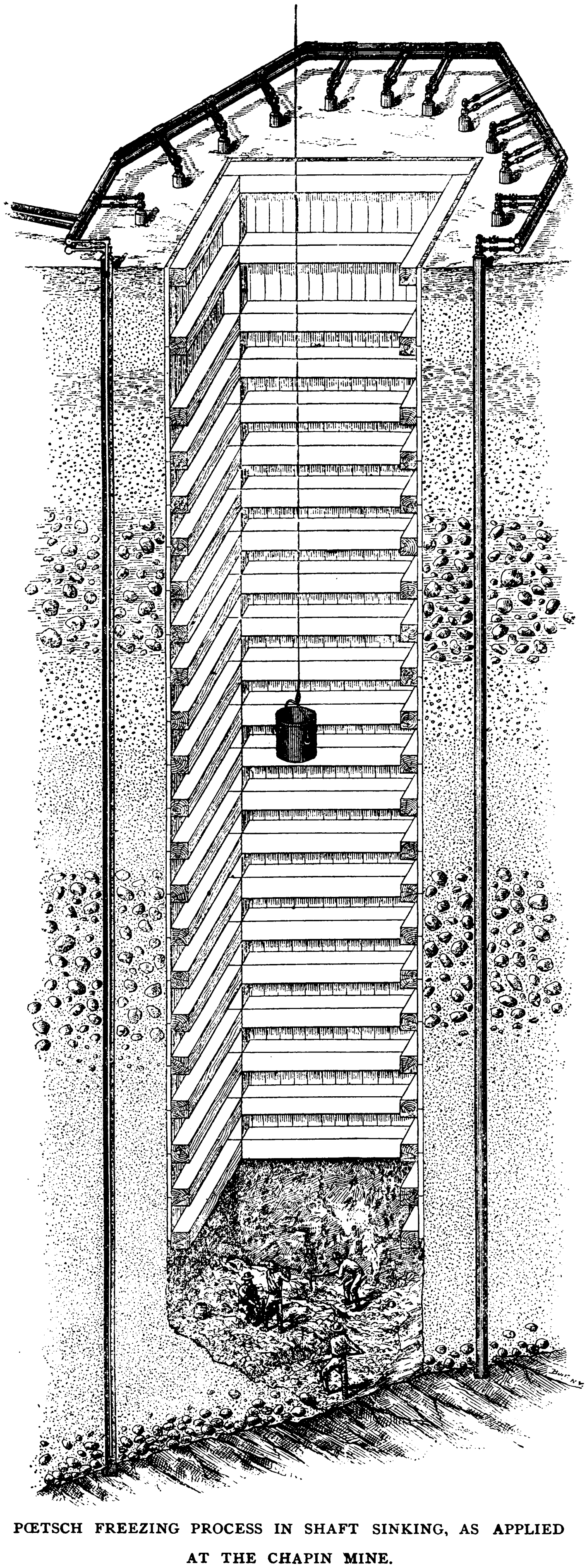

PŒTSCH FREEZING PROCESS IN SHAFT SINKING, AS APPLIED AT THE CHAPIN MINE.

ing was obtained for the timbers, and the timbering was completed from the surface of the ground to the excavated depth.

The obvious remedy for inflow from the rock will be in the future to put the pipes far enough into the ledge to freeze off the surface seams. Pipes are now being put down for a coal mining shaft at Wyoming, Pa., and they will be put several feet into the rock, which will no doubt intercept all troublesome percolation.

This operation of this process was the first application on any considerable scale in the United States. Water is the engineer's most troublesome enemy, and its conversion into a barrier of defence is a triumph of engineering as effective as it is novel. This process can be applied to excavations for bridge piers, to tunnels, and to other general work of a difficult and expensive character as well as to shafts. But in shaft work alone it should be invaluable, as by it numerous valuable deposits of coal and other minerals, now inaccessible on account of overlying strata of water-bearing materials, can be reached, as in the case of the Chapin mines, and in those Belgian coal mines which first led Mr. Poetsch to devise his process.

THE PRODUCTION OF SUGAR.

YESTERDAY the formation of sugar by plants, says Ward Coldridge, in *Knowledge*, was one of the mysteries of nature. Chemists and botanists, while they knew that ordinary chemical attractions must be the cause, were yet completely in the dark as to how these forces worked. They realized that plants started with carbonic acid and water, and from these waste products of animal existence built up in some unknown way the complex compound, sugar. From the deadly choke-damp to the luxury sugar was a great transformation. The plants could thus build, but men of science could not comprehend the process.

To-day, as the result of some brilliant researches, the explanation has been found. A simple compound, the formation of which by the plant can be readily accounted for, has been transformed into a sugar. To understand the process, it must be realized that abundant evidence proves that plants promote processes which are the opposites of combustion or oxidation. Plants liberate oxygen from its compounds, and absorb that with which it was previously combined. They can liberate oxygen from so stable a compound as carbonic acid, and in water find a source for the hydrogen which is essential to their development. The products which could thus be formed are, respectively, from carbonic acid, the lower oxide of carbon and oxygen; from water, the gases hydrogen and oxygen. Experiments have shown that under the influence of the silent electric discharge, and even without it, carbon monoxide and hydrogen combine to form a simple compound, formic aldehyde, which is immediately connected with the formic acid of the ant and of the stinging-nettle. So the changes which occur in the plant under the combined influence of sunlight and chlorophyl may be represented in symbols as follows: —

$$\underset{\text{Carbonic acid.}}{CO_2} = \underset{\text{Carbonic oxide}}{CO} + \underset{\text{Oxygen}}{O} \;;\quad \underset{\text{Water}}{H_2O} = \underset{\text{Hydrogen}}{H_2} + \underset{\text{Oxygen.}}{O}$$

$$CO + H_2 = \underset{\text{Formic aldehyde.}}{CH_2O}$$

This formic aldehyde was the substance experimented on. When it was suitably treated in the presence of the hydrate of lime, Ca $(HO)_2$, it was induced to combine with itself and to form another compound. The latter is composed of the same ultimate indivisible particles (atoms) and in the same proportions; but they are now differently arranged side by side, and with a larger number in the unit aggregation which chemists call molecules. This compound has now been finally proved to contain not one, but at least two or three members of the family of substances, carbohydrates, to which sugar belongs. Thus in our laboratories can now be imitated the process of which plants previously held the secret.

While, however, the fact is marvellous that a sugar has been obtained artificially, it must be remembered that the process is absolutely uneconomical, for the yield is very small. This remark, too, applies to another process of artificial production. The sweet viscid liquid, glycerin, and its stinking, irritating offspring, acrolein, which gives the nasty smell of burning fat, have both been transformed into sugar; but the quantity obtained is very small in proportion to the glycerin or acrolein used. The importance of these researches lies in the fact that they show how the chemical changes which characterize the vital action of the plant can be imitated with dead matter, and that, further, they shed a bright gleam of light on the hitherto obscure question of the arrangement of the indivisible particles, atoms, within the compound particles, the molecules of these substances.

Our supply of sugar will always be drawn from the vegetable kingdom, the synthetic laboratory of nature. Many plants work hard and economically at the production of sugar, and form it in quantity. It occurs in all parts of plants, — root, stem, leaves flower, fruit, and seed. In some grasses it is very abundant, in the sugar-cane, in the sorgho grass, and in the young shoots of the maize. In the common carrot and parsnip, and especially in the fleshy beet, large quantities are contained. But for its commercial extraction two sources are chiefly used — the sugar-cane and the beet-root, and a third is of growing importance, the sorgho grass.

The sugar-cane has far greater natural advantages than the beet-root. At one time the former held the field without a rival. But during the Napoleonic wars, France was deprived of her supply of sugar, and she was driven to produce her sugar at home. This resulted in the commencement of the beet-sugar industry, and thus amongst the secondary results of war must be reckoned bounty-fed sugar. To judge of the economic aspects of the two industries, many factors have to be taken into account. When that has been done, this balance will be found distinctly in favor of the cane. Sugar-canes contain sufficient sugar to yield seventy to eighty per cent of their weight of juice, in which there is some twenty per cent of sugar. Beet-roots, as an extended series of investigations have shown, possess a percentage of sugar varying from seven to a maximum of under fourteen, and on the average about eleven. Now an acre of land which can be used for beet-growing will be rented for, say, £4 per annum, while in the colonies an equal area of cane-producing land will be rented for about one-tenth of that amount.

Further, a great divergence is found in the quantity of beet and cane which two equal areas can grow. For instance, in the environs of Magdeburg, an acre will yield about ten hundred-weight of sugar; whereas, in the home of the sugar-cane, some forty to fifty hundred-weight can be obtained. Then other items in the cost of production have to be considered; the difference in wages in the two regions, the difference in the cost of fuel, — in Europe where coal is necessary, in the colonies where the waste matter of the cane supplies the whole, or nearly the whole, of the fuel required. One can thus realize the grounds on which the Brazilian commission on the sugar industry reported, that, in their opinion, "the cost of production may be reduced in Brazil to such a degree as to defy competition, and the struggle between cane and beet-root must become ominous to the latter, which thrives only by the artificial advantages which European countries have devised."

Hitherto the artificial advantages have been on the side of the European countries; but now the greatly improved means of transit, and the diffusion of knowledge, are raising the colonists to a position nearer equality in these respects, of course excluding bounties. And by this time the colonial sugar planter has learned a severe lesson. He understands that, while nature has showered her gifts on him with a lavish hand, she mercilessly punishes him for carelessness and lack of promptitude. For if he cuts his canes, they must within a few hours be crushed and extracted; if he is negligent, and leaves them for only two days, fermentation rapidly ensues under the conditions of tropical temperature, and the canes turn sour and must be thrown aside for fuel. In this way nature has fined men whole fortunes.

FATTENING LAMBS.

AT the Cornell Agricultural Experiment Station some experiments have been carried out recently on the effect of different rations on fattening lambs, under the direction of Professors J. P. Roberts and Henry H. Wing. These experiments were, in the main, a continuation of those carried on at this station one year ago, and very nearly the same foods were used, none of them being out of the reach of the general mass of farmers.

The period of feeding lasted five full months, from November 25, 1888, to April 25, 1889. The lambs, twelve in number, were selected from a lot that had been picked up in the surrounding country for shipment. They were coarse wool grades, Shropshire or Southdown, dropped late the previous spring, and had evidently been scantily fed during the summer. They were not such animals as would have been selected to give the best financial results, but being thin in flesh and fairly uniform, were well adapted to the purposes of the experiment. The twelve were closely shorn, and then divided into four lots of three each, in such a manner as to have as nearly as possible an equal weight in each lot. Three lambs were used in each lot, so that if for any reason there should be an accident to one there might be two left at the end, from which to gather data in regard to the effects of the rations.

The lots were numbered respectively III, IV, V, and VI, and each lamb was labelled with a separate numbered ear-tag, so that data in regard to increase in weight, etc., could be collected individually and by lots. The experiment progressed satisfactorily from beginning to end, with but two exceptions.

Lot III was fed what may be called a carbonaceous ration. The lambs were given all the timothy hay and whole corn they would readily eat, and in addition about a half pound of roots each per day. Turnips were fed as long as the supply lasted, after that mangels were used.

Lot IV was fed a nitrogenous ration, although it was not so excessively rich in nitrogen as that used by some experimenters in trials of this kind. The grain ration was made up of two parts wheat bran and one part cotton-seed meal. A pound per day per lamb of this mixture was fed at first; afterward it was somewhat increased or diminished, as the needs of the case required, the object being to feed about all that would be readily eaten. This lot received clover hay instead of timothy, and roots, as lot III.

Lot V was fed an intermediate ration. The grain part was composed of three parts corn and one part each of wheat bran and cotton seed meal. It was eaten in about the same quantity as lot IV. Timothy hay was used for this lot, and roots were fed as in each of the others. Lot VI was fed the same as lot V, except that they received no roots at all.

The lambs had access to water the whole time. In the winter it was warmed to about 80° before being offered them. The weight was obtained in the following manner. A pail of water was weighed and placed in the pen, where it remained till the next morning, the sheep drinking whenever they wished. Each morning the pail, with whatever water remained in it, was weighed back, the difference in weight being the amount consumed. A fresh pailful was then weighed out, and the process repeated. This was kept up during the whole course of the experiment. The water was warmed when it was first put in, and during the cold weather the lambs soon learned to take nearly all their water as soon as fresh water was given them. From the first a marked difference was seen in the amount of water consumed by the different lots, and this difference continued through the whole course of the experiment. The total amount of water drank was as follows: Lot III drank 308 pounds, or 1.03 pounds per lamb per day; lot IV drank 1,185 pounds, or 3.95 pounds per lamb per day; lot V, 735 pounds, or 2.45 per lamb per day; lot VI, 847 pounds, or 2.82 per lamb per day.

The very much larger quantity of water consumed by the lambs fed a highly nitrogenous ration is at once apparent. It will be seen that lot IV drank nearly four times as much as lot III (fed carbonaceous food), and about 60 per cent more than lot V. These three lots were all fed roots in equal kind and quantity, so that it would seem that the different amounts of water consumed must be due to the nitrogen in the ration.

Lots V and VI were fed on the same ration, except that lot VI had no roots. Probably for this reason they drank about 15 per cent more water. The lambs fed on nitrogenous food, or lot IV, made much the largest average gain, and those fed on carbonaceous food, lot III, made the smallest gain, though not very much smaller than lot VI. Animal individuality, a very perplexing consideration in all work of this kind, showed its influence very strongly.

Notwithstanding the gain in live weight was very markedly in