brewing yeasts would predominate, and these produce less alcohol than the distillery types. Thus at 75° F. (and above) distillery yeasts tend to predominate. The conditions of fer­mentation which are more or less forced upon the distiller are unfortunately also very favourable to the development of bacteria, and if special methods are not adopted to check their development, the result would seriously affect not only the quantity but also the quality of alcohol produced. The micro-organisms chiefly to be feared are those belonging to the class of fission fungi (schizomycetes), such as the butyric, the lactic, the mannitic, and mucic ferments.

*Souring.—*It has long been known to practical distillers that in order to avoid irregular (bacterial) fermentations it is necessary either to let the wort “ sour ” naturally, or to add a small quan­tity of acid (formerly sulphuric acid was frequently employed) to it before pitching with yeast. The reason for this necessity was until recent times by no means clear. It has, however, now been demonstrated that a slightly acid wort is a favourable medium for the free development of the desirable types of distillery yeasts, but that the growth of brewery yeasts, and especially of bacteria, is very much restricted, if not entirely suppressed, in a " soured ” liquid. The acid which is the result of a properly conducted souring is lactic acid, formed by the decomposition of the sugar in the wort, by bacterial action, and according to the equation C6H12O6= 2C3H6O3.

For various reasons (one being that in order to restrict the lactic fermentation when sufficient acid has formed it is neces­sary to heat the soured liquid to a higher temperature than is desirable in the case of the main wort) it is inexpedient to allow the souring process to take place in the main wort. It is usual to make a small mash, prepared on special lines, for the produc­tion of the “ bub ” (German *Hefegut),* as the soured wort is termed. This is allowed either to " sour ” spontaneously, or, better, is inoculated with a pure culture of *B. acidificans longissimus,* which for this purpose is undoubtedly the best variety of the lactic acid bacteria. The optimum developing temperature of this organism is about 104° F., but it is better to keep the wort at 122° F., for at the latter temperature practically no other bacteria are capable of development. When the lactification is completed the wort is raised to 165° F. in order to cripple the lactifying bacteria—otherwise souring would go on in the main fermentation—and after cooling to the proper point it is pitched with yeast. When a good crop of the latter is formed the whole is added to the main wort. The beneficial effects of souring are not due to any specific action of the lactifying bacteria, but purely to the lactic acid formed. It has been found that excellent—and in some respects better—results can be obtained by the use of lactic acid as such in place of the old souring process. Some success has also attended the introduction of hydrofluoric acid and its salts as a substitute for lactic acid. Hydrofluoric acid is poisonous to bacteria in doses which do not affect distillery yeasts, and the latter can be cultivated in such a manner as to render them capable of withstanding as much as 0∙2% of this acid. Bacteria, apparently, cannot be “ acclimatized ” in this fashion. Worts treated with hydrofluoric acid produce practically no side fermentation, and it seems a fact that this substance stimulates diastatic action, and thus permits of the use of relatively low mashing temperatures. The yeast employed in British and Irish pot-still and in some patent-still distilleries is still generally obtained from breweries, but it is now generally recognized that—at any rate for the production of industrial alcohol and for “ plain ” spirit—a special type of yeast such as the so-called " German " yeast, a good deal of which comes from Holland, but which is now also produced in the United Kingdom on a considerable scale, is desirable in the distillery. This variety of yeast, although closely allied botanically to that used in brewing (belonging as it does to the same class, namely *Saccharomyces cerevisiae) ,* is capable of effecting a far more rapid and far more complete fermentation than the latter. Probably the most widely known and best " pure-culture” distillery yeast is the one called " Species II,” first produced in the laboratories of the Berlin Distillers’ Association. The optimum working tempera­ture of distillery yeast is at about 81∙5° F.; but it would be inexpedient to start the main fermentation at this temperature, as the subsequent rise may be as much as 36°. It is, therefore, usual to pitch at about 80° F., and then, by means of the attem- perator, to cool down very slowly until the temperature reaches 60° F. The temperature subsequently rises as fermentation goes on, but should not exceed 85° F. Pot-still malt whisky distillers frequently work at somewhat higher temperatures. Fermentation is carried on until practically all the saccharine matter is converted into alcohol; and when this is the case, the gravity of the mash is about equal to, or even a little below, that of water. In malt whisky distilleries the original gravity of the wort is usually from 1∙050 to 1∙060, occasionally lower, but in grain and potato distilleries the worts are often made up to a higher gravity. In Germany gravities as high as 1·11 are em­ployed; but in that country “ thick ” mashes, owing to the method employed to raise the duty, are a matter of necessity rather than of choice.

It will be seen from the above that the employment of malt for the purpose of rendering starch soluble and fermentable leaves a good deal to be desired in regard to both the mashing and fermenting operations in the production of spirit. The use of acid for this purpose is also attended by serious drawbacks inas­much as a considerable proportion of the starch is converted into “ reversion ” products which are practically unfermentable and thus considerable caramelization is brought about by the action of the acid. In the case of the production of potable spirits such as whisky, where the alcohol yield is not the only object, and the conservation of a specific flavour is desired, it is doubtful whether any material improvement can be made in this connexion, as it seems probable that part of the flavour may be due to some of the circumstances which from the point of view of alcoholic yield alone are most undesirable. For the production of industrial alcohol, however, and for the preparation of spirit intended to be used in compound potable spirits and liqueurs, these difficulties have now been surmounted. The older methods at the disposal of the distiller have of late years been enriched by the discovery that certain micro-organisms (or rather the enzymes contained in them) possess the power of converting starch into sugar, and also of splitting up saccharine materials into the ordinary products of alcoholic fermentation. It is possible to inoculate a sterilized wort with a pure culture of a micro-organism of this description and subsequently with a pure culture of yeast, and so to avoid all undesirable features of the older processes.

Details concerning the practical application of this discovery will be found below under *Industrial Alcohol.*

*Distillation.*—The primary object of the distillation of all fermented liquids is that of separating, as far as possible, alcohol from the non-volatile constituents of the wash. In the second place the object of the distiller is to rectify and concentrate the dilute alcoholic liquid obtained by simple distillation. The degree and manner of rectification and concentration vary in accordance with the type of spirit to be produced, and it will be better therefore to discuss methods of distillation under the headings of the different types of spirit concerned.

1. *Scotch Pot-still Whisky.—*The raw material employed in the manufacture of Scotch pot-still whisky is practically without exception malted barley only. The malt is prepared in much the same way as brewery malt, except that it is generally cured (dried) with a peat; or mixed peat and coke, fire. It is to this peat drying that the so-called smoky flavour of most Scotch pot-still whisky is due. The malt is mashed in a mash-tun on lines similar to those obtaining in the brewery, except that the mashing heats are somewhat different. They should be so regulated as to obtain the maximum yield consistent with the preservation of the proper flavour. In order to obtain as high a yield as possible four separate mashes are as a rule made with the same lot of grist, the temperature of each successive mash being somewhat higher than that preceding it. The worts obtained from the first three mashes are united prior to