

SIR BARTLE FRERE and suite arrived at Zanzibar Jan 12.

NORTH Africa is at present overrun by exploring expeditions. The latest news from Sir Samuel Baker is contained in a telegram dated Khartoum, Nov. 7, 1872. According to this he left Gondokoro in 1871 for Kimrasi, but from the hostility of the natives was compelled to return some distance. In consequence of the prolonged absence of Sir Samuel, we learn from *Ocean Highways*, the Viceroy of Egypt decided upon sending a relief expedition of sixty-five men under the command of Colonel Purdy, an American officer in the Egyptian service. The plan is to start from Mombas and to make a journey to the supposed position of Baker, above Gondokoro. If the expedition is successful, very important geographical results may be expected from the route to be taken by Colonel Purdy, which will lead him across the Victoria Nyanza region.

Ocean Highways for February contains the first part of an article by Dr. Beke, entitled, "Position of the Sources of the Nile," his object being to show the influence which Ptolemy's determination of these sources has had on later geographers, down even to Livingstone, who adheres essentially to Ptolemy's opinion. The almost unanimous conclusion, however, come to by geographers of the present day, Dr. Beke tells us, is that the rivers described by Livingstone are tributaries of the Congo, and that the numerous sources described by him as the great water-parting of Southern Africa, are those of that river, and not of the Nile.

COMANDATORE NEGRI is making satisfactory progress in his endeavour to enlist Italian public opinion in favour of an Italian Arctic expedition.

THE first number of *Kosmos*, an Italian geographical bi-monthly journal, edited by Guido Cora, has just appeared.

IN NATURE for Jan. 23, we noted the supposed discovery of a great Arctic Continent by M. Pavy. The story appeared many weeks ago in the *Scotsman*, which took it from "the American papers." We, however, took no "note" of it till a similar account appeared in the *Times* a week or two ago, when we noted it with some expressed distrust. According to *Ocean Highways*, the story, as we feared, turns out to be, in all likelihood, a hoax. The French Geographical Society have received no such report as the American papers say has been transmitted to them. Far from M. Pavy having reached Wrangell Land, there are now doubts whether the expedition will start at all.

WE learn from the *Athenaeum* that Sir John Lubbock is preparing a Bill, to be brought forward early this session, having for its object the preservation of the megalithic monuments to the United Kingdom.

WE have received the first number of the *Journal of the Women's Educational Union*, the main purpose of which is to promote the very commendable objects of that Union.

FROM pamphlets and periodicals before us we cull the following notes:—Dr. Hollis's *Astronomical Almanack* for 1873 contains a large quantity of very valuable and well-arranged information, which will be found useful to the rapidly increasing number of amateur astronomers, and to those who do not possess or who shrink from consulting the "Nautical Almanack."—The *Garden* learns that the celebrated Jardin Fleuriste of the city of Paris, which since the war has been in a ruinous condition, is at last to be entirely abolished, and the ground whereon it stood let for building purposes. A few years ago it was one of the most interesting and instructive gardens in existence.—The principal articles in the *Journal de Physique* for January are a review of the fundamental theories relative to electro-dynamics and induction, by M. A. Potter: one by M. Berthelot on Calorimetric thermometers, in which he expounds the results of his studies on the subject for a number of years past; and a

short one by M. C. Decharme, giving the results of a number of experiments to show the rate at which different liquids ascend a capillary tube.—A French newspaper, the *Monde*, contains a justly laudatory article on the Abbé Moigno's *Salles du Progrès*, which it seems are being more and more taken advantage of by the Parisian middle classes.—The "Annuaire de l'Academie Royale de Belgique," besides a mass of valuable information concerning the Academy, contains memoirs of a number of deceased Academicians, including one of the late Mr. Babbage, who was an associate of the Academy.—The *Penn Monthly* (Philadelphia) for May, July, August, and September, contains a series of articles by Mr. Edward D. Cope, on "Evolution and its consequences," in which is expounded the theory of evolution so far as it concerns animals and plants.—We have received a reprint from the *Quarterly Journal of the Geological Society* of the admirable paper "On the Evidence for the Ice-sheet in North Lancashire and adjacent parts of Yorkshire and Westmoreland," by Mr. R. H. Tiddeman, M.A., F.G.S., of the Geological Survey. It is accompanied by a well constructed map.—An address delivered before the Chemical Society of the Lehigh University, by Dr. B. Silliman, on "Deductive and Inductive Training," contains a very interesting history of the two systems from the earliest times to the present day.—A translation of Prof. Donati's oration at the inauguration of the new observatory at Florence, October 27, 1872, appears in the *Astronomical Register* for February.

ON THE COAL QUESTION*

THE North of England Institute of Mining and Mechanical Engineers was, in its origin, a society limited in its scope to the discussion of subjects belonging to the practice of mining, and especially of coal mining. At that period the working of coal and other minerals was carried on with less aid from machinery than at present, and the district in which the society is located was not so distinguished as it now is for the practice of mechanical engineering in all its branches. Hence, the society, in its growth, has gradually assumed more and more of an engineering character; and my recent election, as your president, indicates that mechanical science is no longer regarded by the members as secondary, or merely subsidiary, to the practice of mining. But we must guard against this tendency of the engineering element to outgrow the mining element of this institute. We must not forget that we are situated in the very heart of the coalfield which, more than any other, has rendered England pre-eminent as a producing nation, and that, notwithstanding the increasing magnitude and importance of the engineering works of this district, the raising of coal is still foremost amongst the industries of the North, both as regards the extent of the interests involved, and its importance to the general prosperity of the nation.

For these reasons, although I come before you as the first president of this society elected from the ranks of mechanical engineers, I shall, in this address, make coal the principal topic of my remarks, including, however, mechanical applications associated with its use or involved in its production. As I shall speak of coal in an economic as well as in a technical point of view, I cannot well avoid making some reference to its present excessive cost, because coal, like everything else, must be governed in the extent of its application by its price in the market. In addressing an institution, so largely composed as this is of colliery proprietors, it is not an agreeable task to dwell on the evil of dear coal; but our institution is not a commercial one, and I must speak of this subject, not as affecting individual interests, but as bearing upon mechanical art and national prosperity. For many years past the consumption of coal has been increasing at the rate of about 4 per cent. per annum, computed in the manner of compound interest. We are all familiar with the cumulative effects of compound rates of increase; and it is easy to see that if the consumption of coal continued to advance at this rate, we should speedily arrive at impossible quantities. Thus in 18 years our present enormous consumption would be

* Inaugural Address by Sir William Armstrong, C.B., President of the North of England Institute of Mining and Mechanical Engineers, delivered at Newcastle, February 1.

doubled; in 36 years it would be quadrupled; and in 54 years it would be eight times greater than at present. It is clear, therefore, that our consumption has been increasing at a rate which could not possibly last. If nothing else was destined to arrest it, a failure of mining labour was inevitably approaching to have that effect; but a few years would probably have yet elapsed before the number of hands became inadequate to meet the required demand, had not the miners precipitated the event by restricting the hours of work. The hours of mining labour in this district 25 years ago were 9 per day. At a subsequent date they were reduced to 8, then to 7, and finally to 6. Hitherto, the men have worked 11 days a fortnight, but it seems doubtful whether more than 10 can now be worked consistently with the very proper limitations of the recent Coal Mines' Act, in regard to the labour of the boys. The full hours per fortnight will, therefore, at the most, be 60, or 33 hours per week of labour at the face of the coal; but as it is only the steadiest men that work full time, the average time will, of course, be considerably below that limit.

I am not aware to what extent reduction of time has been carried in other parts of England; but we hear of the same policy of restriction, either of time or output, or of both, being put in practice in all the important coal districts. I do not suppose that the average output, per man, has fallen off proportionately to the reduction of hours. The men work hard, even harder than formerly, while at their post, but it is impossible that so great a reduction of working time can have taken place without so lessening the output, per head, as to neutralise in a great degree the increase of production due to the numerical growth of the mining population. Under these two conditions of increasing consumption and restricted labour, we have reached a point at which the demand has overtaken the supply. As yet, the deficiency cannot be great, for it has only very recently become apparent. Consumption does not advance by jumps; and we may assume that if a progressive increase of four or five per cent. per annum could have been maintained in the production of coal, a balance would still have existed between supply and demand. Though production has ceased to keep up with demand, it has not, so far as we can judge, actually receded, and it would therefore appear that a small addition to the present supply would restore the equilibrium. But small as the deficiency must be, it is sufficient to create a sense of scarcity, and as a consequence, to send up coals to a famine pitch.

The situation is a grave one, and the public has not yet fully realised how very grave it is. Taking the present consumption at 110 millions of tons (exclusive of exportation) and estimating the extra price to consumers at 8s. a ton over all, the annual loss to the community from the additional cost of fuel, amounts to 44 millions sterling. Had a Government tax of 44 millions been levied upon coal, in addition to existing taxation, the effect would have been regarded as utterly ruinous, not only in regard to its prodigious amount, but on account of its repressive effect upon every kind of production. Yet it is a fact that we are now paying the equivalent of such a tax, with this unfavourable difference, that the money does not go into the coffers of the nation. Whether it chiefly goes to coal-owners or coal-miners is a question which I need not discuss, but I may observe that the restrictive action of the men has benefitted their employers as well as themselves, and that the public are the only sufferers. Coal-owners have long been aware that limitation of quantity was the only effectual mode of raising price, but they have never been able, by their own action, to maintain a restricted production. At last their workmen have done it for them, and we see the result.

Whether the trade of the country will bear up against the heavy burden of dear coal, combined as it is with dearness of other products, arising from similar causes in other industries, is a question on which I shall not attempt to prophesy. It will be more to the purpose to consider what can be done to mitigate the evils under which the nation is now labouring in regard to the price of coal. It is vain to appeal for relief either to coal-owners or coal-workers. Self-interest is the ruling principle of trade, and it is visionary to expect that men will sell either labour or the produce of labour for less than the market price. However generous a man may be, he will not exhibit his generosity by selling an article below its value. Speaking then, as one of the public and not as a coal-owner, I say, we must strive to economise the use of coal; speaking as president of an institution of mining and mechanical engineers, I say, we must endeavour to make up for the deficiency of

human labour by a more extended use of machine labour. The waste of coal, both in domestic and manufacturing use is a threadbare subject, but there never was a time when its consideration was of so much importance as at present. The small deficiency of supply which is now so violently stimulating the market would be just as effectually expunged by economising consumption as by increasing production. If, on the one hand, the mining population could easily, by a few hours' addition to their weekly labour, restore the equilibrium between supply and demand, so on the other hand consumers taken as a body, could do the same thing, by discontinuing in a small degree those reckless habits of wasting coal to which they obstinately adhere.

The consumption of coal takes place under three great divisions, each absorbing about one-third of the whole produce:—(1) domestic consumption; (2) steam-engine consumption; and (3) iron making and other manufacturing processes. In the first two divisions the waste is simply shameful; in the third it is not so great, but still considerable, though in some processes, and especially in the smelting of iron, economy of fuel has been so diligently pursued that there remains but little apparent scope for further saving. I shall not dwell on the waste of coal in domestic consumption, as it is scarcely a subject for engineers; but the circumstances of the times are such as to forbid my passing it unnoticed. It is impossible to conceive any system of heating a dwelling more wasteful than that of sinking the fire-place into a wall directly beneath the chimney which carries off the products of combustion. Nothing can be clearer than the advantage to be gained by merely advancing the fire-place a little into the room, and constructing it with proper heating surfaces, as in the "Gill-stove," and many other stoves acting on the same principle. There is no occasion to shut out the fire from view. Neither is there any difficulty about ventilation, since fresh air can easily be introduced from the exterior by a pipe delivering its supply against the heated plates, so as to temper the air before it enters the room. By this simple and unobjectionable departure from the conventional fire-place, the quantity of coal required to produce a given heating effect might easily be reduced to one-half, and still greater economy would be effected by the use of hot-water apparatus, which, however, has the objection of being too costly in first outlay to admit of very general application. For cooking purposes also, the consumption of coal is in most houses equally extravagant, and I may add, equally inexcusable, since the means of prevention are attainable by the adoption of known methods and appliances for concentrating the heat upon the work to be done.

A more appropriate subject for the consideration of this institution is the wasteful employment of coal for steam power. The steam engine is, at best, a very imperfect machine for utilising the mechanical power of heat, for in no case do we realise more than about one-tenth of the theoretical effect of the fuel. But the difference in economy between our best steam engines and our worst is enormous, and unfortunately by far the most numerous class belong to the category of the worst. In the best kind of engines, the consumption of coal per horse-power is rather less than 2 lbs., but there are thousands of steam engines in daily use which burn from 12 to 14 lbs. per horse-power. This excessive wastefulness arises from defects, both in the mode of raising the steam and in the mode of applying it. Theoretically, 1 lb. of coal is capable of evaporating 13 lbs. of water, but the conclusion arrived at on this subject by the late Royal Commission on the duration of coal was, that in practice 1 lb. of ordinary coal did not, on an average, evaporate more than 4 lbs. of water. The causes of this deficient result are perfectly understood, and, therefore, cannot be excused by ignorance. They are—insufficient boiler surface to absorb the heat, insufficient steam space to allow of a complete separation of the steam from the water, unclothed boilers, and imperfect combustion of the fuel, arising from badly constructed furnaces and from bad firing. The defects in the mode of applying the steam, or in other words, the defects which belong to the engine, in contradistinction to the boiler, are equally well known and equally remediable. The steam—to begin with—should be taken from the boiler at a much higher pressure than is usual. It should be admitted upon the piston at the full boiler pressure, and allowed to expand in the cylinder until its power is practically exhausted. The cut-off valves should be close to the end of the cylinders, as in the Coriiss arrangement, so as to leave the smallest possible amount of space between the valve and the piston when commencing its stroke. Finally, the cylinder should be steam jacketed to prevent its cooling during the

expansion of the steam, and thereby causing condensation on the next admission of steam. Nobody disputes these requirements of a good engine, and yet how few engines there are in which these conditions are fulfilled. The responsibility, however, for this waste of coal lies more with the users than with the makers of steam engines. Old-fashioned engines are retained in use partly on account of the outlay involved in replacing them, and partly from a dread of novelties and refinements requiring more care and delicacy of treatment than steam engines commonly receive. Even in replacing old engines the repugnance to any increase of first cost, and the distrust of departure from long-tried patterns, powerfully tend to a conservation of antiquated types of steam engines. As an encouragement to those who contemplate reforming their engine power, I may state what my own experience has been of the advantage of so doing. The engines and boilers originally applied at the Elswick Works, though representing a fair average of efficiency, were of the simple description then almost invariably used in factories. My firm, like others, was naturally averse to changing them on account of the expense of so doing; but about two years ago they determined to begin the renovation of all their old engines by putting down, as a first instalment, two large engines of the Corliss pattern to do the work previously performed by ten smaller engines. These two Corliss engines are now both at work. They have boilers of the best construction, and are fitted with various accompaniments favourable to economy of fuel, including Jukes' arrangement of mechanical firing. One of these engines uses twenty-four tons of coal per week against sixty tons used by the engines it has superseded. The other appears to be doing equally well, but I have not the necessary data for making a similar comparison. Assuming the economy effected to be the same in both cases, the aggregate saving of coal amounts to seventy-two tons per week. The number of firemen required is also much diminished, and the general result is, that, notwithstanding the enormous rise which has taken place in the price of coal, the required steam power is now obtained at a less cost than before, after allowing for interest on the capital expended.

Thus, then, the consumers of coal, as well for domestic use as for steam engines (under which two heads about two-thirds of our own consumption are comprised), have it in their power to economise their use of coal to an enormous extent, without any diminution of effect. In metallurgical and other manufacturing processes there is also room for much saving of coal; but I must not extend my observations into that division of the subject. Speaking generally of coal consumption in all its branches, there can be little doubt that without carrying economy to its extreme limits, all the effects we now realise from coal could be attained with half the quantity we use. If a reduction to that, or any approximate extent were effected, we should hear nothing more of scarcity or prohibitive prices for many years to come.

And now as to the practicability of economising human labour in coal mines by the employment of machinery. Much has already been done in applying machinery for the underground traction of coal, and a great reduction has thereby been effected both in men and horses; but the cutting of the coal is still almost exclusively performed by human labour. The service is a hard and dangerous one, and as it requires skill and experience, it is not easily taken up by untrained men. In every point of view, therefore, there is the strongest inducement to substitute mechanical appliances for manual labour in the process of cutting coal. Many attempts have been made to make a machine do the work of a man in this kind of labour, but with only imperfect success; and yet the problem does not appear, upon the face of it, to be one of very difficult solution to persons accustomed to mechanical invention, and thoroughly acquainted with the conditions under which the work has to be performed.

What is wanted, is a machine capable of cutting a groove at the base of the coal, so as to allow the superincumbent mass to be easily dislodged. The mode of cutting may be by hewing, by slotting, by sawing, or by scooping. The machine must travel along the face of the coal so as to follow up its cut. It should have a long face to work at, so as to avoid frequent stops and changes, and for this purpose the long-wall system of working must be adopted. The difficulty of supporting the roof may, in some cases, be an impediment to the adoption of the long-wall system; but I believe the cases would be few in which this difficulty would be insuperable.

Then, as to the power for driving the machine: that must

clearly be compressed air transmitted from a steam-engine at the surface, as is now actually practised for the propulsion of all forms of these machines. Compressed air is not an economical medium for transmission of power, partly because the power expended in its preliminary condensation is not recovered by corresponding expansion in the exercise of its power, and partly because much of the force exerted in compression takes the form of heat, which is dissipated during the transmission of the air. In other respects compressed air is peculiarly adapted for conveying power into a mine, because, unlike water, it requires no provision for its removal, and actually helps to supply the necessary ventilation. This is a fair statement of the nature of the work to be done, and of the conditions under which it must be performed. Whatever difficulties there may be of a nature capable of being surmounted by mechanical skill and careful observation of the impediments to be overcome. Partial success has already been realised, and I confidently look forward to a time when, to the many services which we exact from coal as a source of motive power, we shall add the cutting of the parent material from the solid beds in which it is deposited.

But it is not alone in coal-mines that the extension of machinery is called for. The dearth of labour is being felt in every department of industry, and we have to fear on the one hand a ruinous collapse of trade, and on the other a continued rise in the price of all productions, threatening to neutralise the advantage of high wages, and impoverish persons dependent on fixed incomes. The only hope that I see of escaping one or other of these alternatives is by increasing the use of machinery and diminishing the direct employment of men. It is in the interest of working men, as well as of all other classes, that we should throw the burden of our wants as much as possible upon inanimate power; and it is a high function of mechanical science to relieve man from that description of labour which consists in the exertion of mere animal force, and leaves him more free for the exercise of skill which is beyond the province of machinery.

One of the worst effects of dear coal is that it involves dear iron. Coal may be economised, but iron cannot, without positive loss. Production of every kind, as also steam navigation and railway transport, are essentially dependent upon the use of iron as well as of coal. Hence, dear iron, like dear coal, is a burden, both on manufacture and on commerce, and its dearth diffuses itself over every article which we derive either from foreign trade, or from home manufacture. But although the present high price of iron is chiefly due to the scarcity of coal, it is not wholly so. The dearth of labour employed in its production is also telling seriously upon its cost, and the importance of substituting some system of mechanical puddling for the present laborious process is daily becoming more apparent. Many inventions for attaining this object have been tried, but no substantial success was realised, until Mr. Danks produced his rotating furnace in America. If Mr. Danks' success be confirmed by continued trials, he will have conferred an immense benefit, both upon the makers and the consumers of iron. Unhappily for him, the general ideas embraced in his apparatus appear to have been suggested before, and although he has the great merit of having shown how the previous ideas on the subject can be rendered available, the patent laws do not afford him that protection which they so lavishly bestow upon others who have accomplished no practical result. Under an equitable and discriminative system of patents, Mr. Danks would have obtained a monopoly as due to the importance of his invention, notwithstanding the abortive attempts of others to reduce the same ideas to successful practice. It is to be hoped that advantage will not be taken of Mr. Danks' unprotected position to deprive him of an adequate reward.

Having spoke of steam engines in reference to the great defects of those in most general use, it is only fair that I should acknowledge the great improvements which are exhibited by nearly all classes of those engines in their most modern forms. Mr. Bramwell, in his recent presidential address to the Mechanical Section of the British Association at Brighton, points out with justice how much has recently been done to improve the efficiency of marine, locomotive, and agricultural engines, and urges the importance of carrying out to a still greater extent the application of those principles which have already been productive of so much advantage. To this recommendation I may add that we must not neglect to follow up any new line of improvement which the progress of discovery may present to us.

(To be continued.)