extra strength, The visitors were also shown the testing of steel and bronze, and of the large spiral springs which are now so extensively used with the quick-firing ordnance. The cartridge factory created great interest, for there the foreign officers saw all the processes, of drawing out cartridges in operation, but what created the greatest amount of interest was a large exhibit of modern quick-firing guns.

In the English navy the largest gun that deserves the name of quick-firing is a 6 in., but Elswick has just produced a very powerful 8 in. gun which may certainly be termed quick-firing, although no cartridge case is used with it, the obturation being performed by a modified De Bange obturator. To exhibit this gun a crew of five men were in attendance, and went through the drill. Some shot had had their driving bands turned off, and thus prepared, they were placed in the gun and pushed forward into the bore each time that the operation of loading was gone through. The drill, therefore, very accurately imitated actual practice, and yet the crew were able to go through the motions of firing three rounds in the very short interval of thirty seconds, and it should be observed that the present service 8 in. gun, which is a far less powerful weapon, could not possibly fire more than one round per minute. But not only is the new 8 in. gun so rapid in firing, but it is also extremely easy to work; one man trains, elevates, and fires the gun just as if it was a small gun of 4·7 in. caliber, and he does it with perfect ease, although the gun weighs 19 tons and the total revolving weight amounts to 33 tons. Passing from the 8 in. gun, the visitors were shown a similar trial with 6 in. and 4·7 in. guns, the crew going through the motions of firing four rounds from the 6 in. gun in twenty seconds, and seven rounds from the 4·7 in. in twenty-five seconds. Practice from an aiming tube out of a 4·7 in. gun at a target completed Wednesday's programme.

The programme on Thursday, November 9, commenced with the inspection of the steel works department, where the visitors were shown forgings worked under large hydraulic presses, the biggest of which can exert a pressure of no less than 4,500 tons. In the afternoon the first thing shown was one of the new torpedo guns. A trough had been erected in one of the long shops at Elswick, and a dummy torpedo was actually fired in this trough. The special feature of the torpedo tube, which is the outcome of a long series of experiments carried out at Elswick, are that by using cordite as a propellant a high velocity of wonderful regularity is obtained, and this with an entire absence of smoke or fouling. Having completed the inspection of the remainder of the works, Elswick shipyard was reached; here the visitors were shown the powerful Chilean cruiser Blanco Encalada, which has just been finished, and which is one of the fast cruisers of which Elswick has made so great a specialty. The Japanese cruiser the Yoshino is still in English waters, and it will be remembered that this vessel attained a speed of no less than 23·1 knots, the highest speed ever reached by an ocean-going vessel. Another vessel of the same class, that is to exceed all previous ships in speed, was shown to the visitors on the building slip.

By the time the inspection of the shipyard was completed it had begun to grow dark, and advantage of this was taken to exhibit a search light mounted on a steady platform, an arrangement recently invented by Mr. Beauchamp Tower. This novelty proved one of very great interest. The apparatus was placed aboard a small vessel and a beam of light was fixed on an object in the water. The vessel was then violently rolled, but in spite of this the beam of light remained as steadily fixed as if the search light had been secured to the jetty. To give the visitors an idea of the advantages gained by this apparatus, it was then thrown out of gear, and the search light became an ordinary fitting. It was immediately seen that in its then condition it had become perfectly useless while the boat was rolling, for it was impossible to keep the beam of light on any object for a moment.

On November 10 a special train left Newcastle central station at 7:30 and conveyed the party of officers to Silloth, where they arrived at 10. The first gun shown was a large 10 in. 30 ton gun, fitted with automatic breech mechanism. When this gun is fired the recoil energy is utilized for opening the breech screw, and for compressing a spring which is capable of closing it again; there is therefore no delay in opening the breech after the gun is fired, and as soon as the loading is completed it is only necessary to pull a small lever for the breech to automatically close itself. The advantage of this mechanism is apparent, for by its means a great increase can be obtained in the rapidity of loading. Three rounds were fired from the 10 in. gun, and the visitors were immensely impressed with the easy but rapid motions of the breech mechanism. A howitzer on a new mounting, designed for use in the field, was next shown. The peculiarities of this howitzer—which has a caliber of 4·7 in. and fires a shot weighing 40 lb.—is that the carriage automatically anchors itself, and the piece recoils within a jacket surrounding it. Several rounds were fired from this howitzer, used both for direct fire and for high-angle fire. The importance of such a weapon cannot be too much appreciated.

It is well known that some of the military powers of Europe have already adopted howitzers for field ordnance, and it is contended by Elswick that the howitzer exhibited has marked improvements on any previously constructed. A somewhat similar method of anchoring the carriage and absorbing the energy of recoil, by means of an hydraulic recoil press, was next shown, with a 15 pounder field gun. This field gun is also a quick-firing gun using cartridge cases, the breech of which is opened by a single motion of the lever. Several rounds of shrapnel and segment were fired at a target to show the accuracy of which the gun was capable, and to exhibit the anchoring and recoil arrangements. It was found that after the first round, which is used to set the anchor into the ground, the recoil only amounted to 8 in. Five rounds fired with shrapnel for rapidity, the gun requiring but little adjustment at each round, were completed in 53 seconds. The effect was exceedingly pretty, for scarcely did one shrapnel burst and scatter its bullets all round the target but that another followed its example, the target being 1,000 yards distant. Although this gun throws a shell weighing 15 lb., so well has the weight of every part been considered that the total of the whole equipment, with the limber loaded with thirty-six rounds, only amounts to 32 cwt., and it must be recollected that a considerable addition has to be allowed for the cartridge cases.

Other field guns followed, showing various systems of brakes and of obturation. These included one gun of 90 mm. and one of 76 mm. A fifteen pounder mountain screw howitzer was also shown, and created as much interest as anything else on the programme. When the visitors were brought up to the gun it was lying in two pieces, just as it would have been taken off the backs of the mules which are supposed to carry it. In five minutes the gun was screwed together, and on its carriage, and ready for firing. Both shrapnel and segment shell were used, and the practice at a target 1,500 yards distant was greeted with loud applause. A 6 in. gun, on a light portable disappearing mounting, was shown in position behind a parapet which had been purposely erected. This mounting is specially designed for transport in the siege train, and it can readily be taken to pieces, so that the heaviest load does not exceed three tons, and yet it can be readily erected, the time required, if plenty of labor is available, being about ten hours. The erection could therefore take place during the night. Several rounds were fired from this gun, and each time the recoil brought it down into loading position with a wonderful precision and ease. The mounting is on the spring principle, that is to say, the gun is raised again after loading by means of a strong spiral spring; there is thus no air pressure system about it, and every part is so simple that it seems impossible that it should get out of order.

It should also be remarked that the range at Silloth being on loose sand, the most trying conditions possible are imposed upon guns and mountings that are experimented with there. The visitors were next shown firing from a 6 in. naval quick-firing gun on a new mounting, the principal object of this trial being to show the great ease with which the mounting could be manipulated. Five rounds were fired, each round being at a different range and at a different target, so that not only had the sights to be corrected after each round, but the elevation and a considerable training had also to be gone through. In spite of this the five rounds were fired in 69 seconds, and most excellent practice was made. A 4·7 in. gun on a pedestal mounting was then fired for rapidity, the shots all being directed at a target 1,000 yards distant. The total time of firing these five rounds was only twenty-two seconds, and so good was the practice that at the second shot the target, which only consisted of a cask with a flagstaff on it, was knocked to pieces. It should also be observed that this 4·7 in. gun was of a much more powerful type than those used in the British Navy, the velocity obtained from it being 2,500 ft., against 2,150 ft. from the English gun. A 4 in. 30 pounder gun was then shown. This gun and mounting possess several peculiarities, the principal of which is that the keys which guide the gun during recoil are on the sides instead of on the top and bottom. The advantage of the new position lies in rendering the top of the cradle unnecessary, and better protection is given to the keys. The gun and mounting are protected by a shield 4½ in. in thickness, and the sighting is done over the top of the shield in such a manner that the firer has always got an all-round view.

Aiming practice was carried on from this gun at a target 2,000 yards distant, and each shot was pitched within a few yards of the target. A new pattern of aiming tube to be used with these naval quick-firing guns was then shown to the visitors, who were much pleased with its extreme simplicity, and who entertained themselves for some time in firing at a target erected for the purpose. With the 6 in. gun an aiming tube firing a 1 lb. projectile was used, and with the 4·7 in. an aiming tube firing Martini-Henry ammunition. A trial of great interest was then carried out against a special steel plate manufactured by Elswick. The plate tried was of 0·223 in. thickness, designed for use for shields of small guns, especially when those guns form part of the armament of vessels, such as torpedo catchers, where weight is of great consideration. To exhibit the properties of the plate, another plate of similar thickness, but of ordinary steel, was also fired at. The trials the plates were subjected to consisted of ten rounds from a magazine rifle and 160 rounds from a Gatling gun. The dimensions of the plates were only 2 ft. by 1 ft. 6 in.; the range was 100 yards. In each case every shot was put on the plate, and although the firing was normal not a single bullet got through the special plate. On the other hand, with the ordinary plate, every bullet from the magazine rifle penetrated, and the stream from the Gatling gun practically cut it in two.

During the experiments a new naval range finder, invented by Messrs. Barr & Stroud, was exhibited, and during the intervals between the firings the visitors amused themselves by taking the distances of all the surrounding objects. The ease with which the instrument was understood and manipulated was most remarkable, and the visitors were fairly astounded by the accuracy of these readings.—*The Engineer, London.*

FERMENTATION.

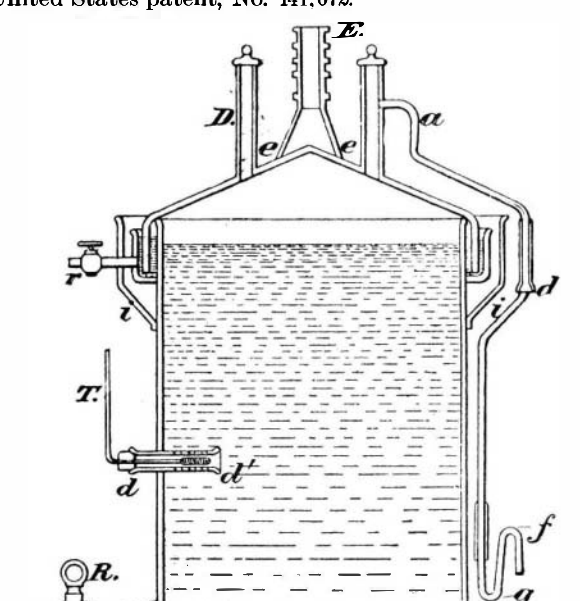
By C. C. Stauffer.

Fermentation is an effect concomitant with a large number of biological processes. The acts of mastication and digestion, the germination of seeds, the formation of cheese, the decay of all tissues, whether living or dead, the formation of wine, beer and vinegar, are some of the processes which are due, in whole or in part, to the growth of micro-organisms, which may be broadly defined as ferments. There is, at first sight, a wide difference between the dreaded cholera bacillus and the familiar yeast germ of all brewing establishments, but they are both minute forms of life whose modes of existence and of propagation are, in many respects, similar. This article, however, has to do with the ferments used in the production of wine and beer and the apparatus by means of which they can most readily be made to produce a desired result.

In the ordinary mode of making beer, two ferments, or rather ferments of two kinds, are employed. The first of these are the soluble or diastatic ferments or enzymes, which serve to convert the raw grain into fermentable substances during the process of malting, and are characterized as four, viz., diastase, invertase, peptase and cytase. These all have distinctive functions, the diastase acting upon the starch of the grain to convert it into the sugar called maltose, the invertase having the power of converting any cane sugar present, which is not fermentable, into dextrose and levulose which are fermentable, the peptase serving to convert the albuminoids into peptones, leucin and tyrosin, and the cytase serving to bring about the dissolution of the walls of the starch cells and thus render the starch more accessible to the diastase.

The effect of the soluble ferments is, however, simply to prepare the raw material for the action of the true ferments or yeasts, which belong to another class. The ferments which are apt to exert an influence upon the wort during the process of fermentation are of three genera, viz., the saccharomycetes, or yeasts, the schizomycetes, or bacteria, and the hyphomycetes, or moulds. Among the bacteria is included the butyric ferment which is the dreaded cause of the so-called "sickness" in beer. As might be imagined, both the bacteria and the moulds are injurious and are to be avoided as much as possible. The patents referred to below have special reference to the exclusion of all harmful organisms and the encouragement of the growth of the true yeasts. The nature of the resulting beverage depends mainly upon two factors, the material employed and the character of the yeast with which it is set. These are, of course, more or less modified by conditions of temperature and pressure. It is necessary to consider yeast as a plant of which there are a number of species and capable, when placed in a suitable environment, of growth and reproduction with a concomitant breaking up of the sugar and albuminoids present into ethyl and other alcohols and carbon dioxide. Of the several species of yeast, the *Saccharomyces cerevisiæ* is the one chiefly employed in the production of malt liquors and the *Saccharomyces ellipsoideus* is the main ferment of fruit juices and wines. Besides the ones mentioned, there are a number of others which are apt to be present to some extent, some of which are known as wild yeasts. The wild yeasts are injurious equally with the bacteria and moulds. The effect of all these is the production of bitter, acid or otherwise badly tasting substances. As a rule, however, the conditions of temperature and environment which are favorable to the thorough and rapid production of yeast of one kind hinder the production of others. Hence these injurious bodies lie dormant until a suitable time and temperature occur. This fact is of importance when we remember that commercial yeast is a mixture of several saccharomycetes, the normal yeast (*cerevisiæ*), of course, largely predominating. Other varieties are abundant, however, and it is upon the presence and character of some of these that the differences in flavor of fermented liquors, in a large measure, depend. The brewer's difficulty lies generally with the wild yeasts and the bacteria present.

The nature and essential characteristics of yeast were first made clear by Pasteur, and his researches have been followed up and supplemented by many other savants, among whom Dr. E. Chr. Hansen, of Denmark, is one of the foremost. Pasteur was the first to point out the relation between pure yeast and good products, and the practical application of his conclusions in many breweries throughout Europe led to a general and rapid improvement in the character of their products. One means employed by him for the isolation of pure yeast germs and the subsequent propagation of yeast of a definite character is shown in the accompanying figure, which is taken from his United States patent, No. 141,072.



PASTEUR'S DEVICE.

He takes impure yeast and causes it to act on a solution of sugar candy in pure water. When the fermentation is terminated, he decants the fermented liquid and adds a fresh quantity of sugared water on the top of the yeast deposit. This operation is repeated two or three times, more or less, according to circumstances. He then takes a shallow porcelain dish, first dipping it in boiling water, and puts in it a little beer wort which has been recently boiled or preserved by the Appert process. He then dilutes a little of the yeast deposit of the above described fermentation in the wort, and covers it with a glass plate. The yeast, which has become more or less exhausted by its action on the sugared water, will then rise and rapidly revive, purified of all germs of disease.

This treatment may be repeated by diluting a little of the yeast deposited at the bottom of the first dish in some fresh wort.

The degree of purity of the yeast may be ascertained with the aid of a microscope, which will indicate the presence of the germs, and show whether, by means of the yeast, a beer may be produced which shall not vary in condition at any temperature.

The apparatus consists of a cylindrical vessel, closed by a cover, the rim of which dips into a water trough around the top of the vessel, provided with a cock, *r*. The beer wort, properly so called, or other wort used in beer making, is first boiled in the copper, and then poured into the cylinder, which is completely filled, and the cover put on. Then, by means of a rubber tube, *c d*, the metal pipe, *a c*, opening into a stoppered pipe rising from the cover, is connected with the tube, *d c f g*. Boiling water is then poured on the cover and on the pipes rising therefrom, which fills the trough, the overflow passing into a gutter, *i i*, from which the water escapes through a slit or a number of small holes in the bottom, and is collected in another gutter at the bottom of the cylinder, provided with a discharge pipe, M.

T is a bent thermometer, for indicating the temperature of the wort, the bulb of which is protected by a perforated guard, *d' d'*. R V are cocks or apertures for discharging the liquid and sediment from the cylinder.

The cylinder thus filled is allowed to cool by contact of the external air, afterward assisted, if necessary, by cold water introduced at pipe E on the cover, which passes through apertures, *e e*, and trickles down over the cylinder. Air enters the long tube, *g c f d e a*. The yeast is then introduced through the pipe, D, which is immediately closed, the carbonic acid produced during the fermentation passing off at tube *f g*.

A tube similar to *a e d c f g* may be adapted to pipe, D, of a different length, if desired, for the escape of the carbonic acid gas, while a limited quantity of air is admitted by the other tube.

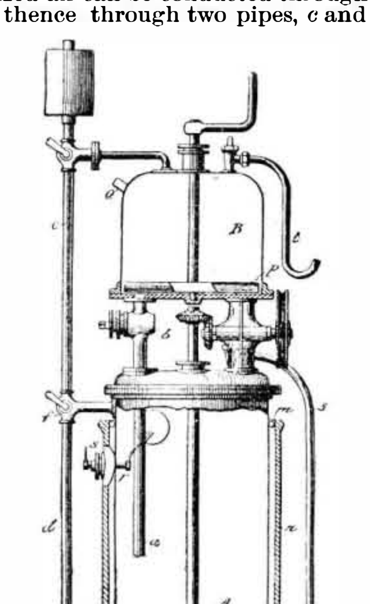
The wort may be readily cooled in presence of carbonic acid gas by introducing the latter beneath the cover during the cooling.

The tube, *f g*, may terminate by a loose plug of asbestos or cotton, or by a metal tube heated during the admission of the air. A drop of liquid in bend *g* will serve to indicate the movements of the gases.

It should be borne in mind, however, that several species of yeast are so closely allied to each other and so nearly of the same form that they can only be distinguished by a careful study of their effects. The method just described would not therefore suffice in all cases.

Another later and somewhat improved apparatus is that shown in the following illustration, which is taken from the United States patent to Jorgensen & Bergh, No. 467,993. This device is especially designed for use in carrying out some of Hansen's ideas. The operation is as follows:

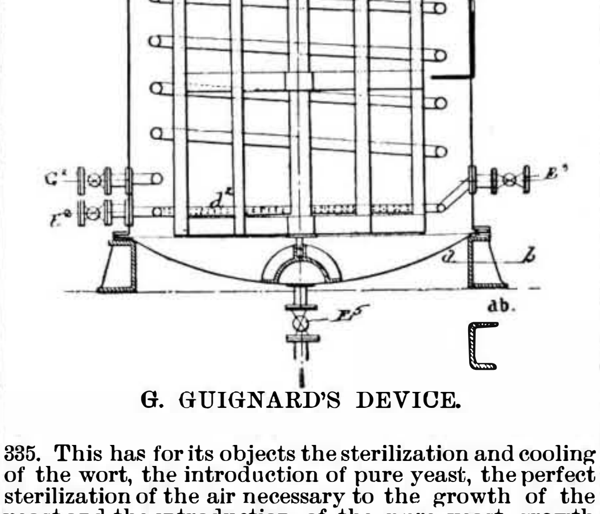
Sterilized air can be conducted through an air filter, C, and thence through two pipes, *c* and *d*, and three



A. JORGENSEN & A. BERGH, 1892.

cocks, *e*, *f*, and *g*, to both cylinders. The wort is preferably introduced in the sterilized state into the lower cylinder, A, directly from the brewery, or it may be sterilized in the same cylinder by admitting steam to a chamber, *i*, at the lower part of a casing which surrounds the aforesaid cylinders. After the desired quantity of wort has been admitted the air is introduced in a suitable manner. For this purpose the third or lower of the above-mentioned cocks, *g*, communicates with a pipe, *k*, which is arranged in the lower cylinder at a short distance from the bottom of the same, this pipe being closed at one end and provided with small holes at the inner and outer sides. The three cocks, *e*, *f*, and *g*, are so placed that the air is forced through the filter, C, directly into the said pipe, *k*, from which it issues on both sides. At the same time an agitator, *l*, which is preferably made of helical form and arranged as closely as possible to the bottom and sides of the lower cylinder, A, is caused to rotate for the purpose of stirring the wort. The cooling is effected by causing cold water to pass from an annular pipe, *m*, surrounding the upper part of the said cylinder along the outer periphery of the latter, or to circulate either in the chamber, *n*, at the lower part of the latter casing round the cylinder or in the entire casing. A quantity of the aerated and cooled wort is forced by air pressure into the upper cylinder, B, which is sterilized by steam or in any other suitable manner. Absolutely pure yeast produced in the laboratory is introduced through a pipe, *o*, into the upper cylinder and is intimately mixed with the wort by means of the helical agitator, *p*, arranged at the bottom of this cylinder. In order to enable the quantity of wort which has been introduced into the lower cylinder and forced upward into the upper cylinder to be indicated without the use of a gauge glass, a float, *r*, is connected by means of an arm to a spindle, *s*, which extends to the outside of the cylinder and carries a hand which indicates the level of the liquid in the said cylinder, A. When the yeast has been intimately mixed with the wort in the upper cylinder, B, the charged wort can be caused to pass through the above mentioned cock, *b*, and pipe, *a*, back to the lower cylinder, A, either at once or after it has been allowed to ferment in the upper cylinder. After the wort contained in the lower cylinder, A, has likewise been started and the yeast has been properly mixed with the same, a definite quantity is forced into the upper cylinder, B. The charged wort and both cylinders must be kept at a temperature adapted for the continuation of fermentation. As this apparatus has for its object to produce pure yeast for use on a large scale, it is a matter of course that this yeast can be removed either when the fermentation has reached its highest stage or after the yeast formed has fallen to the bottom of the cylinder. In the former case the entire mass is stirred on the third or fourth day of the fermentation by means of the above mentioned agitator, *l*, and is then removed and added to the wort in a large fermenting vessel. In the latter case the beer standing over the yeast is let off through the pipe, *k*, near the bottom of the cylinder and the lower of the three cocks, *g*, as the said pipe, *k*, occupies such a position that enough beer will remain in the cylinder to keep the sediment sufficiently liquid for removal. The superfluous air and the carbonic acid produced escape through two bent pipes, *t* and *u*, connected with the upper and lower cylinder. In either of these cases a sufficient quantity of fermenting wort must be forced beforehand into the upper cylinder, B, for enabling a fresh fermentation to be subsequently commenced therewith in the lower cylinder, A. When the yeast has been removed, the lower cylinder, A, is cleaned and sterilized. The wort is introduced in the manner described and treated with the yeast formed in the upper cylinder, B, under similar conditions, where upon the upper cylinder, B, is cleaned and sterilized. This operation is repeated every time.

Another and more complicated device is that of Guignard, described in United States patent No. 471,-

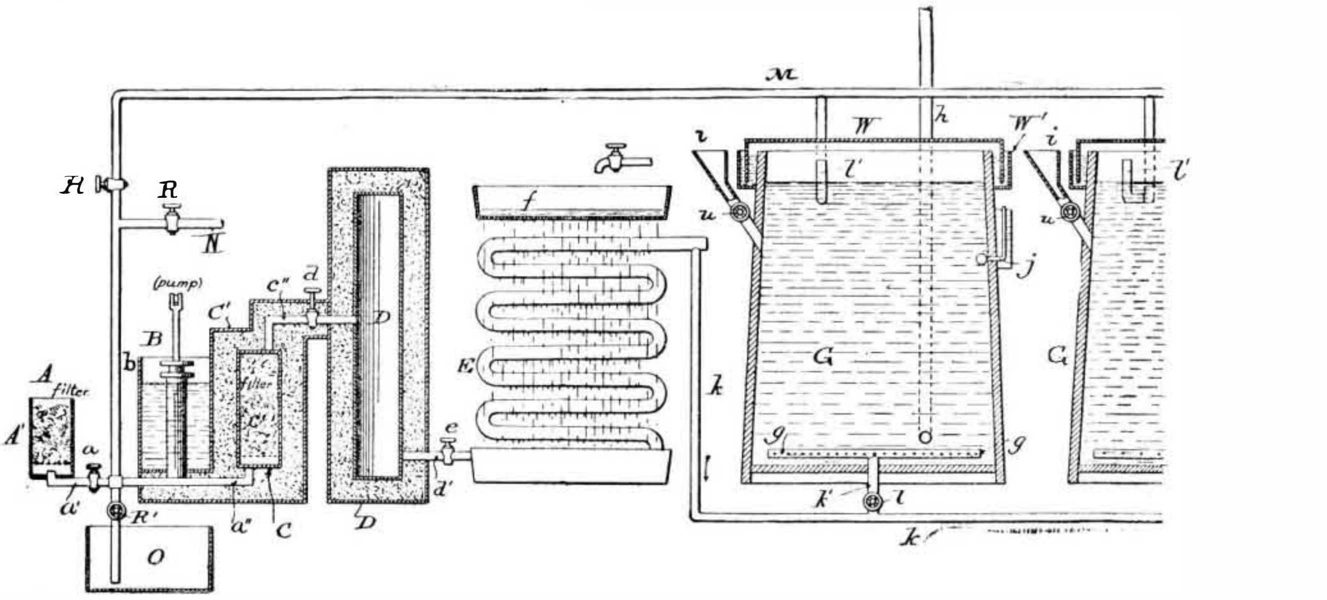


G. GUIGNARD'S DEVICE.

335. This has for its objects the sterilization and cooling of the wort, the introduction of pure yeast, the perfect sterilization of the air necessary to the growth of the yeast and the introduction of the pure yeast growth into sterilized flasks without exposure to contagion. The fermenting vat which he employs is here shown in section.

All the cocks being turned on, the apparatus is sterilized by a current of superheated steam, which is led through the cock, E^2, during about twenty minutes at a temperature of about 120° Centigrade after the exit of all the air. Thereupon the apparatus is cooled and the steam inlet, E^2, is closed, and the cock in pipe, A', is opened to admit the worts from the cooler. During the fermentation the steam inlet, E^2, is closed and cock, E^3, is opened to admit sterilized air, which is forced under pressure through the mass in the vat, thereby greatly increasing and expediting the production of the yeast. B' is an escape cock for the air or steam, and is closed when the fermentation begins, at which time the cock, F, is opened, and through it the carbonic acid and water generated in the vat pass into a general piping, M, the end of which may be submerged in an antiseptic liquor—such, for example, as a solution of corrosive sublimate. By this means unsterilized air is prevented from flowing back. The cock, a^3, is used to control the admission of sterilized air at the top of the vat to aid in the expulsion of the matters therein by the exit pipe at the bottom controlled by cock, E^5. G is an agitator.

The accompanying cut is taken from the patent to Lawton, No. 468,809. The apparatus is used for the purpose of preventing the introduction into the wort of deleterious ferments and bacteria from the air while it is subjected to the proper yeast ferment. This result is effected in a rather unique manner. The hot wort is run into the tuns, G, through funnel, *i*, or pipe, *h*, and the covers, *w*, put on while the liquid is still hot and sealed by the antiseptic liquid in the trough, W'.

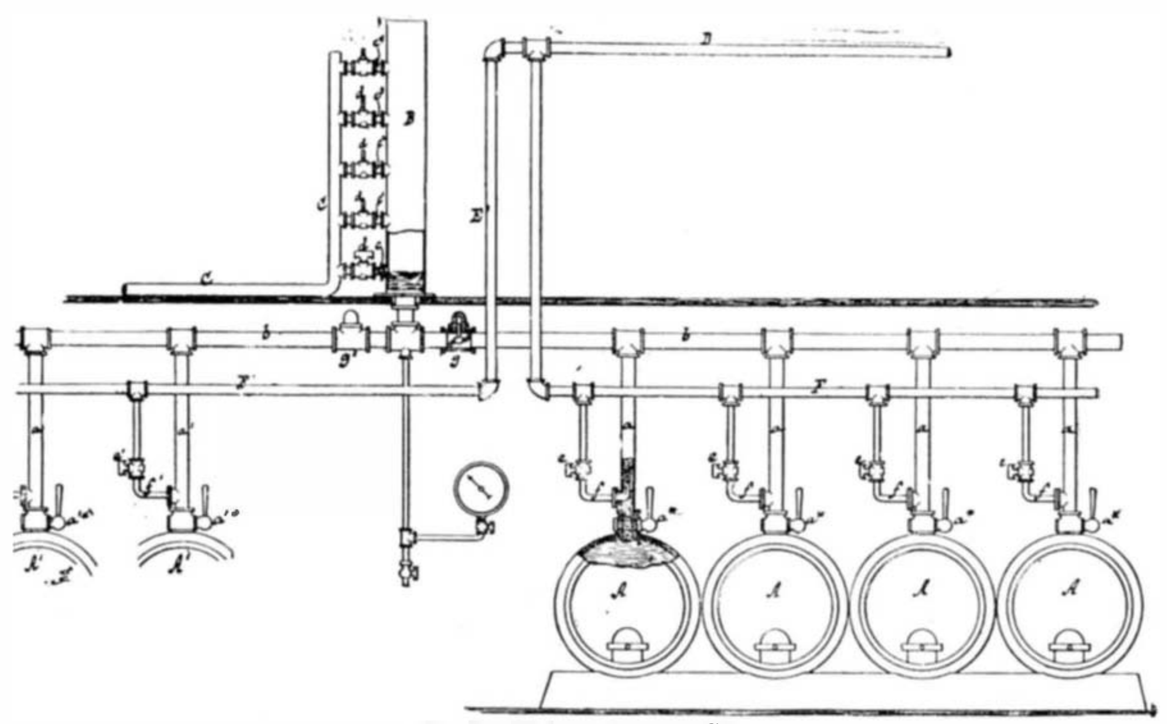


C. F. LAWTON'S DEVICE.

Air is then forced by pump, B, through filters, A and C, reservoir, D, and cooling coil, E. The filter, A, removes the mechanical impurities from the air. The filter, C, is packed with sand or compressed asbestos, and this filter, as well as reservoir, D, are surrounded by a non-conducting packing or covering. The air being drawn in by the pump more rapidly than it can escape into the fermenting tuns through the cocks, *l*, which are opened but a little way, is condensed and heated in filter, C, and chamber, D, to a temperature sufficiently high to kill all the germs which it may contain. It is subsequently cooled at E. This device may be used to cool the wort, as well as to supply the air requisite for fermentation. The carbon dioxide produced by the fermentation is drawn off at O. The pipe, N, may be used to charge the liquid with another gas, if desired.

The foregoing patents have dealt mainly with the purification of yeast, wort or air. There are, however, other conditions which sometimes maintain and which may modify the result to some extent. The alteration of atmospheric pressure is one of these. The first suggestion of this kind to be set forth in any patent is that disclosed in a patent to Sheridan as early as 1837 (No. 245). In this it is said that the pressure is maintained during fermentation at from 15 to 20 inches of mercury, the latter pressure being used in the last 24 hours of the process. The patentee asserts that this diminution of pressure prevents the development of the acetous ferment, but it is somewhat doubtful whether his assertion can be maintained. It is probable that the development of this ferment is prevented in the usual way—that is, by keeping down the temperature. In British patent, No. 4,746, of 1890, it is asserted that "in highly rarefied spaces the efficacy of yeast as an exciter of fermentation is far more energetic and productive than in non-rarefied spaces, and the quantity of yeast necessary for a given purpose is greatly reduced. . . . In the case of bakers' goods, about 50 per cent. less yeast than is usual may be employed," if the pressure be greatly diminished. The two cases last referred to are to be contrasted with that of Lawton's, alluded to above, in whose apparatus the pressure must always be, to a slight extent, at least, greater than that of the atmosphere. This is also true of the apparatus used by Jorgensen and Bergh, as well as of that used by Guignard. The device of Pfaudler, patent No. 293,909, illustrated is one in which it is especially intended that the pressure shall be greater than that of the atmosphere. The patentee has, however, failed to point out any advantage to be derived from this increase of pressure during fermentation.

In this drawing the letters A A A represent a series of fermenting vessels or casks, which are connected by pipes, *a a a* (which I term the "hydrostatic" pipes), to a pipe, *b*, which extends from the bottom of a vertical tube, B. This tube is filled with water or other liquid, and it is provided with a series of nozzles, $c\ c'\ c^2\ c^3\ c^4$, which communicate with a common discharge pipe, C. Each of the nozzles is provided with a stop cock, *d*, and if the nozzle, *c*, is opened the liquid in the tube, B, sinks down to the level of this nozzle; but if this nozzle is closed and the second nozzle, *c'*, is opened, the liquid in the tube, B, sinks down to the level of this second nozzle, c', and so on. If the casks, A A A, are filled with beer or other fermentable liquid, and the stop cocks, a^*, in the hydrostatic pipes, *a a a*, are opened, the liquid in the casks is exposed to the pressure of a column of liquid, the height of which can be regulated by means of the nozzles, $c\ c'\ c^2\ c^3\ c^4$. I place the tube, B, at such a level above the casks, A A A, that if the nozzle, *c*, is open the liquid in the casks is

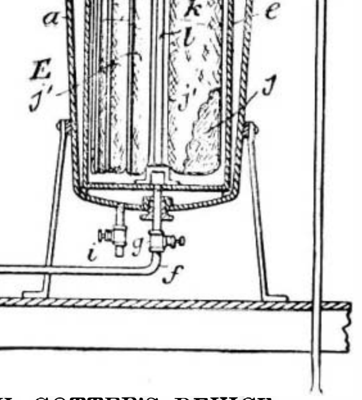


C. PFAUDLER'S DEVICE.

exposed to a pressure of, say, five pounds to the square inch. If the nozzle c' is open, the pressure is increased to, say, six pounds to the square inch, and so on.

D is a water supply pipe, the water supplied by this pipe being under a pressure of, say, fifteen pounds or more to the square inch. This water supply pipe connects by a vertical pipe, E. with a horizontal pipe, F, from which extend a series of spouts, *f*, one into each of the hydrostatic pipes, *a*. The spouts, *f*. are provided with stop cocks, *e*, and when these stop cocks are opened jets of water are injected in an upward direction into the pipes, *a*, and the water thus injected flows off through the open nozzle (*c*, for instance) in the tube, B. The stop cocks, *e*, also serve to regulate the force of the jets injected into the pipes, *a*, and they are only opened just far enough to enable said jets to produce an upward current of the requisite force. The liquid in all the casks, therefore, is held under a hydrostatic pressure of, say, five pounds to the square inch if the nozzle, *c*, is open, or six pounds to the square inch if the nozzle, c', is open, and so on, as will be readily understood from the foregoing description. The barm, as it forms from the fermenting mass contained in the casks, A A A, enters the hydrostatic pipes, *a a a*, and by the upward currents produced by the jets injected through the spouts, *f*, such barm is carried off into the tube, B, when it flows off through the open nozzle, *c* or c', as the case may be, and through the discharge pipe C.

Fermentation under pressure is also a feature of the Gotter patent shown below.



H. GOTTER'S DEVICE.

The fermenting vessel, E, is illustrated as containing spun glass, *j*, as the material immersed in the wine while undergoing fermentation. In order that this spun glass shall be distributed in all parts of the vat, it is placed in bags, j', of suitable material, which are suspended from the rods, *k*, radiating from a central standard, *l*. Obviously, this supporting mechanism may be varied—for instance, silver wire may be used—the object in view being to distribute the substance, whatever it may be, in various parts of the vat.

It is obvious that the more evenly and thoroughly the yeast is maintained in a state of distribution throughout the liquid, the more rapid and complete the fermentation will be. The maintenance of this state of distribution is the design of a patent to Gotter, No. 443,190. He fills the fermenting vessel, E, with spun glass in sheets and with the barm or yeast thoroughly distributed through these sheets. This keeps the yeast from rising to the top or settling to the bottom of the wort, as in ordinary top or bottom fermentation.

Other means have been used by other patentees, as paper, cotton, flax, hemp, chopped hay, fiber, pulp, sawdust, fruit skins, etc., by Reihlen (patent No. 301,-006), and animal fiber, especially wool, by Meyer (patent No. 467,308), both of whom state that peculiar advantages result from the use of their respective materials.

The foregoing patents have been selected with especial reference to their relation with the mechanical features involved in the process of fermentation.

There are many patents which deal with the chemical features of the subject, some of which may be discussed in a future article.

THE DENSITY OF THE EARTH.

By HENRY WURTZ, Ph.D.

To the five figures that we have heretofore had for the mean specific gravity of the planet we live upon—the outcome of five distinct sets of experiments—there has been recently added a sixth, by Alphonse Berget. His new figure is now one of three which agree even better than should be expected from such delicate and difficult work as the weighing of a globe 24,000 miles in circumference. Yet we appear now to have figures inspiring much confidence. Berget's method was by measuring the relative attraction upon a "hydrogen gravimeter" of a lake of 100 acres surface, in the province of Luxemburg, Belgium, at its highest and lowest points, varying in level about a foot and a half. The mass of water was, therefore, 6,534,000 cubic feet; and weighed 2,721,411 tons. His earth density determination was 5·41.

One method used by Maskelyne at Mt. Schiehallion, near the Tay, in Perthshire, Scotland—also by Col. James, at Arthur's Seat, near Edinburgh—was based on the divergence from the exact radial direction of a plumb line produced by the attraction of the mountain. It is therefore subject to errors in the determination of the mass of the mountain. Col. James' figures led to a density = 5·316, the smallest of the six here discussed. Professor Airy, the British Astronomer Royal, made many attempts, at first unsuccessful, to obtain figures in another way, by establishing duplicate pendulums, at the surfaces and bottoms of deep coal mines. He succeeded, in 1854, at a mine 1,260 feet deep. He here found an acceleration of the lower pendulum of but 2¼ seconds per 24 hours. From this he computed for the density 6·565, the highest figure on record, and probably higher than the truth by more than a unit. Cavendish measured the attraction of two spheres of lead weighing 174 lb. each upon two leaden balls of one hundredth part this weight, suspended in a torsion frame. The amount of torsion was measured through a telescope, first producing the torsion in one direction, then in the other. He obtained 5·48, which is one of the three best concurrent figures. The third was obtained by Reich, by a method which the writer cannot now refer to.

The six figures alluded to are as follows:

No. 1.	Col. James	5·316	
" 2.	Berget	5·41	Mean of 3 = 5·443
" 3.	Cavendish	5·438	
" 4.	Reich	5·48	
" 5.	Baily	5·66	
" 6.	Prof. Airy	6·565	

Mean of all = 5·645
Mean of 1 to 5 = 5·461

The method of Cavendish is, to judge from these few figures, the most likely to lead in the path of success. Instead of six, however, we ought to have a hundred determinations made under all possible variations of the conditions.

No one will doubt, however, that the three figures, Nos. 2, 3 and 4, giving us the mean 5·44, must be approximations to the true mean density of our globe. It follows that the average density of all the materials of the sixteen miles of the earth's crust that we know geologically is less than half the mean density.

Moreover, the average of the materials thrown out by volcanoes—believed by geologists generally to come from several hundred (some say 800, others 1,000) miles below the surface—is also less than half the above mean. The conclusion then follows that the average mass of the globe, below the sphere of volcanic action, must be very greatly heavier than the mean, and we shall not exaggerate in assuming that it may be higher than 10 (water being =1). For if we compute the volumes of spheres of 8,000 miles and 6,000 miles in diameter, according to Hennessy's mathematical investigations, we find the former to be 268,083,200,000 cubic miles, while the latter is only 113,097,600,000 cubic miles, much less than half the whole. Even if we take off a shell of but 800 miles, as Mr. Hopkins has mathematically deduced for the thickness of the crust, from the precession of the equinoxes—which gives us an inner sphere of 6,400 miles in diameter—we find for this latter the volume 137,258,598,400 cubic miles, which is little more than half the whole volume of the earth. The writer believes, therefore, that we are entirely justified in assuming a density even greater than ten times the weight of water for this inner nucleus of the earth, below the solid stony crust, of the deeper portions of which volcanic eruptions furnish us samples.

This slight discussion has now led us directly to a stupendous question. What is it that we have in this inner half of our globe? Geologists of the highest class are apparently mainly agreeing of late years in the view that this internal nucleus must be a *solid* mass and not liquefied by heat, as formerly imagined. We get no decisive solution of this great question from the materials we find in the outer portions of the crust or from what volcanoes send us of the inner portions. The loose assumption has been long since made, and is often reiterated, that this problem is fully solved by an absence of oxygen in this internal nucleus, and that the *metals* found in the outer crust being, therefore, in their elemental state, are, of course, heavier than on the surface.

This assumption abjectly fails, on examination, to unriddle the problem. What do we find in the outer crust accessible to us everywhere and in the samples of the inner crust sent to us by volcanoes? In the first place the latter is generally quite as highly oxidized as the outer crust. But this is not the main point. At least fifty per cent. both of the outer crust and of the volcanic matters erupted is silica, the specific gravity of the elemental base of which, *silicon*, in its densest crystalline (adamantoid) form is only 2·48. The next most abundant metal, probably 8 or 10 per cent. of the whole, is *aluminum*, whose greatest solid density is 2·807. Next to these in abundance, we have *potassium* and *sodium*, both lighter than water; *magnesium* (heaviest form), 2·14; *calcium*, 2·584; *carbon* (the heaviest, diamond), 3·55; *sulphur* (heaviest), 2·086; and *hydrogen* (liquefied), 0·33. Those already mentioned (with oxygen, which alone constitutes half the weight of the solids of the crust, including the lavas) virtually make up the bulk of the said crust—all the heavier metals together summing up, in all probability, not more than one per cent. Where, then, is the rationality or the justification for the assumption that this nucleus, below the volcanic shell, is made up of heavy metals? The most abundant of these heavy metals, *iron* and *copper*, have the maximum densities respectively of about 8·14 and 8·96 (see SCIENTIFIC AMERICAN SUPPLEMENT, No. 938, pp. 14996–7). As for *lead*—the only common metal that is heavy enough to satisfy the conditions of the problem, being as heavy as 11·5, when compressed—we can scarcely admit so monstrous a supposition as a sphere of lead 6,400 miles in diameter inside our planet. As for *silver*—whose maximum known density is 11·1—it is quite as violent a hypothesis to assume that our globe carries so much of that in its bowels. Were it so, there ought to have been, among the multitude of volcanoes, some one, say like Krakatoa, whose voice is heard a thousand miles or more, obliging enough to throw up for us a million tons or so of it. *Gold*, *platinum*, *iridium*, and other very heavy metals it is scarcely worth while to consider in this connection. They probably never occur among volcanic products. Briefly to sum up; our conclusion must be that in the central parts of the planet earth there is a mystery which, so far as we can yet see, must remain altogether inscrutable to mortal man, whose mission it is nevertheless to "replenish the earth, and *subdue* it." This was the first command ment given to him by his Creator, as found in the first chapter of the first book of Holy Writ.

THE LUMINIFEROUS ETHER.

SIR G. C. STOKES has recently published some interesting remarks upon a subject about which, he says, the study of light has caused him to think a good deal—namely, the nature and properties of the so-called luminiferous ether. It appeared from his discourse that Sir G. C. Stokes is one of those philosophers who regard the luminiferous ether as a conception of the scientific mind put forward as supplying the obvious need of something for light and gravity to act through or by, thereby avoiding the alternative of supposing these phenomena to be the results of action at a distance. Newton himself scouted the idea of action at a distance as too absurd for any "man who has in philosophical matters a competent faculty of thinking" to entertain. He accepted the existence of an "agent" between bodies affected by gravity; but what this necessary agent might be he was content to leave to the consideration of others. Now, as Sir G. C. Stokes points out, modern science has shifted into the background the difficulty of defining the nature of this unknown agency, by calling it the "ether," which term is in this connection no more than the mathematician's eternal x written in five letters. All that is certainly known about it is negative; while of many aspects from which the conception can be regarded it is impossible to say anything either positive or negative. Granting the physicist his ether, is this the same thing that propagates light and gravity? Sir G. C. Stokes confesses that "we do not know." We cannot conceive of space as other than infinite—is the ether likewise infinite? Again we do not know. Does the ether gravitate toward what we call ponderable matter? This is another question to which no positive scientific answer can be given; and the same remark applies to the question as to whether the ether consists of ultimate molecules, such as those of which there is strong reason for believing that ponderable matter consists. The undulatory theory of light was greatly promoted in the first instance by the known phenomena of sound; but the latter failed to show a counterpart to the phenomena of polarization and double refraction. These phenomena are only intelligible according to the theory of undulations by supposing the vibrations of the ether differ