.

5. Reduction of general business expenses per ton of iron, amounting to one-half, caused by increased production.

6. Reduction of wages, by reason of the diminished labour, of 40 per cent. per ton of iron.

7. The puddling furnace cinders of the refined metal contain but about one-fourth of the phosphorus, as compared with the cinders resulting from the use of pig-iron; and when smelted produce better qualities of pig-iron.

The cost of refining in the pig-moulds is very little. Fluorspar is a cheap material, and but about seventy pounds are required to refine a ton of iron. The cost is nearly compensated by the saving of the fuel and lime which would be required to reduce the puddle cinders of the refined cast-iron to pig-iron, as they contain but small portions of silica, and will require less fuel and limestone. The residue of the fluorspar and oxide is agglutinated, and remains in the pig moulds, and is pure lime and de-oxygenised iron ore, and is available as so much lime and ore in the blast furnace.

JAMES HENDERSON

SOME EXPERIMENTS ON COLOUR

THE theory of colour perception, although in England it has not yet made its way into the text-books, still less into the popular works on science, is fully established with regard to many important points. It is known that our perception of colour is threefold, that is, that any colour may be regarded as made up of definite quantities of three primary colours, the exact nature of which is, however, still uncertain. More strictly stated, the fundamental fact in the doctrine of colour is that, between any four colours whatever given, as well in quantity as in quality, there exists what mathematicians call a linear relation, that is, that either a mixture of two of them (in proper proportions) can be found identical, so far as the eye is able to judge, with a mixture of the other two, or else that one of them can be matched by a mixture of the other three. There are various optical contrivances by which the mixture spoken of may be effected. In the year 1857, Mr. Maxwell published an account of some experiments with the colour top undertaken to test the theory. From six coloured papers, black, white, red, green, yellow, and blue, discs of two sizes were prepared, which were then slit along a radius so as to admit of being slipped one over the other. Any five out of the six being taken, a match or colour