will be seen that with 11°C. temperature difference between *Te* and *Tb* this can be obtained, and thus the economical limit has been established.

To compare the figure of 29,200 kcal/kWh. with the results at Aarberg factory, the average obtained heat capacity of the rotary thermal compressors is :

For the evaporators—

70,000,000 : 3,000 = 23,300 kcal/kWh.

For the vacuum pans—

17,000,000 : 3,000 = 5,600 kcal/kWh.

Future development of thermal compression in this way may open a new field of thermal engineering.

The Economics of Rum Production.

By RAFAEL ARROYO, CH.E. & S.E., F.A.A.A.S.,
Consulting Chemist and Fermentologist.[1]

PART I.

Desirable as it always was, economical rum production becomes, under the present outlook, a necessity. The days of high prices coupled with practically unlimited demand are a thing of the past, and from now on, until no one knows when, rum producers must face a buyers' market. With molasses selling at unprecedented heights, the producer of rum must keep up high standards of quality and at the same time reduce prices to the consuming public. This is his dilemma before a highly competitive and declining market.

New investors must be careful and cautious about capital outlay and initial costs, as well as about operating production expenses. Old-fashioned establishments must change their practices if they are to have a chance against new installations using more modern equipment, more efficient design, new processes, and more skilful personnel. This article, and the one to follow, will present some points by which economy in production and initial capital requirements for new investments may be effected.

Selection of Distillery Site.

The prospective rum producer must, in the first place, select with utmost care the site for the distillery, for at this initial stage errors may be committed that may later jeopardize the very existence of the enterprise as a paying proposition. The essentials to be considered in the selection of a distillery site are : (1) proximity to sources of supplies ; (2) facilities for disposal of distillery wastes ; (3) assurance of a practically unlimited supply of good water, deep well water in particular ; (4) good road connexions, both for rail and truck transport ; (5) accessibility to light, telephone and power from central stations.

(1) In some rum producing countries, as Jamaica for instance, where to become a producer of rum it is indispensable also to be a producer of sugar (a very wise provision for many good reasons) this first requisite is solved when the distillery uses only the molasses produced at the adjoining sugar factory. In other rum producing countries, as Puerto Rico for instance, where there are distilleries not operating with sugar factories, the problem exists. In such cases we find that the cost of molasses transportation may amount to as much as 25 per cent. of the actual cost of the molasses. Also, if the distillery lacks appropriate molasses storage facilities it may suffer severe and expensive shut-downs due to breakdowns, traffic accidents, strikes, etc. It should be realized that from 65 to 80 per cent. of the production cost of the finished product is represented by the cost of the molasses employed to produce it.

(2) The matter of slops disposal often becomes a very serious and difficult problem to solve for the independent distiller (by which term we designate those not operating adjunctly to the sugar factory). No matter how it is finally solved, the expenses involved will always gravitate against the economics of production, especially in the cases of the small and medium size producer.

(3) The third point, that dealing with the water supply, is one of great importance, influencing as it does more than any other the economy of production and the quality of the raw distillate. Greatly desirable is the assurance of a practically unlimited supply of water, deep well water in particular. Deep well water is preferred to surface water because of its chemical composition and especially because it is less contaminated with injurious micro-organisms ; it is more suited for cooling on account of its lower temperature compared with surface water.

(4) and (5).—As to these requisites, we feel they are self-evident and need no further comment or explanation.

The next step will be selection of buildings and equipment. Our researches in rum manufacture and our consulting experience at home and abroad have shown that up to the present time rum distilleries have been wasteful of both floor space and equipment. Little or no thought has been exercised in the adequate first capital requirements, or first costs of buildings and equipment. Often to produce a certain number of proof gallons of rum per day more than twice the necessary capital has been invested, and

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operating conditions have resulted which are far from economical and efficient.

With the prevailing high prices for land, building materials, labour and equipment, it has become customary to calculate an expense of around $75·00 per U.S. proof gallon produced daily, when estimating costs for the installation of a new rum distillery. This figure does not take into account expenses involved in warehouses, barrels, rectification and bottling plants, etc., but refers mainly to the production of the raw product. This means an expense of $75,000·00 for a rum distillery with a daily production of 1000 proof gallons.

This figure may be greatly reduced, however, by economical and efficient designing of equipment and by using this equipment at its highest efficiency and capacity. This reduction in first costs becomes more certain and more pronounced in those cases when the distillery has access to an abundant supply of pure, cool, deep well or surface water. With an adequate supply of water and an efficient plant design, the $75,000 for first costs may well be reduced to about $50,000 or $55,000, thus effecting a considerable saving. The one condition that must be met in order to effect this economy consists in obtaining the features of design necessary for the production of fermented mashes or "beers" of very high alcoholic concentrations. Let us see how this is possible.

Under ordinary working conditions, rum distilleries produce beers of an alcoholic concentration varying between 5·0 and 6·0 per cent. by volume. Allowing for a still efficiency of 90 per cent. we find that, in order to produce 1000 U.S. proof gallons of raw rum per day, at least 1110 U.S. proof gallons of alcohol must be formed during fermentation. Since the beer contains an average of 5·5 per cent. alcohol by volume, the total volume distilled must be not less than 10,100 U.S. gallons per day. This means a fermenting room of about 30,300 U.S. gallons total capacity; or the use of, say, six fermenters of at least 5500 gallons capacity, allowing for fermenting tank bottoms, and empty space above the fermenting liquid for foaming. To handle the 10,100 gallons of fermented mash, the distillery still must have a diameter of not less than 24 inches; and a boiler of from 50–60 rated B.H.P. will have to be installed.

Let us now consider the initial design of this same distillery, having in mind the cutting down of expenses through the production of 11 per cent. alcohol beers instead of the 5·5 per cent. content usually produced. It will be evident that in this case we can produce the same 1000 proof gallons of raw rum per day with much less expense in first costs for building and equipment. Operating expenses will also be less on account of less labour involved, and the great economy of fuel for distillation. In the first place, the volume of fermented mash to be prepared will be cut exactly in half. That is, 5050 gal. of mash will have to be prepared, fermented and distilled, instead of the former 10,100 gal. This means that instead of six fermenters of 5500 gal. each, we shall need only three of them, with a saving of 50 per cent. in both floor-space and fermenting vats. The 24 in. diam. column may be replaced by one of 18 in. diam. thus effecting further saving in the cost of the distilling apparatus. Finally, the 50 or 60 B.H.P. boiler may be replaced by another of about 30–40 B.H.P., thus effecting another saving not only in the first cost of the boiler and its installation, but also in the daily use of steam, as obviously the distillation of 5050 gal. of 11 per cent. alcohol beer will take much less steam than the distillation of 10,100 gal. of 5·5 per cent. alcohol beer.

Selection of the Yeast.

Another point to which the prospective investor must give careful thought is the selection of his fermenting agent, that is, the rum yeast strain which he will use in his distillery. This very important point is perhaps the one least thought about by the prospective investor in a new rum distillery. Under conditions of adventitious fermentation, economical distillery management becomes impossible, as distilleries which use only the yeast occurring naturally in the raw material will only obtain about 40–60 per cent. of the theoretical yield of alcohol from the sugars in the mash; or from 2·9–4·4 gal. of absolute alcohol per 100 lb. of fermentable sugars. In striking contrast to the above figures, rum distilleries using pure culture yeast will obtain from 85–95 per cent. of the theoretical alcohol yield, or from 6·2–6·9 gal. of absolute alcohol from every 100 lb. of fermentable sugars.

For economical operation, no matter what other characteristics may be desirable in the yeast strain used, it must be a quick fermenting, high alcohol producing strain. It should also stand without loss of activity relatively high fermentation temperatures. The characteristics of the yeast are thus intimately related to the economies of the rum distillery.

The most important item in the cost of manufacturing a proof gallon of raw rum is the cost of the molasses from which it is produced. Usually this cost represents from 65–80 per cent. of the total manufacturing expenses per proof gallon of spirits, depending on the fluctuations in the price of molasses. Hence it becomes the duty of distillery managers and superintendents to see that the best quality of raw material is purchased, and that the best possible use is made of the sugars contained in the molasses.

Purchase of the Molasses.

Economy of production of rum is related not only to the price at which the molasses may be obtained, but also very particularly to the chemical composition of the latter. In purchasing molasses for distillery purposes, constituents other than the total sugars must be taken into consideration, the most important of which are: (1) ash, (2) nitrogen, (3) phosphoric acid, and (4) non-fermentable copper-reducing substances, the so-called unfermentable sugars. Molasses gums, *pH* values and natural molasses aroma are also of relative importance; but for economic reasons the first four mentioned above are the most important in addition to the content of total sugars. We need not worry about the content of potash, as this ingredient exists always in great excess in all molasses entering the distillery. The ratios of total sugars (as invert) to ash, and that of total phosphoric acid (as P_2O_5) to total nitrogen are also of the greatest importance to the economical conversion of the sugars into alcohol. For maximum yields and rapidity of fermentation, the first-mentioned ratio should be not less than 6·5 : 1·0; and the second not less than 1 : 5 nor more than 1 : 2.

The percentages of total sugars, total nitrogen and total phosphoric acid (as P_2O_5) vary a great deal in molasses from different countries, or even in molasses from different districts or zones in a given country. These variations depend on the type of soil, the cane variety, the cultivation methods followed, the methods of sugar manufacture employed at the factory, and the quality of the marketable sugars produced. These differences in the chemical composition of blackstraps profoundly influence the economies of rum production.

The economical distillery manager, whenever possible, should select that blackstrap whose chemical composition most nearly approaches ideal conditions for rum fermentation purposes. As the ideal type of molasses will be very difficult to obtain in practice, the distillery manager will see that he at least is not buying a raw material of subnormal standard if he can help it. The practical points to consider in buying the molasses for the distillery, so as to obtain a raw material within the range of economical operation, are: per cent. total sugars (as invert) should not fall below 52·5; the percentage of ash (as carbonated) should be around 8·0 as a maximum; the percentage of total nitrogen should fall within the range 1·0–1·5 by weight of molasses; the percentage of total phosphoric acid should be within the range 0·2–0·5 by weight of molasses. The ratio of total sugars (as invert) to ash should not fall below 6·5 : 1·0, and the ratio of total phosphoric acid (as P_2O_5) to total nitrogen should never fall below 1 : 5 nor exceed 1 : 2.

These are the minimum values the distillery manager should insist on obtaining in the chemical composition of his molasses, and these are the pertinent ratios that must exist for good fermentation work. Other important determinations have already been pointed out, such as the matter of non-fermentable copper-reducing substances almost always present in molasses, the *pH* values, molasses gums, and natural aroma of the material. But for purposes of the efficient and economical conversion of the fermentable sugars into alcohol the controlling items are those already discussed above. The table shows analytical results representative of a good, a medium and a poor molasses for purposes of rum making. The pertinent relations among different constituents are also given.

Since, as already stated, the ideal molasses will not be easily found, or other inferior molasses must by necessity be used, the next question involves the transformation of a poor type of molasses into one of medium or even perhaps good type, through artificial conditioning and pre-treatment at the distillery. This stage of manufacture is being used at present in those distilleries under the technical direction of the writer. We lack the time and space to give a detailed account of the technique followed in this pre-treatment and conditioning operation; but the fact is that this may be accomplished with very little extra labour and expense, the extra expenditure being returned tenfold to the rum producer.[1]

TABLE I.

SHOWING THE COMPOSITION AND CHARACTERISTIC RATIOS BETWEEN COMPONENTS OF A GOOD, FAIR AND POOR SAMPLE OF MOLASSES.

(All Percentages are by Weight).

	Good.	Fair.	Poor.
Brix Density	87·60	85·40	88·20
Total Sugars as Invert, per cent............	57·97	52·91	49·93
True Sucrose, per cent...	36·44	31·30	34·61
Reducing Sugars, per cent.	19·61	19·96	13·50
Ash, per cent.	7·31	9·35	11·57
Total Nitrogen, per cent.	1·10	0·60	0·45
Total Phosphoric Acid, as P_2O_5 per cent.	0·19	0·09	0·21
Gums, per cent.	2·00	2·55	3·75
pH value	5·50	5·70	6·30
Total Sugars—Ash ratio..	7·93	5·65	4·31
Reducing Sugars—Sucrose ratio	0·54	0·64	0·39
P_2O_5—Total Nitrogen ratio	0·17	0·15	0·47
Gums—Total Sugars ratio	0·03	0·05	0·08
Natural Aroma by Steam Distillation	Good	Fair	Indifferent

(*To be continued*).

NEW INSECTICIDES.[2]—Benzene hexachloride is equal to D.D.T. as an insecticide in many respects, and one investigator, E. R. McGovran, has found its gamma isomer to be eight times more toxic to flies when used as a space spray. It is also effective against fly maggots, whereas D.D.T. is found lacking in this direction. Other promising new insecticides are T.D.E., which excels D.D.T. in combating *Anopheles* larvae, though it is less effective against lice, flies and mosquitoes. Chemical '1068' (mixed isomers of $C_{10}H_6Cl_8$) and '3956' (a chlorinated camphene) are pronounced very promising as general insecticides, and their development should be carefully watched.

[1] The reader may find a description of this operation in the writer's work entitled "Studies On Rum," distributed free of charge by the Experiment Station of the University of Puerto Rico, Rio Piedras, Puerto Rico. Information will also be found in recent pages of the *I.S.J.* as indexed under the author's name. [2] Article by E. F. KNIPLING in "Science in Farming," p. 632 (U.S. Department of Agriculture).

The Economics of Rum Production.

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PART II.

(*Continued from page* 294).

It will be pertinent to observe that those backward distilleries which even at the present time are depending on the wild, adventitious yeasts that perchance may exist in their raw material, will never produce rum at economically low prices; and, in the face of a price-competing market, will always be under a great disadvantage. We must not fail to emphasize here that thorough knowledge of the chemical composition of the molasses and of the characteristics of the yeast strain used will influence not only yields and daily outputs of finished product, but also, and to the same extent, its quality as a potable spirit. But, knowing the chemical composition of his molasses, the distiller will be able to remedy its defects in a precise way without guesswork, and will use just the necessary ingredients, without waste of valuable and sometimes scarce chemicals.

CONDITIONING THE MOLASSES.

Let us consider a case of how deficiencies in the chemical composition of molasses should be corrected by scientific pre-treatment and conditioning previous to mashing operations. Suppose that the analysis of the available molasses reads as follows: total sugars (as invert) 50·4 per cent., ash 12·6, total nitrogen 0·6, and total phosphoric acid (as P_2O_5) 0·12 per cent. These analytical results demonstrate the molasses to be low in total sugars (as invert), in nitrogen and in phosphoric acid, but high in ash. The ratio of total sugars (as invert) to ash is below 6·5 : 1 (the minimum acceptable), and while the ratio of phosphoric acid (as P_2O_5) to total nitrogen lies within the accepted low limit, both of these ingredients show deficiencies in actual amounts contained in the molasses.

The thing to do in this particular case is to so treat the molasses during pre-mashing operations that the respective percentages as given above would acquire the following new values: Total sugars (as invert) 52·5 per cent., ash 8·4, nitrogen 1·0, and total phosphoric acid 0·25 per cent. The total sugars concentration need not be raised by the addition of extra sugars to the molasses but merely by the extraction of non-sugars from it. Hence, when treating the molasses for removal of part of the ash and other non-sugars, we are automatically raising the concentration of the total sugars in the material, although, of course, the basic amounts of these sugars remain the same. The lowering of ash, and the raising of the total-sugars concentration, favourably affect the ratio of total sugars to ash and, hence, the efficiency of fermentation. The nitrogen may be raised by adding the amount of ammonium sulphate, or of ammonium hydroxide or carbonate, calculated to raise the percentage of total nitrogen to 1·0; and the phosphoric acid by addition of the amount of phosphoric acid of or calcium superphosphate necessary to raise the percentage of P_2O_5 to 0·25.

In his consulting practice the writer has found very few, if any, rum distilleries to be using a salt of phosphoric acid, or the acid itself, for the correction of the phosphoric acid deficiency in the raw material. He also found that most of those distilleries employing sulphate of ammonia to remedy nitrogen deficiency were using this chemical in certain fixed proportions, irrespective of the content of nitrogen naturally residing in the molasses. In this manner, either not enough of the yeast food was added, or too much of it was being used, in both cases making uneconomical use of the chemical. Savings may also be effected at mashing time by a judicious use of sulphuric acid, but it was also almost always used in fixed quantities, irrespective of the natural titratable acidity and *pH* value of the raw material. We have found the natural *pH* values of molasses used for distillery purposes to vary between the range 5·0 to 6·4. Optimum values for alcoholic fermentation (at least in Puerto Rico) vary between 4·5 and 4·7 *pH*.

Table II shows the fermentation results obtained when using the different molasses, whose analyses were given in Table I of Part I. In these tests no conditioning of the molasses was done, as the object was to find out the results obtainable when fermenting these molasses in their natural state, using the same amount of total sugars concentration in every comparative test. The results show the great advantages of obtaining the right sort of raw material when purchasing molasses for distillery purposes.

SETTING UP THE MASH.

Having acquired the right quality of molasses, either through expert choice when purchasing, or through correction of deficiencies after purchasing, the next step leading to economical use of the sugars in the molasses comes at the moment of mashing, when dilution to the proper density for fermentation must be effected. It should be remembered here that the ideal fermentation from an economic point of view is that which would convert *all* of the available fermentable sugars into alcohol in the shortest possible time. At this point, not only the chemical constitution of the molasses must be considered, but also the inherent characteristics of the yeast strain used as fermenting agent. A third important factor entering here is the available facility for controlling the temperature of the substrate during the period of fermentation.

TABLE II.

COMPARATIVE RESULTS OF FERMENTATION TESTS (using the three types of Molasses described in Table I).*

Molasses Type No.	Test No.	Initial Brix	Total Sugars, grm. per 100 ml.	Initial *pH* Value.	Fermentation Time, hours	Final Brix.	Final *pH* Value.	Residual Sugars, grm. per 100 ml.	Attenuation.	Alcohol by Volume. per cent.	Grm. Alcohol per 100 ml. beer.	Alcoholic Yield on T. Sugars, per cent.	Fermentation Efficiency per cent.
1	1	15·00	10·87	5·20	25·50	4·30	4·85	0·56	10·70	6·35	5·01	46·09	94·93
(GOOD)	2	18·00	12·76	5·20	30·00	5·50	4·90	0·60	12·50	7·50	5·92	46·45	95·67
	3	20·00	14·78	5·20	30·00	6·20	4·97	0·67	13·80	8·80	6·95	47·00	96·80
2	1	17·00	10·87	5·20	30·00	6·80	4·85	1·02	10·20	6·05	4·78	43·97	90·56
(FAIR)	2	19·80	12·76	5·20	36·00	7·90	4·80	1·18	11·90	7·20	5·68	44·51	91·67
	3	22·50	14·78	5·20	40·50	9·20	4·90	1·37	13·30	8·15	6·43	43·50	89·59
3	1	18·00	10·87	5·20	36·00	8·90	4·80	1·67	9·10	5·60	4·42	40·68	83·78
(POOR)	2	21·00	12·76	5·20	42·50	9·85	4·87	2·03	11·15	6·30	4·97	38·99	80·30
	3	24·50	14·78	5·20	48·00	11·80	4·85	2·33	12·70	7·00	5·53	37·39	77·01

* Page 294.

In the first place, the initial concentration of total sugars at which the material is mashed should depend on the ability of the yeast to use these sugars efficiently in their conversion to alcohol. Mashing at higher sugars concentrations than those within the range of the yeast used will only result in a great economic loss of residual sugars via the factory slops.

The writer had a case in his consulting practice where mashing was being done at 30° Brix density, and after fermentation was over, only 5 per cent. of alcohol by volume had been obtained in the resulting "beer"; more than 50 per cent. of the available sugars being wasted as residual sugars in the distillery slops. On examination of conditions, it was found that the mash, if properly fermented, using the right type of yeast strain, should have yielded not less than 12·0 per cent. of alcohol by volume. This represented an extreme case of carelessness and utter disregard of waste and loss.

Different strains of rum yeasts require differences in the setting of the mash so that they may perform their work of sugars conversion into alcohol under optimal conditions. Of special importance in this respect are the initial total sugars concentration, balancing of yeast nutrients, *pH* and temperature. Therefore, the distiller should know, or should find out by actual tests, what the optimum conditions are for his particular case. Table III shows fermentation results obtained from different yeast strains under variable conditions of total sugars concentrations. It also shows the optimum values, from an economic standpoint, of total sugars concentrations, in the case of each strain of yeast tested.

The initial total sugars concentration that may be used at mashing is also dependent on the temperature at which the subsequent fermentation of the material will take place. This point is one of real practical and economic value, especially in the tropics, where high temperatures of fermentation are apt to occur unless artificial refrigeration of the fermenting mash is resorted to. Mashes intended to be fermented at temperatures within the range 35–40°C. cannot be mashed at high sugars concentrations; while the lower the temperature at which fermentation shall take place (within the range of the yeast), the higher the initial sugars concentrations may become.

HIGH-ALCOHOL BEERS.

Our insistence in this article upon the importance of availability of cool deep-well or surface water at the rum distillery lies in the proven fact that, without proper control of fermentation temperature, the formation of high-alcohol concentrations in the fermenting mash becomes an impossibility. By high alcoholic concentrations in the beers, we mean percentages of alcohol by volume within the range 10–13 per cent., this being dependent primarily on three factors: (1) the method of fermentation; (2) the fermentation temperature control; (3) the inherent ability of the yeast strain to build-up and withstand such high alcoholic concentrations while giving high yields and efficiencies.

Another economical effect of forming high-alcohol concentrations during fermentation lies in the fact that fermentation failures due to infections from harmful bacteria are practically eliminated. When, due to a breakdown or to a strike, the fermenting vats must be left standing for long periods of time filled with fermented mash, if high concentrations of alcohol exist in the beers there is no fear that any harm will come through souring of the liquid due to bacterial attack during the enforced period of rest. The writer remembers a case of his own experience when six fermenters of the closed type were left filled with fermented mash for a period of six weeks. On resuming distillation it was found that all six fermenters had kept very well; no coating of any kind could be observed over the surface of the fermented liquid, and the only loss of alcohol was sustained through evaporation, but this was not greater than 0·4 per cent. in any of the contents of the six fermenting vats. It was significant that the average initial alcoholic content of the fermented liquid was over 12·0 per cent. by volume.

In the distillation end of the distillery, and in the boiler-house, we also find the economic advantages

TABLE III.

SHOWING FERMENTATION RESULTS OBTAINED FROM DIFFERENT YEAST STRAINS UNDER VARIABLE TOTAL SUGARS CONCENTRATIONS;

AND OPTIMUM VALUES OF SUGAR CONCENTRATION FOR EACH STRAIN.

Number of Fermentation Tests	Grm. Total Sugars per 100 ml. mash.	Residual Sugars, per Sugars, grm. per 100 ml. beer.	Yield of Absolute Alcohol, per cent. on Total Sugars.	Fermentation Efficiency, per cent.	Total grm. Alcohol produced per 100 ml. mash.	Optimum Total Sugars Concentration grm./100 ml. mash.
YEAST STRAIN No. 502:						
1	10·14	0·71	43·79	90·21	4·43	
2	10·87	0·89	43·68	89·98	4·75	
3	11·59	0·89	43·44	89·49	5·03	
4	12·32	1·07	43·17	88·93	5·32	
5	13·04	1·09	43·05	88·67	5·61	13·04
6	13·77	1·32	41·91	86·34	5·77	
7	14·49	1·60	40·90	84·26	5·92	
8	15·22	2·05	38·42	79·13	5·84	
9	15·94	2·20	37·14	76·51	5·92	
YEAST STRAIN No. 766:						
1	10·15	1·06	42·74	88·05	4·34	
2	11·11	1·09	42·47	87·49	4·72	
3	12·06	1·16	42·44	87·43	5·12	
4	13·00	1·27	42·53	87·60	5·53	
5	13·98	1·37	42·24	87·00	5·91	
6	14·94	1·88	42·15	86·83	6·30	14·94
7	16·03	2·15	39·27	80·90	6·29	
8	16·98	2·45	37·26	76·76	6·32	
9	17·94	2·69	34·86	71·80	6·25	
YEAST STRAIN No. 533:						
1	9·88	0·55	43·92	90·46	4·34	
2	11·52	0·70	43·49	89·59	5·01	
3	12·18	0·89	43·26	89·11	5·27	
4	13·03	1·05	42·89	88·34	5·59	
5	13·88	1·21	42·28	87·08	5·87	13·88
6	14·97	1·78	40·68	83·78	6·09	
7	15·45	2·35	37·54	77·32	5·80	
8	16·29	2·59	35·36	72·83	5·76	
YEAST STRAIN No. 531:						
1	10·12	0·45	47·28	97·39	4·78	
2	12·20	0·60	46·81	96·41	5·71	
3	14·57	1·02	46·26	95·28	6·74	
4	15·12	1·25	45·21	93·13	6·84	
5	15·67	1·62	43·98	90·58	6·89	15·67
6	16·37	1·90	41·34	85·16	6·77	
7	16·92	2·35	38·94	80·21	6·59	
8	17·48	2·81	35·63	73·40	6·22	

of high-alcohol beers. In the first place, high-alcohol beers, produced under controlled temperatures, will have almost identical alcoholic strengths, i.e., the percentages of alcohol by volume in beers from different fermenters will not vary to any extent. It is well known how beneficial this is in the operation of the still, as one setting of the operation conditions will keep unchanged for long hours. On the contrary, fluctuations in the alcoholic concentrations of the beers from different fermenters leads to constant setting and re-setting of injection water valves, steam valves, beer feed control, etc., all of which is detrimental to efficient operation of the still. A great saving of steam is also produced during distillation of high alcohol beers, due to the fact that the boiling point of the liquid entering the feed plate is lower than is the case with low alcohol beers, and also due to the fact that less refluxing is necessary for attaining a predetermined alcoholic concentration of the final distillate. The unit output of stills handling high alcohol beers is from 50–100 per cent. higher than those handling low alcohol beers. The economy of steam per proof gallon produced is very apparent in the former over the latter.

A final necessity for ensuring economy in the distillery (but by no means the least) is the technical training and practical experience of the superintendent or manager, and the chemist. The existence of a well-equipped control laboratory where all the necessary analytical work may be conveniently effected is also of paramount importance. If should be equipped for carrying out at least the following determinations: nitrogen, phosphoric acid, ash, total sugars, density readings, *pH*, titratable acidities, alcohol in the final products, in the beers and in the slops, and other miscellaneous tests of lesser importance that become necessary from time to time. It should also be provided with the necessary apparatus and chemicals for the performance of the biological work in connexion with the yeast.