

third is to be coked. With this amount at least 17,000 horse-power is generated in gas engines, while only 10,000 is used in the collieries. The surplus energy is sent in form of electric current at 10,000 to 20,000 volts, to the city of Krefeld and its new Rhein harbor, where it is transformed and sold at 1.9 and 1.7 cents per kilowatt-hour respectively.

Another and very promising way of disposing of the surplus energy is to utilize it for driving electric railways through the commercial distribution sphere. This proposition is interesting, both commercially and technically, and will be made the subject of a separate article. The employment of cheap gas power is destined to become a promoting factor of great weight in the electrification, also, of long-distance railways.

If one keeps in mind the facts that the application of gas power in the iron and coal industries from the blast furnace and coke oven, disregarding entirely the utilization of culm, will generate in the neighborhood of four and a half million horse-power the year around, and, in addition to what is consumed within the works will liberate an enormous amount of surplus energy which may be supplied to neighboring districts in form of heat or light or power, and that the actual saving thereby effected in the iron industry amounts under favorable conditions to one dollar per ton of pig produced and to three or four dollars per ton of finished goods turned out, then considerations of the character developed in this article will doubtless be given more attention than they would without referring to the extreme economic importance of the problem.

MUSHROOM CULTURE IN FRANCE.*

By JACQUES BOYER.

THE tourist who for the first time visits the southern and western plains of the suburbs of Paris is sure to be puzzled by certain quadrangular wooden towers which he perceives here and there rising out of the ground, and what still more excites his curiosity are the clouds of smoke that occasionally ascend from the strange structures, which are scattered over waste grounds, cultivated fields, and gardens. These structures, however, do not serve as housings for the secret prosecution of business of a criminal or questionable nature, but are simply shafts for the ventilation of old quarries that are at present used for the cultivation of those mushrooms that are so highly prized by the gourmets of the old and new worlds. The *Agaricus campestris*, called the field-mushroom, the only species that it is possible to domesticate, grows by preference on half-decomposed horse-manure. Dr. Repin says, "Its cradle was a melon-bed." But we do not know the name of the bright gardener who took some "spawn" from one of these beds in which mushrooms had grown spontaneously, and sowed it in new manure in order to obtain a second crop. There is good reason, however, for the belief that such culture originated in France in the latter half of the eighteenth century, and that at the outset the kitchen-gardeners who engaged in it in the spring and fall considered it as a natural adjunct to their business. Then, a century ago, a horticulturist named Chambray conceived the idea of devoting the abandoned subterranean quarries to the culture, since in them are found the conditions of temperature and humidity favorable to the development of the fungus. He succeeded thus in making a handsome profit, with the consequence that he had many imitators, who have tried to lease all the excavations abandoned by the quarrymen, so that the mushroom industry soon became one of the most prosperous of the environs of Paris.

At present, the suburban mushroom exploitations are almost exclusively distributed over the left bank of the Seine, in the section comprised between Meu-

don and Ivry. The most important are situated at Montrouge, Clamart, Vanves, Chatillon, Arcueil, and Sceaux, and formerly extended to the Quartier du Val-de-Grace in Paris.

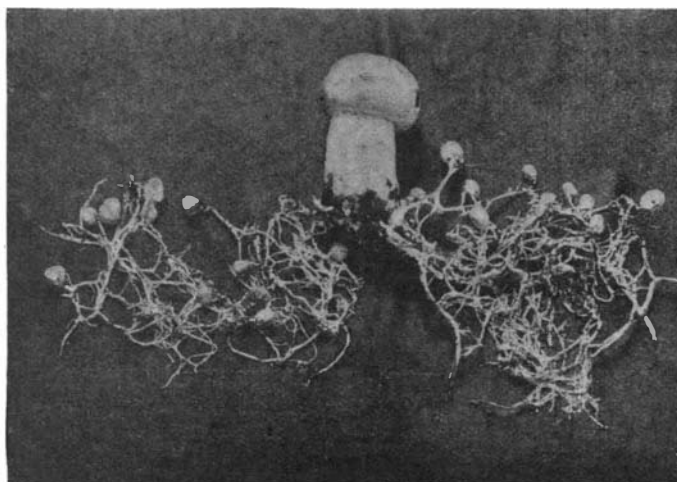
The galleries are excavated in limestone, as at Carriere-Saint-Denis; in gypsum, as at Argenteuil; or in



VENTILATING SHAFT OF A MUSHROOM CAVE.

white clay, as at Meudon; and the oldest of them (those from which the architects of the middle ages took the stone and plaster that enabled them to erect the public buildings of Paris) form a labyrinth of low and narrow chambers in which the workmen can scarcely move about without stooping.

But the more modern exploitations, of which the accompanying engraving gives a faithful picture, consist of spacious galleries, of which the roof is supported by strong pillars carved out of the rock itself.



COMMON MEADOW MUSHROOM AND ITS SPAWN.

Here the mushroom cultivator exercises his somber profession at his ease. The peg-ladder perceived in the interior of the ventilating-shaft will allow us to descend into the mysterious cave where here and there sparkle the oil or kerosene lamps that guide the cultivator.

Much preliminary work must be done to convert a quarry into a place for mushroom culture. After providing for the aeration of the galleries, a well must be dug from which to obtain the large quantity of

water necessary, and after that a supply of horse-manure must be secured, this being the only material favorable to the development of the mushroom. Moreover, the quality of the manure plays a leading part in the yield. Preference is given to the manure of heavy Percherons or other draught horses which perform a great amount of muscular labor and are supplied with highly nitrogenized food.

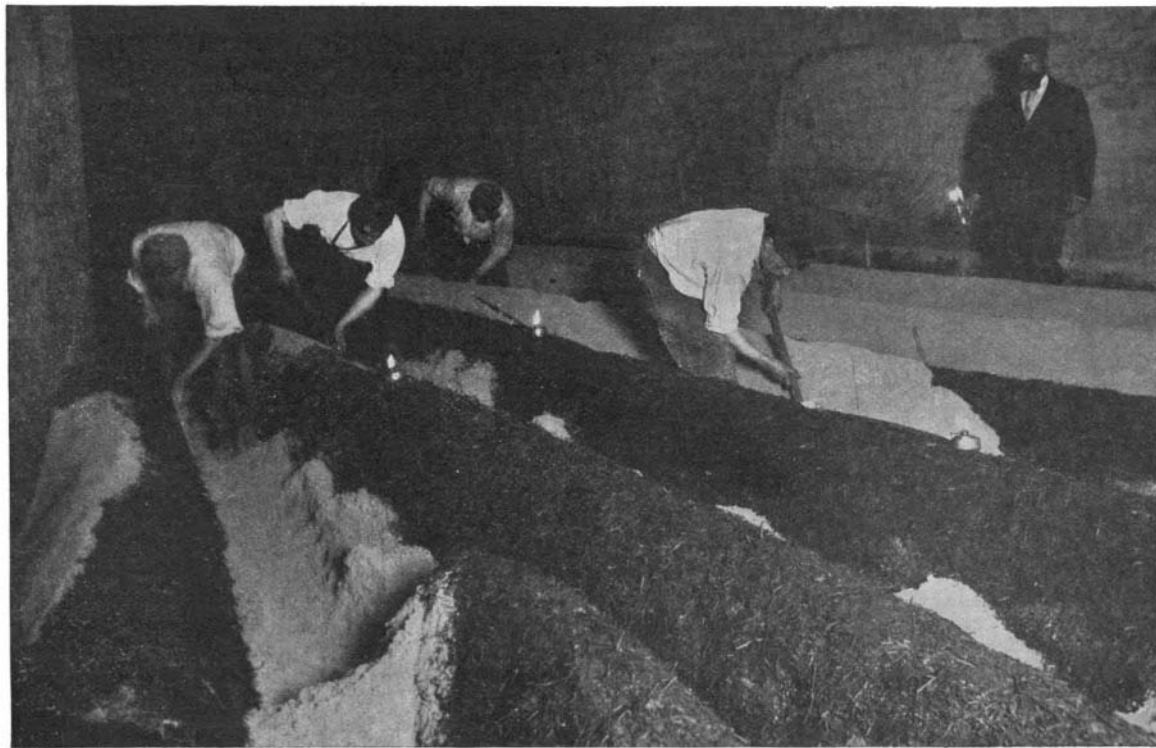
After the material has been selected, the mushroom grower submits it to the following manipulations: It is first arranged in heaps about three feet high called "flows," whose bulk sometimes reaches 3,500 cubic feet, and should be at the least 750 feet. Then the whole is submitted to the action of the air for three weeks, and is turned over from time to time in order to diminish the intensity of the fermentation. In fact, according to Dr. Repin, manure acquires nutritive properties during the course of fermentation, for it is found that if fresh manure is sterilized and sowed with spores of mushrooms beginning to germinate, the fungus never accomplishes its complete evolution in such a medium. It germinates and sends out filaments, but does not fructify. The manure, in fermenting, becomes filled with microbes, which, according to the observations of various biologists, appear to be useful to mushroom culture only through the products elaborated. Their role is confined to favoring the chemical combustion by raising the temperature at the time of establishing the heaps or "flows." However this may be, at the end of a fortnight, the manure possesses a special odor somewhat recalling that of the field mushroom itself, and is ready to be lowered to the mushroom galleries. Here the workmen arrange it in beds as regular as possible in the center of the galleries, the rocky walls of which are supported here and there by piles of rubble to prevent them from falling in. In one of the illustrations workmen are seen in the act of forming rounded beds sixteen inches in width at the base and twenty inches in height, which they carefully align side by side along the galleries, like the furrows in a field. Such dimensions and such arrangement are not arbitrary, for experience has shown that under such conditions the manure becomes

slightly heated anew and reaches a temperature of from 60 deg. F.

It is then time to begin the insertion of spawn into the beds. The vegetation of this mycelium, as botanists call it, which was suspended by dryness, always resumes its activity under the influence of humidity and heat. The fragments of spawn perform the function of slips. They throw out filaments which radiate in all directions and finally become disseminated through the bed in a length of time that varies according to the condition of the surrounding atmosphere. The copy of a photograph which was kindly sent to us by Prof. Atkinson, of the University of Ithaca, shows the ramifications of the mycelium along with the young mushrooms that have developed thereon.

The art of the mushroom grower afterward consists in rendering the local conditions propitious to the culture. The principal difficulty proceeds from the enormous quantity of oxygen which is absorbed by the respiration of the mushrooms, so that when the latter do not obtain a sufficient supply of air, they stop short in their growth. The galleries must, therefore, be strongly ventilated, the air therein be kept saturated with aqueous vapor, and variations of temperature be prevented, so delicate are the young fungi. Moreover, the mycelium, if left to itself, would not fructify well, and so the beds must undergo an operation which consists in covering the surface of the manure with a stratum of calcareous earth or sand and equalizing it with shovels. Finally, at the end of twenty-five or thirty days, during which the beds must be sprinkled, carefully inspected and freed from every bit of parasitic vegetation, the mushrooms begin to pierce the stratum that covers them. They do not, however, grow in a continuous manner. Crops separated by intervals of non-production succeed each other during three months, and the small, grayish white buttons are gathered by the grower whenever they become sufficiently rounded. With a basket under his arm, he walks along the beds and, delicately grasping the mushrooms with his fingers, quickly detaches them.

As for the varieties of mushrooms cultivated in the Parisian quarries, they differ in color, size, and weight. The three principal ones are the white, which are fine and in great demand, but do not withstand carriage very well; the light yellow, which are more



EARTHING THE MUSHROOM BEDS.
MUSHROOM CULTURE IN FRANCE.

* From American Homes and Gardens. Published by Munn & Co.

vigorous, more productive and less fragile; and the gray, which are fragrant, but acquire a dark color by age, which lowers their value in the market. Moreover, the fungi in a short time lose their character and undergo a degeneration. Consequently, growers rarely cultivate a given species for more than two or three years. They prefer to have recourse afterward to virgin spawn obtained by scientific processes that permit of selecting the mushrooms, or to reproduce the kinds deemed to be the best by direct germination of the spores.

The idea of preparing spawn through the germination of the spores occurred to various botanists a long time ago, but Messrs. Constantin and Matruchot alone succeeded a few years since in obtaining positive results. In order to obtain *Agaricus* spores, they placed a mature mushroom on a sheet of paper and then collected them a few days afterward in the form of an impalpable brown powder. In order to cause them to germinate, they had recourse to the media used in bacteriology—moist air, damp sand, or dung, for example. The spores ready for germination become distended in the first place in taking on a light color, and then throw out from one of their poles a very fine tube which enlarges and ramifies in all directions in budding. In this way there is formed a small tuft of mycelium, which, in a favorable medium—manure, for example—will extend indefinitely.

Dr. Repin applies this process industrially in the following manner: After distributing the manure in strata of equal thickness between superposed steel plates, he submits the whole to a pressure of seven hundred pounds to the square inch. On coming from the press the whole is found to be agglomerated into a plate about one-half an inch in thickness and almost as hard as wood. He then sows these plates with spores and places them under conditions most favorable for the development of the mycelium, but in such a way as to protect them from elevations of temperature to as great a degree as possible. The vegetation

essential nutrients for the human organism, including proteids, carbohydrates, fat, mineral salts, and water; it goes without saying, therefore, that it also supplies abundant food for the less discriminating lower organisms, such as the bacteria. In not a few instances, indeed, the bacteriologist resorts to bread as a culture

der it unfit for sale or consumption. They may be the result either of a lack of care in preparing the dough, or of employing inferior or unsound materials, such as adulterated flour or a poor quality of yeast.

We shall now proceed to consider the diseases of bread from the points of view just indicated, viz., (1)



SPRINKLING THE MUSHROOM BEDS.

medium for bacteria. To a great extent, however, bread is protected against these tiny foes by the hard crust in which it is incased as a result of the action of the high temperature in the baker's oven on the wet surface of the loaves. But while this crust effectively protects bread as long as it is fresh, this is not the case when bread is kept for some time in a damp place. The spores of micro-organisms are constantly floating in the air, and while the heat of baking probably destroys the great majority of those present in the

the diseases due to unsound materials; (2) diseases resulting from lack of care on the part of the baker; and (3) diseases due to bacterial infection.

1. DISEASES DUE TO THE USE OF UNSOUND MATERIALS.

By reason of its composition, as well as of its very fine state of division, flour is subject to many undesirable changes. Bacterial growths impart to it a musty odor and taste, while the decomposition of its fat contents may turn it rancid. In both cases the taste may suffer without any chemically determinable quantities of the constituents having been affected; nevertheless, the objectionable taste adheres even to the finished product. Flour should not be stored in damp and ill-ventilated places. Not only is it threatened by a flora of bacteria, molds, and yeasts, but also by a fauna of injurious insects, such as flour mites, meal worms, weevils, etc. Different varieties of flour, too, show very different keeping qualities on storage. Thus rye flour is exceedingly sensitive to various influences, while wheat flour may be preserved for a considerable length of time.

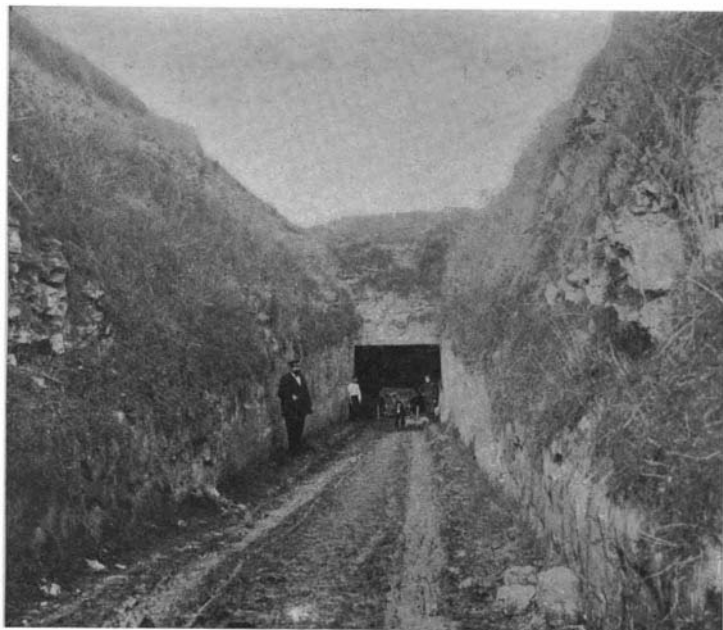
Not infrequently flour is damaged in the flouring mill. The heat produced in grinding may scorch the flour; or, if the grain is damp, the combined action of heat and moisture may cause gelatinization by the conversion of starch into dextrin.

Grain harvested in rainy weather has a tendency to sprout, and flour obtained from it yields bread whose crust shows many cracks and crevices.

The flour used for bread-making sometimes contains seeds of poisonous weeds, like the darnel (*Lolium temulentum*) and ergot of rye (*Secale cornutum*). Other seeds, such as those of *Rhinanthus* and *Melampyrum*, communicate to the bread made from flour that contains them yellowish, bluish, or reddish colorations. The machines now employed for cleaning grain are so perfect that an admixture of such foreign seeds in it is hardly to be expected. Indeed, Stohmann pronounces the contamination of flour with such seeds as criminal.

To a great extent, also, the character of a flour and of the bread made from it depend on the nature of the grain. Thus buckwheat, barley, English wheat, and corn are not well adapted for bread-making purposes, while rye and wheat yield the best results.

Another possible source of infection in bread is the yeast employed for leavening the crumb. The kind of yeast used for wheat bread is the compressed yeast manufactured in large and generally well-conducted plants; but even this product may be infected with bacteria which impart an unpleasant flavor to the bread made with its aid. High-grade compressed yeast should be made from pure-culture yeasts; it should be



THE ENTRANCE TO A PARISIAN MUSHROOM CAVE.

of the spawn is retarded, although its vigor increases when it is introduced into the warmish atmosphere of the mushroom gallery.

After the plates of manure have become entirely permeated by the mycelium, they are cut by a machine into pieces four inches square, each of which represents an insertion. The mushroom grower can therefore lay in a supply of the variety that is best adapted to his quarry, for this virgin spawn remains free from the diseases which attack mushrooms, and particularly that which is called "softening," so dreaded by Parisian growers, whom it annually costs more than a million francs. The mushrooms attacked by the cryptogam that causes the disease become atrophied and covered with a rosy down, and, at the epoch of their maturity, become deliquescent.

We shall finish by giving a few statistics designed to show the importance of this Parisian industry. There exist at present in the department of the Seine about two hundred and fifty mushroom installations owned by eighty individuals, not counting a score of other exploitations distributed through the neighboring departments. The number of workmen employed in the industry exceeds a thousand. The total value of the mushrooms annually produced in the suburbs of Paris amounts to twelve million francs, and certain tradesmen of the Halles make an exclusive specialty of their sale. Naturally the industry thereof ranks as a most important one in Paris.

THE DISEASES OF BREAD.*

Just as the living organisms of man, animals, and plants suffer various changes as the result of disease, so also many of our manufactured products are subject to undesirable changes in their character. Among our most dangerous foes in this respect are those minute living beings, known as micro-organisms, that are endowed with the power to resolve dead organic substances into simpler compounds, as, for example, in the decay of animal and vegetable materials. When such parasites invade the living organism, we speak of this condition as a disease. Bread contains all the

crumb, new ones will find their way to the crust of the loaves. If this crust has become soft by exposure to damp air, then the micro-organisms that have lodged upon it begin to sprout and the threads will thrust themselves into the soft crumb within, producing what may be called diseases of the bread. In some instances such infected bread has been known to produce symptoms of poisoning; the crumb then probably contained some alkaloidal body chemically resembling strychnine.

Among the diseases of bread we may also include such changes in its appearance or character as will ren-

FORMING THE BEDS OF MANURE.
MUSHROOM CULTURE IN FRANCE.

* Pure Products.