

process on testing afterwards was found unsuccessful in practice.

Romily found that on allowing illuminating gas to bubble through ammonia and afterwards igniting and allowing the flame to impinge on the surface of a drum revolving in a solution of KHO , KCN was produced. Still later we have the experiments of Readman, detailed already in the last October number of this Society's Journal.

Early in 1843 a patent was taken out by Laming for the production of cyanides by passing ammonia over red-hot charcoal. In 1860 Lucas patented a process for impregnating charcoal with K_2CO_3 , introducing the mixture into two vertical retorts which were strongly heated, ammonia was now passed in, when the potash was converted into cyanide. If prussiate was wanted iron filings were added to the mixture of K_2CO_3 and charcoal. This process was, I believe, worked on a considerable scale, but proved a failure.

Webster impregnates wood with K_2CO_3 , then chars the same in retorts and passes in NH_3 for the preparation of cyanides.

CLASS 3.

Under this head numerous processes have been patented, following very much on the same lines, but so far as I know none have been worked on a manufacturing scale. I select two or three from the number. Chisholm passes the products of combustion through heated retorts containing carbon, steam being at the same time injected. He says that the nascent hydrogen combines with the nitrogen to form ammonia, but if the combination is not complete the gases as they leave the retort are submitted to an electric discharge which is said to be of great service.

Müller prepares hydrogen by leading steam over heated carbon, and stores it in a gasometer. Nitrogen is likewise prepared by passing air over carbon, absorbing the CO_2 produced, and storing the nitrogen. The gases, in proportion 3 vols. H 1 vol. N, are now passed through a tube, being at the same time subjected to an electric discharge when, he says, ammonia is formed.

Young submits H_2 and N_2 to action of electric discharge in presence of aqueous vapour; he claims this as a decided advantage.

CLASS 4.

Under this head we have a large number of different ideas brought out. Solvay proposes to impregnate fuel with calcium chloride and mix it with limestone or other base. The mixture is then charged into a cupola, steam and air being admitted through the incandescant fuel. Chloride of ammonium is now formed and condensed. It is claimed that by the use of a decomposable chloride the limits of temperature for the successful carrying out of the reaction are not so narrow as when alkalis carbon is used in the ordinary way.

Bassett produces boron nitride by heating a borate with charcoal and alkaline carbonate, the reduction of the latter salt to metal bringing about the formation of amorphous boron, which in an atmosphere of nitrogen forms boron nitride. This compound is then decomposed by heating in presence of aqueous vapour and the ammonia absorbed in the usual way.

Duffrene passes air or nitrogen over charcoal which has been soaked in platonic chloride and heated to produce finely divided platinum. Hydrogen is passed over the prepared charcoal under pressure, when ammonia is said to be formed.

Twinech states that he gets nitrogen into nascent state by depriving air of its oxygen with nitric oxide. This nitrogen is then brought into contact with nascent hydrogen made by passing steam over a metal or by action of zinc on an alkaline hydrate, when NH_3 is formed. There are very many others, but as they are for the most part comprehended under those already mentioned it is of little use detailing them.

Future of the Process.—In conclusion it will be advisable to consider whether or not there is any hope of the process in the future, and, if asked, I should answer in the affirmative. As previously mentioned, Mond takes a hopeful view of the process in which barium oxide is used as the

base. Taking present prices as a basis I should say there is a very much better chance for success if cyanide or ferrocyanide are the products aimed at, as shown by following figures:—

1 ton of N_2 will produce	4.7 tons (NH_4) $_2\text{SO}_4$ at 12l. per ton =	56l.
1 " N_2 " " "	5.0 " $\text{K}_2\text{Fe}(\text{CN})_6$ " 62l. " =	315l.
1 " N_2 " " "	4.6 " KCN " 162l. " =	745l.

You will see that the N_2 converted into KCN has 15 times, and if into ferrocyanide, nearly six times the value that it has if turned into sulphate of ammonia, and as new sources of application for KCN have lately arisen, and thereby increased the demand in a very marked degree, it seems as if attention should be more specially directed to this article. It seems strange converting K_2O or BaO into cyanide for the production of NH_3 when cyanide commanding such a high price has to be decomposed into ammonia, an article of comparatively little value. As to which base is the best for the preparation of cyanides, opinion is divided generally between K_2O and BaO ; of course it depends very much on whether ammonia, KCN , or prussiate is to be the ultimate product. If KCN , taking into account the various results, one would fix on K_2O as if BaO were used. BaCN would require to be reconverted into KCN , which, however, would be easily accomplished by adding K_2SO_4 . If ammonia was desired, taking into account the statement by Mond, one would declare for BaO as, owing to its relative infusibility and non-volatility, it is specially suited to regeneration. I think, however, we should not overlook the claims of ammonia as a base, as it possesses important advantages over the others. If it is a fact that NH_4CN can be easily produced by passing NH_3 over heated charcoal, as has been stated by several chemists, it seems to be of great importance, because we have here a base which has no action on the retort, and as neither it nor the NH_4CN , seeing they are both volatile, are retained by the charcoal no lixiviation would be required. As regards the conversion of the NH_4CN into KCN this could be accomplished by passing the former as it issued from the retort through a hot concentrated solution of KHO , whereby the NH_3 would be set free, and could be returned to the retort to be again converted into cyanide. One great point in having a volatile base is, that as the products of the reaction are formed they are removed out of the sphere of action, and so the reaction is allowed to go on without interruption. Pressure, if it could be applied, would no doubt help this process to a satisfactory conclusion.

It seems to be a question of apparatus more than a modification of any of the processes named which will help to solve the problem, and it seems as if fireclay retorts of not too large dimensions, heated very strongly, would be required, and the nitrogen will have to be almost free from other gases. Considerable attention is being devoted to the question at present, and any experience that I have gained is at the disposal of anyone interested in the matter. (See also pages 61—64.)

The discussion was postponed until March 4th.

THE SALT DEPOSITS OF KHEWRA, IN THE PUNJAB.

BY E. RODGER.

It is well known that the Indian Government derives a considerable revenue from the duty upon salt, amounting to about 6,000,000l. annually, and with a view to the correct realisation of this income, exercises a jealous supervision over all the sources for the supply of this substance. These sources of supply are various. Large quantities of salt are imported into India from this country, a considerable amount is obtained from sea-water by means of evaporation by solar heat, and similar means are used to prepare it from the waters of salt lakes, notably the Sambhar Lake, near Jeypore, in the Rajputana district, and, lastly, there are, in the north-west corner of the Punjab, the extensive deposits of rock salt which are the subject of this paper. The

deposits are situated in the Salt Range, a chain of hills which may be considered as one of the spurs of the Himalaya mountains, although hardly connected directly with them, and the mines are not very far from the battlefield of Chillianwallah. There is now a railway which runs up almost to the entrance of the mine, by means of which Khewra can be reached in about 12 hours from Lahore.

The hills referred to, which seem to be singularly barren, rise boldly and abruptly from a level alluvial plain, through which flows, at no great distance from the base of the mountains, the river Jhelum, one of the tributaries of the Indus. Khewra itself is a small village, built well up the hillside, depending entirely on the salt mines for its existence, and almost entirely inhabited by the miners and their dependents.

One mine only is being wrought at present; it is a very extensive one, called the Mayo mine, which name was bestowed on it in memory of a visit paid by Lord Mayo during his tenure of office as Governor-General.

So far as I could judge, the mine seems to be very economically worked, except as regards the small salt, to which, however, I will refer later.

The manner of working is as follows:—

On the salt being reached, which is done by driving a tunnel for a short distance horizontally into the hillside, a chamber is cut in the salt, 45 ft. deep, from front to back, of a convenient height and length (varying in the early stages with the height and width of the salt deposit). Then a wall of the solid salt, 25 ft. thick, is left standing, with only a 12-ft. gallery running through it, and another 45-ft. chamber is commenced beyond. The wall of salt is left, of course, to support the roof. The workings are carried on at various levels, for the salt runs in layers for 900 ft. above the lowest level at which it is worked, that is to say, above the level of the lowest entrance to the mine. It is arranged that the chambers in the various levels shall coincide with one another, and thus it happens that when one chamber is worked out, another is commenced directly above it, and, being worked downwards, in time the two form only one chamber, but of double the usual height, and in some cases more than two chambers are thus run into one.

Some of the chambers formed by this process are 180 ft. high and 45 ft. broad; one which I saw was so high that blue lights burned below totally failed to illuminate the upper part at all, and, to show the height, a small fire-balloon was made use of. When I say that there are upwards of 20 chambers open, several of them as large as this, besides all the galleries and small cuttings, some idea may be formed of the vast amount of salt which has been removed, and this without doing more than touching the outskirts of the deposit.

About 1,200 labourers are employed in all, and they average about eight annas a day of wages on piece work. The workers are all Mahomedans, and they have a number of curious customs, one being that they work only nine months in the year, the remaining three being spent among the higher hills in holiday making.

The salt is blasted out by means of powder and the lumps are then cleaned if need be, and are afterwards broken to a convenient size.

The tools used are few and simple. A long iron bar or "jumper" for boring the blast-hole (which the miners do by thrusting the bar with both hands, not by striking it with a hammer as we would do), a small hammer for loosening the jumper when it jams, and a scraper for clearing away the powdered salt from the hole, the small dust thus obtained being used for tamping.

A tramway runs through the principal galleries of the mine; it is worked by coolies, who are found to be more economical than mechanical haulage, and large numbers of women are employed as porters to carry the salt from the working spots to the loading stations on the tramway lines. As is usual in subterranean workings the temperature of the mine is very constant, warm in winter and cool in summer. At the time of my visit, in the month of February, the thermometer was about 86° F. inside the mine, and I am told that this temperature is hardly ever much exceeded, so that during the hot weather the officials retire into the mine for the sake of coolness while doing office work, which at other times is done above ground.

The small salt to which I referred in the beginning of the paper consists of the small splinters and fragments produced by the blasting and by the trimming the lumps: it is unsaleable they say, and is used to fill up old workings and prevent collapse. This seems at first sight to be a great waste, but if these disused chambers must be filled up, perhaps this small salt is the cheapest material at hand.

The deposit of salt runs much deeper than they work, as it is not considered advisable to work below the level of the plain; first, on account of water, and secondly, to avoid the extra labour of carrying the salt up to the outer level. The deposit is exceedingly compact and solid, exhibiting very few cavities or fissures, and the mine, therefore, lacks the picturesqueness of some of those salt deposits in which these abound. So far as I know, only one cavity of any size has been found, which, like most similar ones in other salt mines, is partially filled with brine, and has the roof covered with crystals, but it is only of small extent.

I did not see any analyses of the salt, but the superintendent of the mine informed me that the best samples contained about 99 per cent. of chloride of sodium and 1 per cent. of all impurity, including water and insoluble matter, while the worst contained about 96.4 per cent. of chloride of sodium and 3.6 per cent. of impurity, mostly insoluble matter. I may here mention that fine crystals are rare, and that when extracted the mineral is of a pale pinky red hue, when viewed in large masses, when finely ground it is as white as snow. The duty upon salt at the time of my visit was Rs. 2.8 per maund (1 maund equals 82½ lb. nearly), while the cost of the salt itself at the mine is a mere trifle. I need, therefore, hardly point out that smuggling salt would be a very profitable business, and therefore, to prevent any contraband traffic, the mine and its approaches are heedfully guarded by watchmen, and a number of means are used to prevent pilfering, &c.; but these precautions need only be alluded to in passing.

When removed from the mine, the salt is stored in a store near the railway station, to which a siding runs. The salt is packed in bags, and transported in closed trucks, the doors of which are locked, to prevent the contents being tampered with.

In conclusion, I may say that these mines have been worked for many years, how long is uncertain, but they have been a monopoly of the Indian Government since the annexation of the Punjab in 1849, and for long before that date were worked by the Sikhs.

Lastly, I wish to take this opportunity of recording my indebtedness to the courteous superintendent of the mines for the kindness with which he received me, an unexpected visitor, at an awkward time, and for the care which he took that I should be shown everything of interest.

DISCUSSION.

The CHAIRMAN said he observed from Mr. Rodger's description of the mines that the method of working them was much the same as employed at Stassfurt. He observed also that, as at Stassfurt, the salt was of a pinkish colour, and it would be interesting to know from what that colour arose. At Stassfurt it was caused by crystals of peroxide of iron, which formed beautiful objects under the microscope. It would have been a benefit if Mr. Rodgers had brought samples home with him, so that some of our more enterprising members might have had the opportunity of examining them, particularly as to the presence of bromine and potash salt.

Mr. RODGER, in reply, said he had no opportunity of ascertaining whether bromine and potash were present or not, as they could readily understand when they considered in what an out-of-the-way part of the world the mines were situated. There chemical analysis was not brought to any degree of perfection, as the salt was looked upon only as an article of food. Regarding the presence of peroxide of iron, he had no doubt but such did exist, but whether or not it was in crystals he could not say. In reply to a query as to whether the mines were situated far from the sea, he stated that Kunchee was the nearest port, which would be distant, he thought, from 800 to 1,000 miles.