RESULTS ON ORE HIGH IN ZINC.

The results on a small lot of ore selected for high zinc-contents may be of interest. The assay and analysis of the ore are calculated from contents and analysis of concentrates and tailings, weight of ore, and concentrates and contents of bullion.

Ore.—Assay-value of ore, 1.393 ounces of gold per ton. Analysis, Pb, 2.90; SiO_2, 59.0; Fe, 8.8; Zn, 9.7 per cent.

Amalgama ion.—The ore yielded by amalgamation 0.9 ounce fine gold per ton.

Concentrates.—One ton of concentrates was made to 3.8 tons of ore. Assay and analysis of concentrates: Gold, 1.54 ounces; Pb, 7.4; SiO_2, 9.8; Fe, 21.6; Zn, 19 per cent.

Tailings.—Assay and analysis of tailings: Gold, 0.12 ounce; Pb, 1.3; SiO_2, 76.6; Fe, 4.3; Zn, 6.5 per cent.

From the above data the following calculation is made:

—	Contained in Bullion.	Contained in Concentrates.	Contained in Tailings.
	Per cent.	Per cent.	Per cent.
Gold	64.5	29.1	6.4
Lead	....	67.	33.
Zinc	....	51.	49.
Iron	....	64.2	35.8
Silica	....	4.4	95.6

Distribution of Power in Collieries.

—

By LLEWELYN B. ATKINSON, A.M.I.C.E.*

—

The present position of the coal mining industry in the United Kingdom is one deserving of the most thoughtful consideration by all who are interested in the future commerce of the country, and the object of the present paper is to point out how some of the difficulties under which this industry at present labors may possibly be met. The difficulty to be contended with at present may be briefly stated. The possible output, indeed the output at which a reasonable profit can be earned, is greater than the demand at present prices; and even this demand is threatened by the decreasing price of foreign coal. From whatever point of view it is looked at, the question resolves itself into stimulating demand, and this can only be effectually done by lowering the selling price, which cannot at present be done without extinguishing the profit.

To decrease the cost at the collieries there are broadly three courses:—

(1) To decrease the payment per ton to the mineral owner.

(2) To decrease the wages cost per ton raised.

(3) To decrease the fuel expenditure per ton raised.

The first of these is a matter outside the scope of this paper, the second will be briefly touched upon, and the third will be dealt with in some detail.

In the course of the last eight or nine years the author has been in close contact with mining operations in various parts of England and Wales, and the opinion has gradually been forced upon him that there is a very large margin of economy in wages and fuel to be effected. This arises from the fact that economies in labor and fuel which are studied and insisted on in engineering and manufacturing industries are hardly considered in coal mining, at all events in the majorfty of instances. This broad fact mnst appeal to every mind that, whereas in almost every manufacturing process or industrial operation the product per man has nearly doubled and the consumption of fuel been halved within the last fifteen years; in coal mining the product per man has been practically stationary, and the cost of fuel per ton raised probably nearly so. This is frequently attributed to the stringency of mining legislation, but legislation has largely affected other industries also, and the results cannot be altgether attributed to this cause.

It would be a long task to enumerate the causes which, in the author's opinion, contribute to this result; but, broadly, it appears to him that what is required, is to do in mining what has been done in every other department of industry, and to lower the cost of wages and material per ton by increasing the product per man and per pound of fuel by the following means:—

(1) Improved organization, both in the working, and more especially in the original laying out of the scheme of working a colliery.

(2) More superintendence and supervision underground by thoroughly well informed mining and mechanical engineers.

(3) The greater use of mechanical power instead of human and horse labor, and a more economical production of that power.

In short, substitute brains and mechanical power for human labor.

It has been already stated that the immediate object of this paper is to deal with the question of the economical production of power, but a few remarks on the subject of mechanical power in collieries may be useful.

The getting of coal resolves itself into cutting and filling and hauling to the pit bottom.

In the great majority of collieries both cutting and filling are done without using any mechanical power whatever, and the progress made in introducing mechanical coal cutters is slow, at all events in this country. A considerable experience extending over some years with coal cutting machines in various collieries and various parts of the country justifies the author in saying that there are hardly any seams under 3 ft. 6 in. in thickness that could not be more cheaply worked by mechanical coal cutters than by hand labor, and with a better product of round coal, but that in probably not 5 per cent. of the collieries of the country is the existing organization of the filling and haulage sufficiently good to enable machines to be worked with that regularity which will make them pay.

This is the secret of the otherwise unexplained fact that some few collieries have been and are worked by machinery with marked success, whilst the reverse holds good of the majority of cases in which it has been tried. Organization and superintendence, those are the only secrets of success in cutting coal by machinery; till they are forthcoming, mechanical assistance in this direction must be postponed.

In thin seams much might no doubt be done to apply mechanical power to reduce labor and breakage in filling the coal, but the same remark applies as to coal cutting.

The use of machinery in the coal face would so much reduce the length of face under work for a given output that the roads on to the face being less in total length, could without increased cost be kept in a condition enabling mechanical haulage to be used right up to the face, doing away with horses and ponies altogether. There are some of the directions in which mechanical power may be looked for to profitably enable the output per man to be increased. But before this can be done much will have to be done to improve the general organization both above and below ground. And this may well be commenced by the economical laying out and conduct of the arrangements for the generation of power above ground.

Consider the conditions under which this is at present carried out.

Generally speaking, when sinking operations are completed, a winding engine is put down. Subsequently as the workings extend, haulage is considered, and some plant, either steam, compressed air, or electrical, is provided for this. Later, perhaps, pumping becomes necessary, and again a plant (perhaps on another system) is put in. There are various engines at the surface for the screening, repairing-shop and other purposes. All these are of uneconomical types; so there ensues, at every point, waste of heat, waste of steam, particularly when, as in some cases, separate boilers are put down for each plant. And the answer to any criticism generally takes the form: "Oh, fuel is so cheap at a colliery that it does not matter." Why is the fuel so cheap, that is, of such low value? Because it is so small—smashed in hewing, smashed in filling, smashed on the screens, due to imperfect methods and appliances at every point. But, at any rate, it is worth at least 2s. 6d. per ton, and it is generally estimated that from 5 per cent. up to even 10 per cent. of the total output by weight of the collieries is consumed at the surface, and this means, even taking the lower figure, about 9½ million tons, worth about £1,190,000 per annum.

It has been stated by Mr. Foster Brown,* that the probable consumption of coal in colliery engines, taking an average, would be not less than 6 lbs. per h. p. hour. Taking this to refer to indicated horse-power, it is possible to produce the same power with 1½ lbs. of coal, or even less, hence it may be fairly said that there is a possible saving to be effected of 75 per cent., worth annually nearly £900,000. It would probably be well within the mark to say that the saving to be effected in labor of handling and in the maintenance of boilers and appliances for consuming this, would be worth, in addition, say 65 per cent. of the above sum, showing a possible economy of, say 1½ millions sterling per annum, a sum equal to over 2 per cent. on the total value of the coal raised, or about 3¾ per cent. of the whole wages annually paid in the mining industries; and if the coal were raised unbroken, so that its value was equal to the average value of the coal sold, these figures would rise to 3 per cent. of the value of the total coal raised, or 6 per cent of the wages paid.

It may be stated at once that to realize these economies the power required must be produced by compound or triple expansion condensing engines, appliances almost unknown in colliery work, and to do this there is no doubt that the whole power required at the colliery must be produced in one or, at most, two engines, and distributed with as little loss as possible to the points where power is required. There are various methods of distributing power, but some of them are only applicable to particular cases, or in particular circumstances; the only two of general applicability are compressed air and electricity.

Of these, whilst under favorable circumstances compressed air can be made to give a favorable efficiency, its application in mining is discounted by two important considerations of economy. To utilize compressed air with efficiency—(1) The pipes must be free from leakage, (2) the air must be heated before being used. These two conditions are practically unrealizable, and hence the efficiency of air transmission in collieries is and must necessarily be low. The cost of plant and extended air mains is also high.

The advantage, therefore, in point of view of first cost and efficiency as a means of distributing power rests with electricity, the economy of the cables compared with air mains, and the facility for extension and alterations to the position of the machinery make electricity an ideal means of distributing power.

There is, however, a question to which I must refer—viz., that of safety. This question of safety is one which has, from the first introduction of electricity in mining, been prominently before engineers; though it may be noted that among those who have had practical experience of its use in mines the objection is rarely raised. In a paper read in 1891 before the Institution of Civil Engineers by the author, in conjunction with Mr. C. A. Atkinson, this question was somewhat fully dealt with, and certain conclusions were arrived at which time and experience have gone to confirm, but, as this question is to some minds still an open one, and as additional experience has added to the knowledge of the subject, it may be well to deal with it again at some length.

There are two distinct questions:

(1) The safety of an electric motor, which may spark at the commutator.

(2) The safety of a system of cables, which may be ruptured while carrying an electric current.

Dealing with the first of these, it has been shown from theoretical considerations and by practical test that the amount of sparking which exists with electric motors of good construction is unable to ignite firedamp, owing to the fact that the temperature is never sufficiently high, and it is only therefore in exceptionally abnormal circumstances, such as a brush falling out of its holder or becoming displaced absolutely on the commutator, that the inflammation of firedamp can be effected; and it has also been shown conclusively by experiment that there are in the market methods of enclosing either the whole machine or the armature and commutator, or the commutator alone, which, even under these abnormal circumstances, entirely prevent either the access of firedamp or the ignition of firedamp outside the machine.

Practical experience is in accord with the experiment and with the principle named, and the author knows of no recorded instance where there has been an accident from the use of an electric motor in a coal mine. In connection with this, reference may be made to the question of commutatorless motors worked by multiphase alternate currents. As the principles on which these motors work are little understood, the author has appended to this paper some notes on the subject; but a few points are especially worthy of consideration. The first is that although such a motor may have no commutator, if it has to be regulated as to speed, or to start with the load on, it must have brushes and current collecting rings, in which case the displacement of the brushes under abnormal circumstances may have in a modified proportion the same result as in an ordinary motor. Another circumstance in connection with such motors as at present constructed is that the maximum turning moment they will give has a limiting value, beyond which it decreases as the load increases, even although the current increases, and that at any other than the normal speed the efficiency rapidly falls. Curves are given (Plate 21) showing the maximum turning moments given at different speeds, and the efficiencies are shown. For comparison similar curves are given (Plate 20) for a motor in which the speed is controlled by varying the strength of the magnetic field, using continuous current. A further point is that with such motors the losses in the cables and the dynamos, which with continuous currents are proportional to the power transmitted, are not proportional in the case of alternate currents, whilst in addition, as 250 volts alternating will give the same shock as 500 volts continuous, which is generally treated as the maximum advisable in a colliery, the cables have to be of about twice the area of section for the same power; hence these various considerations contribute to this, that the advantage of such motors at full load and full speed are to be balanced against their disadvan-

*Paper read before the South Wales Institute of Engineers

* See Address, British Association, Mechanical Science Section, 1891.