MALTING AND BREWING CONDUCTED ON SCIENTIFIC PRINCIPLES.—I. MALTING.

THE art of brewing is one of great antiquity. It has been decided by Egyptologists that the ancient Egyptians were familiar with the process of manufacture of a species of beer, but it is to the Germans that we must look for the greatest developers and exponents of this industry, which has attained vast proportions in this country. It is a fact that most of the brewing plants in America are now owned by Germans. In the construction, maintenance, and operation of a brewery the services of an architect, a mechanical engineer, a chemist, and a man of great expert knowledge called the "brew-master" are required. The work of the first two is occasional, but that of the two latter is perpetual, as the uniformity and the healthfulness of the product depend to a large extent upon their expert knowledge.

There is hardly an industry that is based on more scientific principles than that of brewing, where man utilizes natural products, and transforms them by means of chemical reactions into a beverage which conserves the natural nutritive qualities of the raw materials. In brief, beer is a product made from extracts of malted barley and of hops, which are boiled together, the resulting liquid being fermented and afterward carbonated.

It is our intention to describe the process of manufacture of beer as carried on in one of the largest and most scientifically conducted breweries in the world, and it is our aim to call special attention to the various points which deal with the purity of the beverage, as they are most interesting from a scientific point of view, especially when the enormous quantity of raw materials consumed and the beer produced are considered.

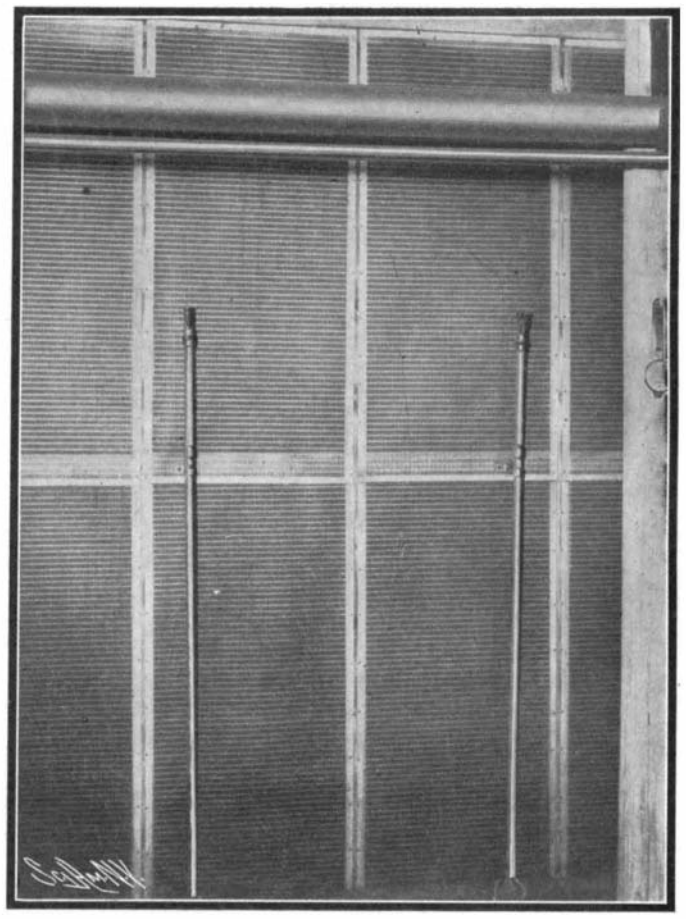
Steeping and Aerating the Grain.

As we have already said, malted barley and hops are the basis of beer. More than 1,500,000 bushels of barley are consumed annually in the Pabst Brewery at Milwaukee. The barley comes from Wisconsin, Minnesota, Iowa, Dakota, and Montana, the latter State producing the best quality of grain. The cost varies from 60 to 75 cents a bushel, so that this is a very considerable item of expense. About 1,000,000 pounds of hops are also used, and come from California, Oregon, Washington, and New York States, from Bavaria and Bohemia. The domestic hops cost about 32 cents a pound, while the imported cost from 70 to 80 cents a pound.

The hops are stored in a special building, which has a storage capacity of 1,000,000 pounds. The temperature is kept at the freezing point by cold storage; this saves the volatile constituents, and retains the flavor of the hop. The barley is stored in elevators when it arrives, and it is taken through grading machines, where all impurities, such as sand, chaff, broken kernels, wheat, oats, etc., are removed and the grain is dusted. In order not to impair the quality of the grain during the time of storing, the barley is given frequent air baths by aerating and spouting; this prevents a spontaneous heating, and serves to cool and keep the grain in such a healthy condition that all danger of deterioration is eliminated. The grains should be also uniform in size, as this will insure a uniform germination during the malting process. We have now dealt briefly with two of the raw materials which enter into the composition of beer. There is one other which is also highly important—this is water. For malting and brewing, Lake Michigan water is particularly adapted, on account of its softness. The supply is obtained from the city mains. There are ten or eleven artesian wells in various parts of the plant, which furnish water for cleansing, condensing, etc.; some of them are 2,000 feet deep. For washing yeast the water is sterilized by steam, cooled, and afterward aerated with germ-proof air. To prevent any possibility of infection, all the air which comes in contact with the wort or the beer itself is filtered by passing through three sterilized cotton filters of enormous size, each having a capacity of 4,000 cubic feet a minute. The air is piped all through the brewery for use where it comes in contact with the wort, the beer, or the yeast.

The necessity for chemical and bacteriological cleanliness will be understood when it is considered that the malt wort is highly nutritious, and affords an excellent culture ground for bacteria, for the nutritious substances which make beer of value for human consumption are seized upon with the same avidity by these minute organisms.

Malting is the process of changing the character of various constituents of the barley, so that it is made suitable for brewing. The principal constituent of barley is starch in the form of small granules of microscopic size. These starch particles are surrounded by a tight cellulosic hull. The starch should be resolved in the brewing process into malt sugar (maltose) and dextrine. This transformation can only take place if these hard walls are softened and the starch made accessible; this is what is done by the malting process.

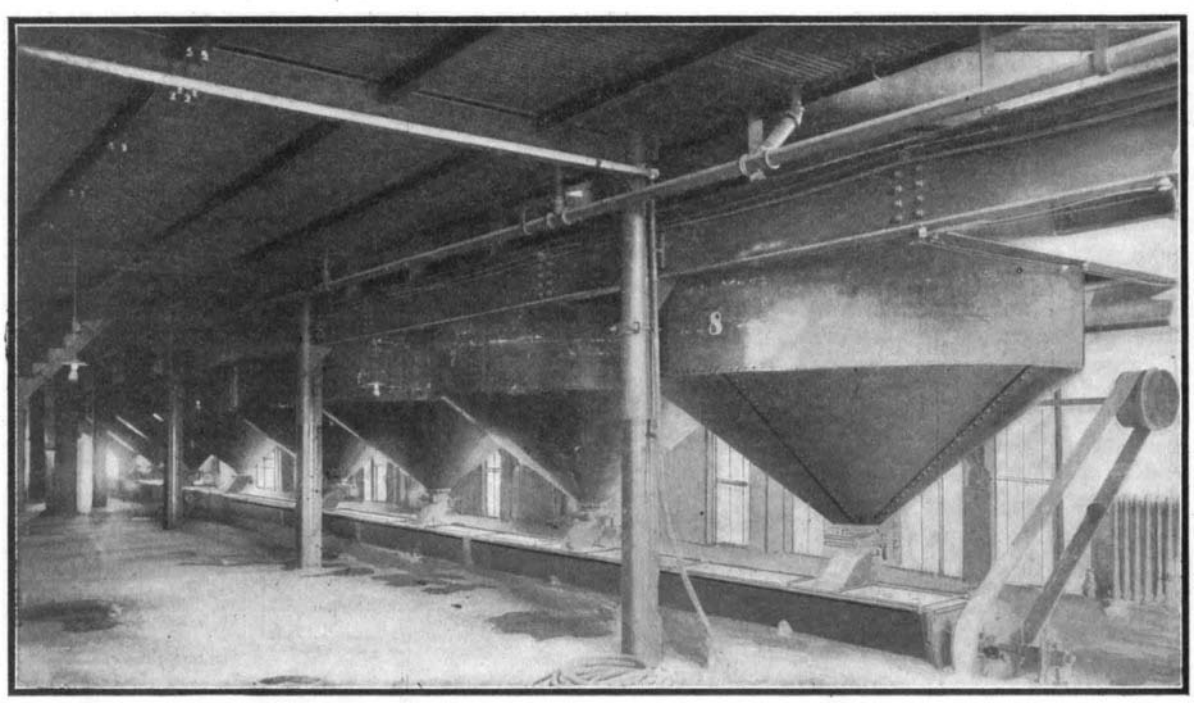


A Portion of an Air Filter, Showing Water Spray.

A recent fire at the Pabst plant occasioned the necessity of building a new malt house, and an expert was commissioned to visit the leading malt houses of Europe, with the result that the best foreign practice has been embodied in the new malt house, which is ten stories high and is built on the pneumatic, or Saladin system. The old plan was to lay the steeped barley on large cement floors, where it was manipulated manually by shoveling. This is still the prevailing system in most malt houses, and the drawbacks are obvious. There was in the old system no regularity in turning, aerating, cooling, etc., and it was necessary for the men to walk around in the wet grain, with heavy boots. The temperature of the malt was also dependent on the outside weather conditions, but in the pneumatic system you make your own weather with regard to temperature and humidity; in summer you cool the air, in winter you heat it. All of the windows are triple, to avoid the entrance of untreated air of an improper temperature and humidity, and even the entrances to the rooms are air-locked.

The barley is conveyed mechanically into large enameled steel steeping tanks, each containing 650 bushels. Water is added, and the steeping process occupies from fifty to sixty hours. During this period the kernel is gradually absorbing moisture; air is admitted from below in a finely-divided stream, for a two-fold purpose. The barley is washed, cleaned, and at the same time absorbs oxygen from the air, thus promoting the subsequent growth in the malting process.

The barley might be said to breathe while in storage, and we might almost say that the water asphyxiates the grains, but this aeration really maintains and enhances the normal functions of the grain for the malting process. After the steeping is completed, the grain is run down to compartments on the germinating floors. These compartments are 100 feet long, 11 feet wide, and 5 feet deep. The walls are lined with cement, and the floor is constructed of perforated metal, giving access to an air passage underneath the compartment. The steeped barley is laid to a depth of two feet on this perforated floor, and then allowed to sprout. This operation is accompanied by the evolution of heat, which must be regulated within narrow bounds; 60 deg. F. is the upper limit, and 48 deg. F. is the lower limit. Thermometers are used to ascertain the temperature. In order that the air may be kept normal at all times, it is introduced to the germinating floors through an attemperating room of enormous size. In this chamber are vertical zinc plates, 150 feet long and 9 feet high, and there are fourteeen series of such plates. They are perforated, to allow the air to pass through them. In front of each series there are a hundred sprays, which finely divide the water, which is thrown against the perforated plates and flows down the whole series, thereby



Bottom of Steeping Tanks, Showing Conveyors for the Wet Grain.

washing the air in its tortuous passage through the filter, removing all dirt and floating organisms. Radiators at the air inlet serve to furnish heat if required, and a refrigerating room at the other end of the attemperator serves to reduce the temperature when necessary. Two large suction-fans throwing 2,000 cubic feet a minute draw the tempered and purified air through large flues to the various germinating floors, and it is only to this air that the barley is exposed.

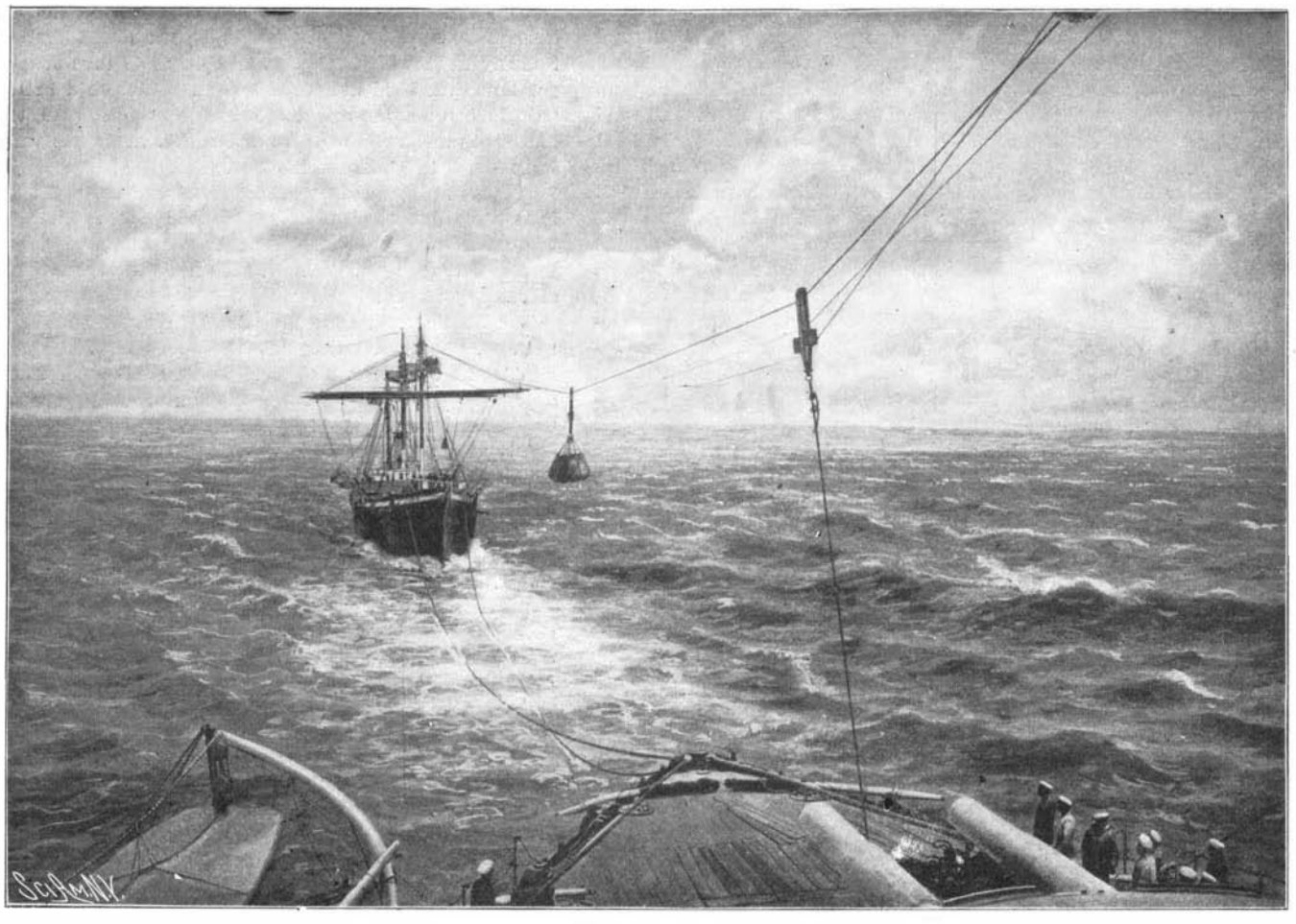
Now, if the heat of the steeping grain reaches the danger limit, a valve underneath the perforated floor is opened, and the air is drawn through the grain by means of the exhaust fans, an equitable temperature thus being maintained. The grain is turned from time to time by a mechanical turner, which, while turning the grain, travels back and forth the length of the compartments. This serves to bring to the surface a new stratum of grain. The sprouting process occupies eight days, and at the end of this time the grains have ceased to be encysted by the hard walls, and the starch can be attacked in the mashing tubs in the brew house. The operation of malting is completed by drying the sprouted barley in kilns, which are large perforated metal floors, through which heated air is drawn by large exhaust fans. The kiln consists of four floors, and the green malt is introduced on the top floor, and gradually descends from floor to floor by gravity, the dumping taking place by the operation of shutters, which constitute the floors and which can be manipulated from outside. As the grain drops from floor to floor, the heat becomes greater and greater, until the barley can be compared to a baked loaf of bread. It is as tender as a cracker, and it has a pleasant aroma. The drying takes about forty-eight hours. To insure the specific character of the malt for various beers, the kilning is conducted in two stages. The malt is then cleansed, and the sprouts removed by shaking in machines, and is stored in dust and moisture proof bins, where it is held in reserve for use in the brew house.

In a subsequent article we will treat the process of brewing.

Germany's pavilion at the World's Fair is under roof. The building is a replica of the castle at Charlottenburg. The plans were revised by Emperor William.

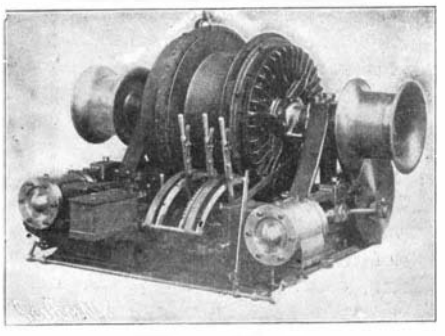
RUSSIA'S LAST HOPE ON THE SEA.

Things are in a pretty bad way with the Russian fleet in the Far East. About as bad, indeed, as they could possibly be. Unless the genius of Makaroff can devise some brilliant strategy that will render the still formidable remnant of the Czar's ships effective, it does not take the eye of an expert to foresee the inevitable catastrophe. As the result of the inexplicable carelessness or lack of forethought of Alexieff, the opening of the war found the armored fleet of Russia divided by about a thousand miles, the armored cruisers being at Vladivostock and the battleships at Port Arthur. The strength of the battleship division was reduced, as we all know, by the Japanese night attack until it was hopelessly inferior to the blockading fleet. For either the Port Arthur or Vladivostock fleet to come out and engage the enemy, would be nothing better than a forlorn hope—so greatly are they now overmatched. At the same time, the mining of the harbors makes it out of the question for the Japanese to enter. For the present the plan of the naval campaign, as far as Japan is concerned, is to maintain the blockade of the two ports so closely, that neither squadron can emerge without being forced to

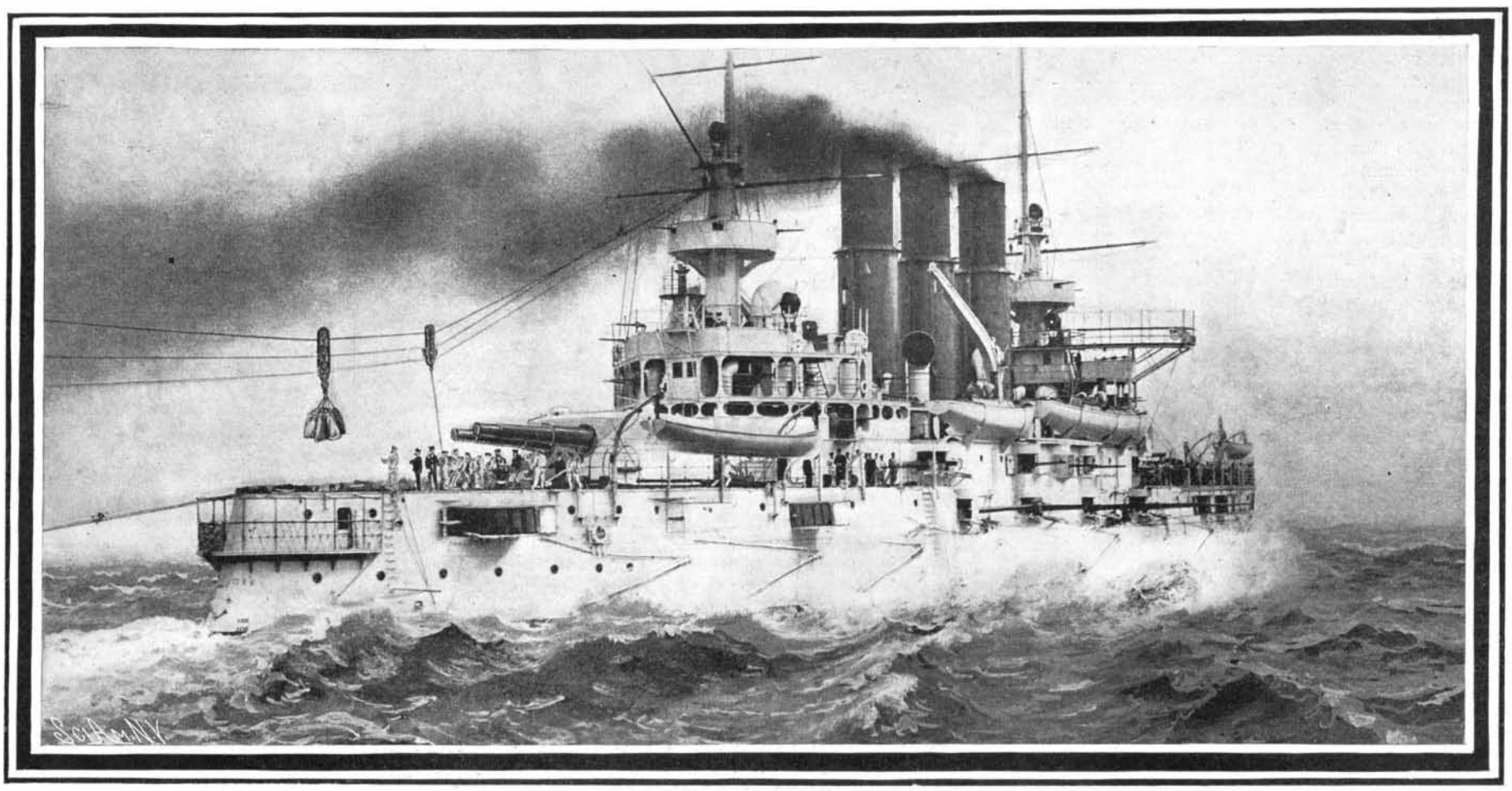


Looking Aft from a Warship Coaling from a Collier Towed Astern.

Elevating Truck Loading Bags on the Deck, Ready for Hoisting to Masthead.



Cableway Winches.



The "Retvizan" While on Her Way to the Far East Coaling from a Collier Which She is Towing Astern.

COALING WARSHIPS AT SEA.