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PRODUCTION OF LIGHT-BODIED RUM BY AN EXTRACTIVE DISTILLATION PROCESS

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SUMMARY

Extractive distillation is a process for simultaneously separating heads and fusel oil from rum high wine by adding water to the top plate of a distilling column. These congeners are removed from the condenser while ethanol at 5-10 p. 100 by volume is removed from the base.

The amount of amyl, butyl and propyl alcohol removed by this operation is a function of 1) the volatility of the particular congener with respect to ethanol, 2) ethanol concentration at the base, 3) reflux ratio (L/V) in the stripping section, 4) the quantity of distillate removed from the condenser. The effect of these variables on percentage of congener removal is presented for a column consisting of 25 stripping and 10 concentrating plates.

By operating an extractive distillation column and a rectifying column in series, light-bodied rum can be produced at 189-190° proof. By means of computerized calculations of the performance characteristics of both of these columns, the fusel oil composition of the rum product can be predicted for any set of operating conditions.

The advantages and disadvantages of this process will be compared with those of a BARBET system in which fusel oil is removed by a fusel oil concentrating column.

INTRODUCTION

The distilling industry owes a debt of gratitude to those technologists in Europe who, during the 19th and 20th centuries, contributed so much toward the development of the science and practice of distillation. Through the efforts of men like CELLIER-BLUMENTHAL, COFFEY, BARBET, GUILLAUME, SOREL, KIRSCHBAUM, HAUSBRAND, RICARD and GUINOT, processes were developed for distillation of fine quality neutral spirits (KIRK and OTHMER, 1963). Today these same techniques are used throughout the world for both beverage and industrial alcohol production.

Separation of congeners from ethanol by distillation

Ethyl alcohol produced by fermentation and distilled on a simple beer still (or analyzing column) contains small concentrations of many components or congeners which may contribute pleasant flavors to some products but which are undesirable in neutral spirits. In order to separate these constituents from ethanol, it is necessary to know how they behave in a distilling column. Their behavior can be classified into four groups as follows :

1) those whose boiling point is less than that of alcohol and can always be removed as heads constituents from the condenser of a distilling column ;
2) those which are soluble in water and whose boiling point is higher than that of water and can always be removed as tails (dregs) from the bottom of the column ;
3) those which are insoluble or only partially miscible with water but whose boiling point is greater than that of water ;
4) those which boil between water and alcohol.

It is these latter two groups of congeners (for example the higher boiling alcohols and esters) which are the most difficult to remove.

BARBET developed continuous distilling processes in which these particular congeners are concentrated and removed as a side draw-off (tails) from the mid-point of a column producing high proof spirits.

However, GUILLAUME (1911) and RICARD and GUINOT (1933) recognized that these constituents at low ethanol concentration behave like heads and can be separated together with the low-boiling aldehydes and esters as a draw-off stream from the condenser. This makes it possible to substantially purify the ethyl alcohol in a single column so that a second column is required only to raise the concentration to 95-97° G.L. (190-194° U.S. proof) in order to remove the remaining congeners and to produce a neutral spirit.

This behavior pattern is illustrated in figure 1 which shows the correlation between volatility of the higher boiling alcohols (fusel oils) and ethanol proof. At high ethanol concentration, they are less volatile than ethyl alcohol and will concentrate in a rectifying column at a plate where the ethanol concentration is 110-160° proof (depending upon the specific alcohol and reflux ratio). At low ethanol concentration (especially 20° proof or less) their volatility is greater than that of ethyl alcohol and they will behave as heads constituents. In figures 2, 3 and 4 the same correlation is shown : 1) for acids which are always less volatile than ethanol, 2) for various aldehydes and 3) for various esters.

The Extractive distillation process

The GUILLAUME principle of separating the low-boiling congeners together with the higher-boiling alcohols as heads by adding water to the top plate of the column and stripping the ethanol freed stream at low proof is now called extractive distillation.

For example, as shown in figure 5, the feed stream containing congeners is introduced into the column (plate 37) and boiling is induced either by injection of live

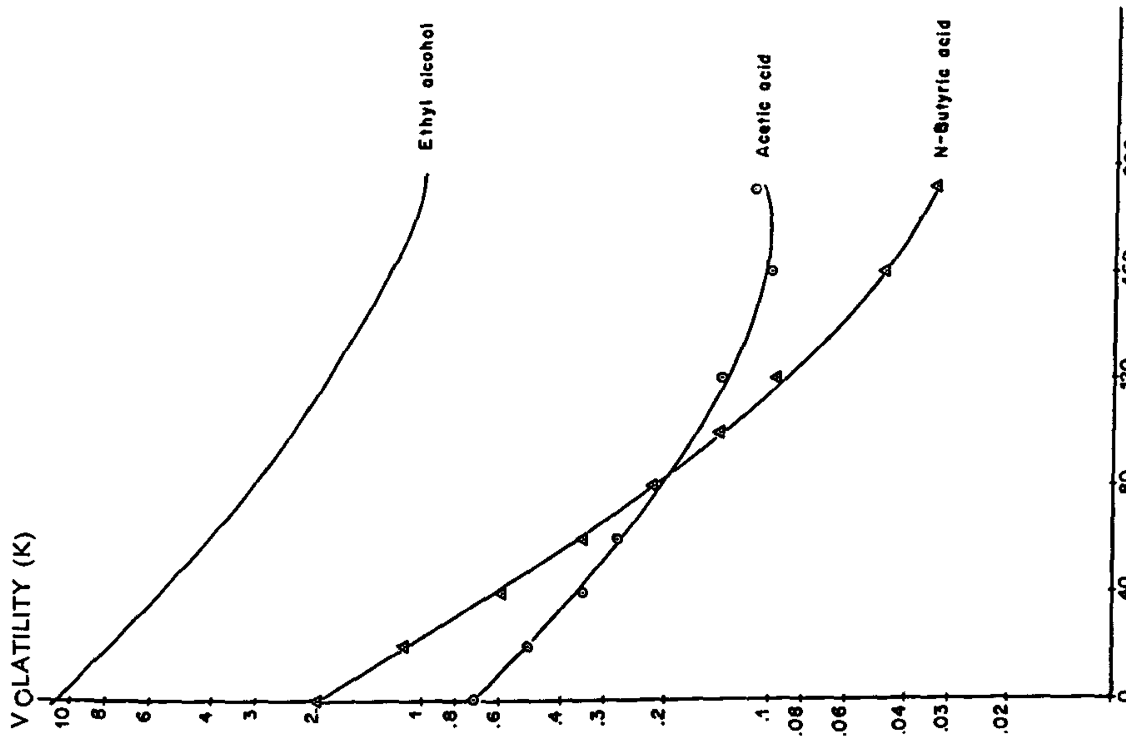

FIG. 2. — *Volatility of acids vs alcohol proof*

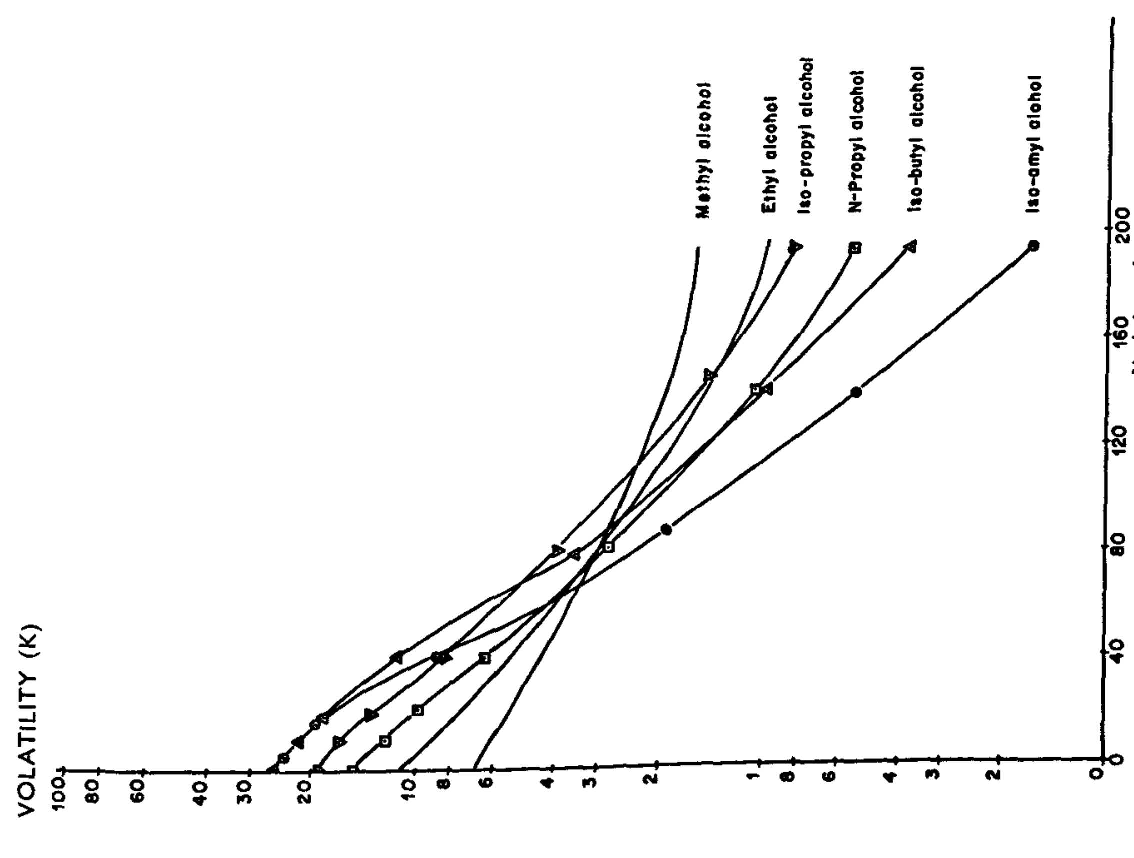

FIG. 1. — *Volatility of fused oils vs alcohol proof*

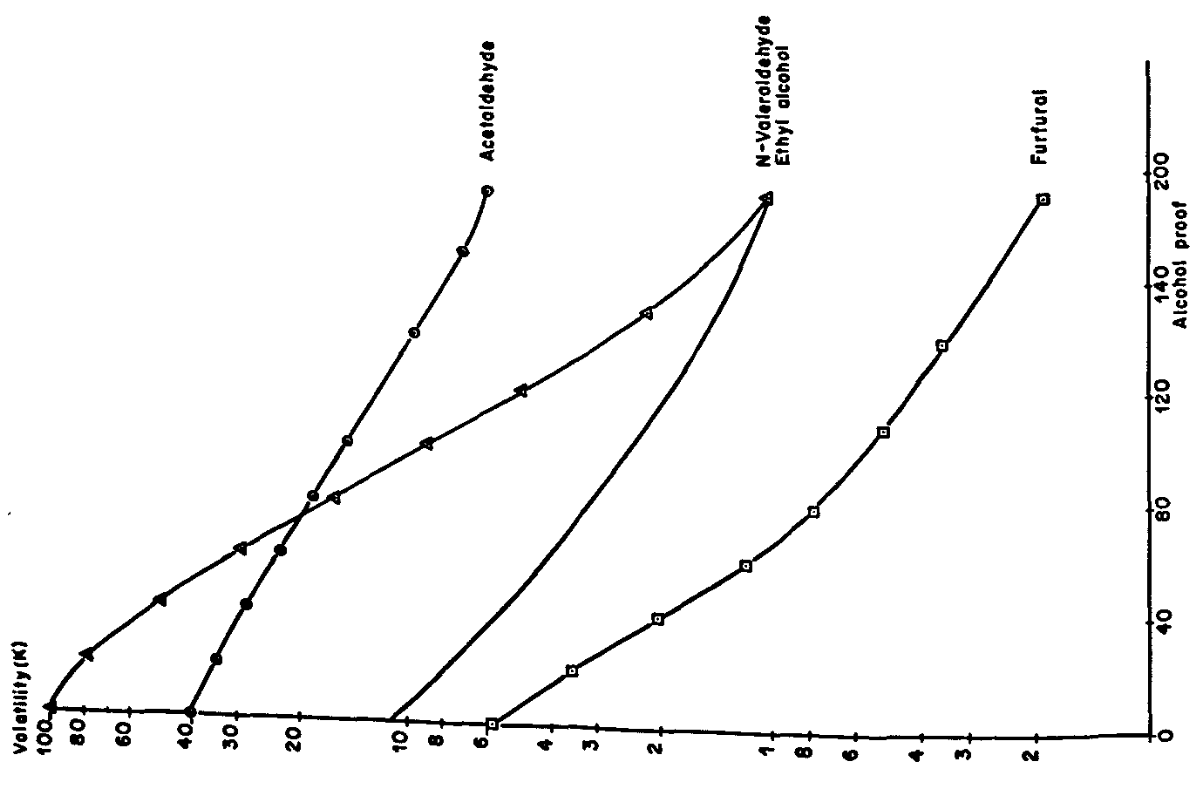

FIG. 3. — *Volatility of aldehydes vs alcohol proof*

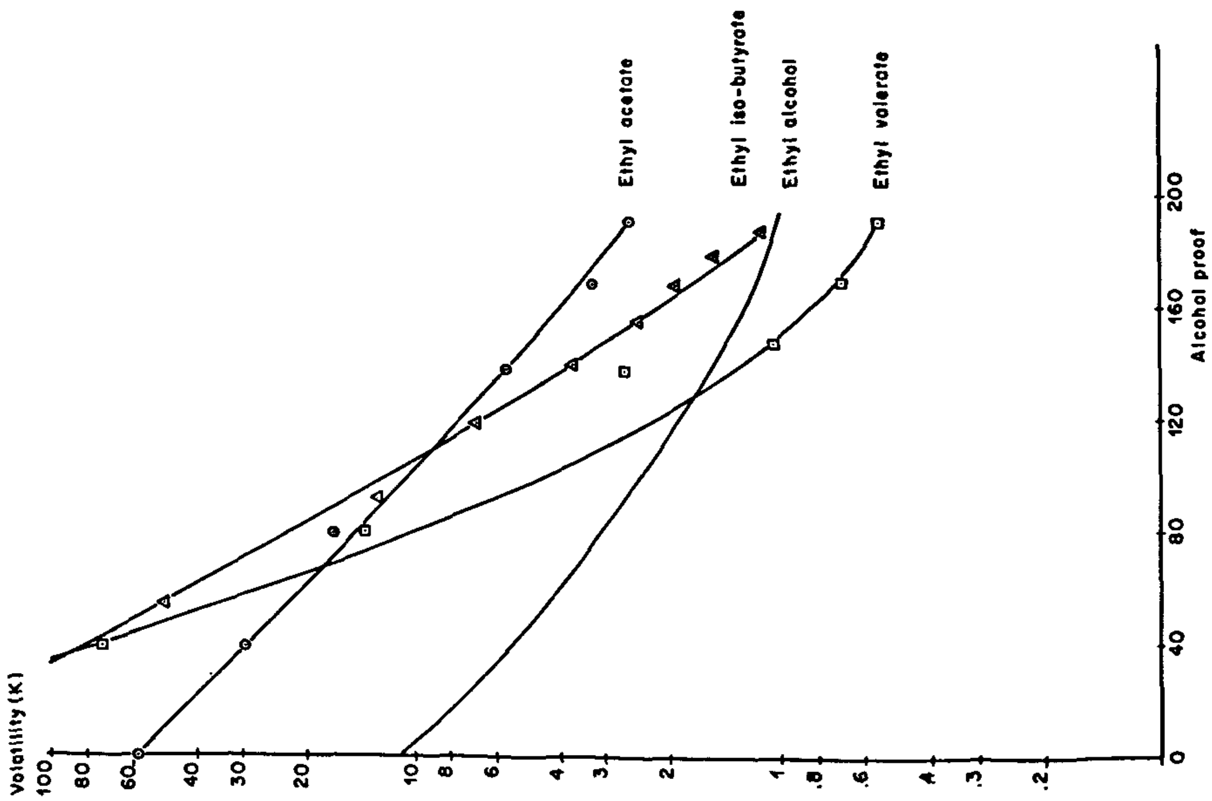

FIG. 4. — *Volatility of esters vs alcohol proof*

steam at the bottom or by means of a steamheated reboiler (calandria). Water at its boiling point is fed to the top plate (50). Heads from the condenser, containing both low-boiling congeners (aldehydes, esters) and fusel oils are withdrawn from a decanter, and the product stripped of these congeners is removed from the bottom at 5-10° G.L. (10-20° U.S. proof). A characteristic of this operation is that a zone of substantially constant ethanol concentration is maintained starting at a point 3-5 plates above the bottom of the column and extending up to the feed plate. This concentration is called the « pinch-proof ». Above the feed plate, the ethanol concentration decreases due to the fact that water is added to the top plate. The entire column operates at low ethyl alcohol concentration, a condition which renders the higher-boiling alcohols and the water-immiscible esters more volatile than ethanol. The purified ethyl alcohol discharged at the bottom is then concentrated to the desired proof in a rectifying column.

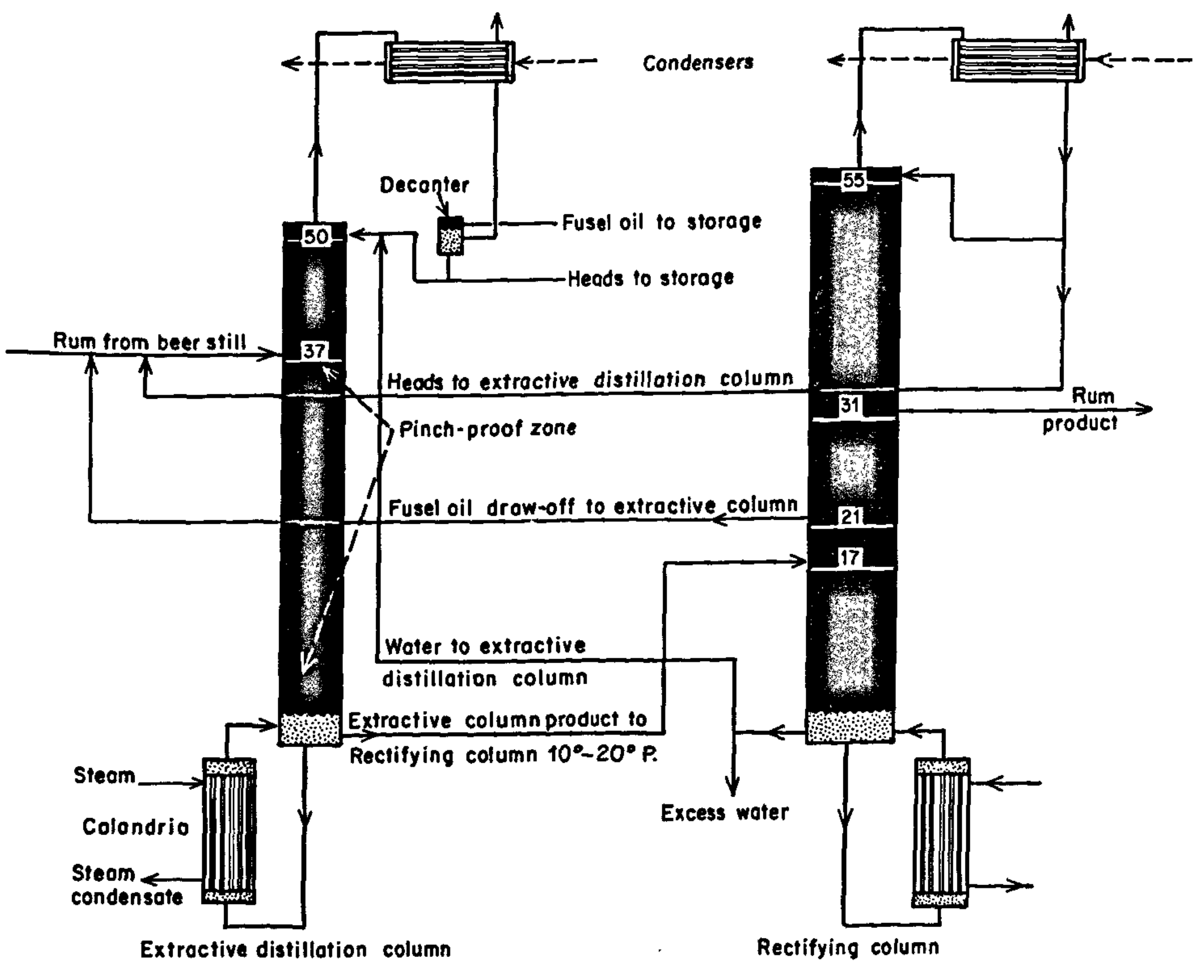

FIG. 5. — *Extractive distillation process*

The degree of removal of a particular congener is determined by four factors : 1) its volatility at the ethyl alcohol concentration on the plates, 2) the number of stripping and concentrating plates in the column, 3) the reflux ratio in the stripping section and 4) the percentage of ethanol in the feed that is removed from the condenser stream.

Figure 6 shows the removal efficiency of *iso*-amyl alcohol as a function of reflux ratio in the pinch-proof section and of ethanol concentration at the bottom of the

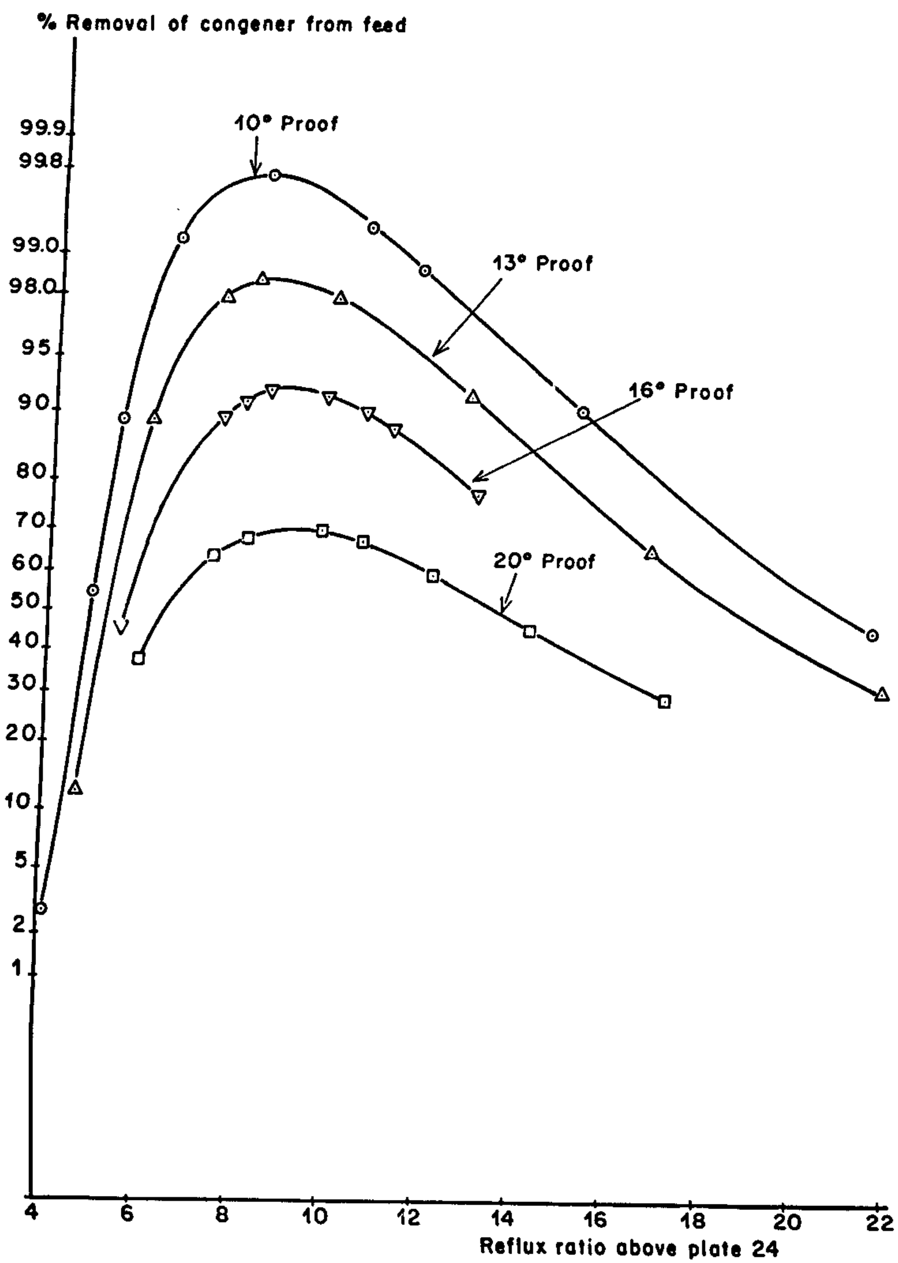

FIG. 6. — *Effect of reflux ratio above plate 24 and proof at bottom of column on efficiency of removal of* iso-amyl *alcohol by extractive distillation*

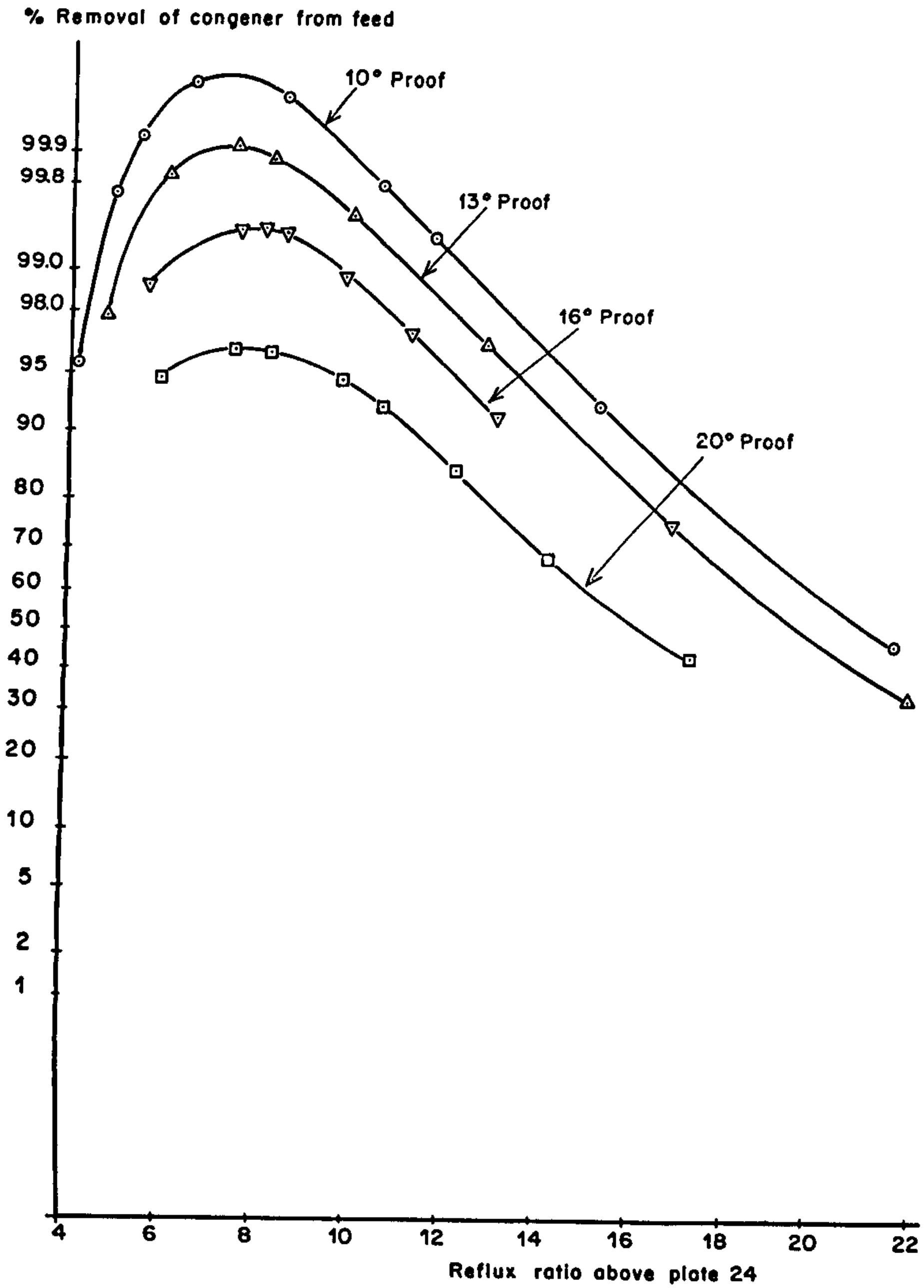

FIG. 7. — *Effect of reflux ratio above plate 24 and proof at bottom of column on efficiency of removal of* iso-butyl *alcohol by extractive distillatiol*

column. These values apply to a column heated by live steam and consisting of 25 stripping and 10 concentrating plates in which 1 p. 100 of the ethanol in the feed stream is removed from the condenser together with the higher-boiling alcohols. The efficiency of *iso*-amyl alcohol removal is a function of ethyl alcohol concentration at the bottom of the column, and increases as ethanol concentration decreases. In addition, an optimum reflux ratio exists for maximum removal. Figure 7 shows the same relationship for isobutyl alcohol removal. This process can achieve a high percentage of removal of these two congeners but in the case of *n*-propyl alcohol (fig. 8) removal is poor under all operating conditions. This is due to the fact that, even at low ethanol concentration, this congener has a volatility only slightly higher than that of ethyl alcohol.

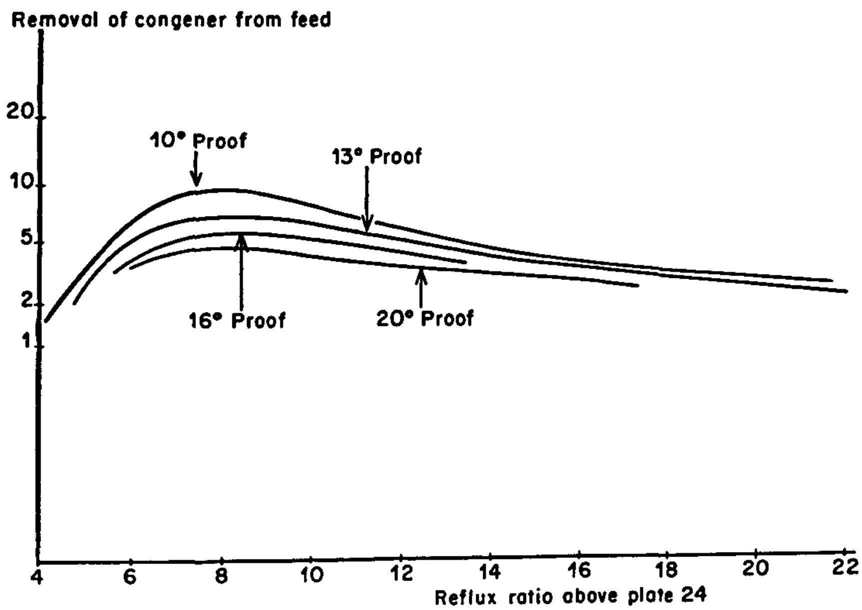

FIG. 8. — *Effect of reflux ratio above plate 24 and proof at bottom of column on efficiency of removal of* n-*propyl alcohol by extractive distillation*

The percentage of congener removal was determined for each operating condition of bottom proof and reflux ratio by means of a computer which is programmed to process the operating data input and perform the necessary computations. These include calculations of :

1. The reflux ratio on each plate based upon the desired proof at the bottom of the column and desired pinch-proof. This calculation takes into consideration the enthalpy (heat content) of liquid and vapor flowing into and out of each plate and corrects for the effects of operating pressure and heat radiation loss from each plate.

2. The volatility of both ethyl alcohol and congeners as a function of liquid proof on each plate. This calculation takes into consideration the plate efficiency which is dependent upon ethanol concentration in the liquid phase.

For the total column and for each plate a balance exists so that : 1) heat in equals heat out and, 2) ethanol, water and congener in equals ethanol, water and congener out.

The physical data used for these calculations were obtained from the sources shown in table I and are stored in the computer program in the form of hyperbolic equations. A similar computer program has been developed for predicting the performance of a rectifying column and also for other distillation processes which we employ.

TABLE I

Souce of data used in Computer program for extractive distillation

A. Enthalpy of alcohol-water liquid mixtures.
B. Enthalpy of alcohol-water vapor mixtures.
C. Boiling temperature of alcohol-water mixtures.

SMITH D. A., LUONG J., BROWN G. G., WHITE R. R., 1945. *Petroleum Refiner*, **24**, 296.

D. Volatility of alcohol-water mixtures.

ALTSHELER W. B., UNGER E. D., KOLACHOV P., 1954. *Ind. Eng. Chem.*, **43**, 2559.
CAREY J. S., LEWIS W. K., 1932. *Ind. Eng. Chem.*, **24**, 882.
CORNELL L. W., MONTONNA R. E., 1933. *Ind. Eng. Chem.*, **24**, 1331.
JONES C. A., SCHOENBURN E. M., COLBURN A. P., 1943. *Ind. Eng. Chem.*, **35**, 666.
KIRSCHBAUN E., GERSTNER F., 1939. *Verfahrenstechnik Z.*, **1**, 10.
RIEDER R. M., THOMPSON A. R., 1949. *Ind. Eng. Chem.*, **41**, 2905.
OTSUKI H., WILLIAMS E. C. Symposium 6, University of California, Berkeley, Cal.

E. Plate efficiency.

SCHOENBORN E. M., PLANK C. A., WINSLOW C. E., 1959. *Final report North Carolina State College, A.I. Ch.E. Research Committee.*

F. Heat loss by radiation.

Johns-Manville, Technical data catalogue, 1939.
Heat loss from bare surfaces and efficiency of insulation.

G. *Volatility of higher boiling alcohols in alcohol-water mixtures*, 1950.

DODGE W. B., Thesis, University of Louisville.

Production of light-bodied rum in Hawaii by extractive distillation and rectification

This extractive distillation and rectification process was employed at our distillery in Hawaii to produce rum intermediate in flavor intensity between a neutral product such as cane spirits and a heavy-bodied (flavorful) rum produced by distillation on a single column beer still only. In order to meet United States requirements, the product must be distilled at a proof less than 190° U.S. proof (95° G.L.) and must have the taste and aroma characteristics of rum.

The operating data and the corresponding computed values are shown in table 2. The close agreement between measured and computed values demonstrate the validity and value of the use of a computer for predicting the performance of proposed operating procedures or in re-producing existing operations. We now use this technique for both purposes in our distillery operations.

In table 3, a comparison is made between the measured and computed concentrations of the higher boiling alcohols in the rum product based upon the analysis of the rum fed to this distillation system. Since heads from the rectifying column and

TABLE 2

Production of light-bodied rum by extractive distillation and rectification

	Measured values	Computed values
Extractive distillation column		
1. Feed to column. Gallons per hour	85	85.15
2. Alcohol concentration in feed. ° Proof	160	159.98
3. Alcohol concentration exit bottom. ° Proof	12-13	12
4. Steam into calandria. Lbs. per hour	650-700	662
5. Reflux to top plate. Gallons per hour	50	64.2
6. Alcohol concentration at condenser. ° Proof	10-14	9.83
7. Heads draw-off rate. Gallons per hour	0.5	0.554
Rectifying column		
1. Reflux to top plate. Gallons per hour	500	532
2. Heads draw-off rate. Gallons per hour	3	3
3. Product draw-off rate. Gallons per hour	66	65.5
4. Alcohol in product. ° Proof	189.3	189.3
5. Fusel oil draw-off rate. Gallons per hour	4	4.15
6. Alcohol in fusel oil draw-off. ° Proof	135	135
7. Steam to calandria. Lbs per hour	1 600	1 546

TABLE 3

Comparison of measured concentration of higher boiling alcohols in light-bodied rum vs. computed concentration

Stream	Flow rate Proof gallons per hr.	Higher boiling alcohol concentration Grams per 100 proof liters		
		Iso-amyl	Iso-butyl	N-propyl
Rum from beer still	124.8	98.25**	18.65**	46.1**
Heads from rectifying col.	5.82	0.00*	0.00*	0.00*
F.O. draw-off rectifying col.	5.605	1 380.2*	106.3*	756.9*
Feed to extractive col.	136.22	146.81*	21.46*	73.38*
Product from extractive col.	136.166	57.10*	5.65*	73.14*
Product from rectifying col.	123.98*	0.3*	1.4*	46.2*
Product from rectifying col.	124.8**	N.M.A.**	6.1**	49.0**

N.M.A. : No measurable amount.
* : Computed values.
** : Values measured.

TABLE 4

Comparison of computed fusel oil concentrations in neutral spirits produced by GUILLAULE *vs* BARBET *distillation processes*

	GUILLAUME process				BARBET process			
	Proof gallons per hour	Fusel oil concentrations Grams per 100 proof liters			Proof gallons per hour	Fusel oil concentrations Grams per 100 proof liters		
		Amyl	Butyl	Propyl		Amyl	Butyl	Propyl
Feed to process	500	98.25	18.65	46.1	500	98.25	18.65	46.1
Extractive distillation colum								
Feed to process	500	98.25	18.65	46.1				
Heads recycle from rect. col.	24.7	0.0	0.0	0.0				
Fusel oil recycle from rect. col.	24.7	4.9	0.0	8 641				
Total feed to column	549.4	89.64	16.97	430.4				
Product to rect. column	544.4	0.2	0.0	394.5				
Heads and fusel oil to storage	5.0	9 825	1 865	4 270				
Heads purifying column								
Feed to process					500	98.25	18.65	46.1
Heads recycle from rect. col.					29.05	0.0	0.0	0.0
Heads recycle from fused oil col.					57.12	0.0	0.0	1.2
Total feed to column					586.17	83.81	15.91	39.44
Product to rect. column					582.17	84.39	16.02	39.71
Heads to storage					4.0	—	—	—
Fusel oil concentrating column								
Feed from rect. column					58.12	845	160.5	397.5
Heads to purifying column					57.12	0.0	0.0	1.2
Fusel oil draw-off to storage					1.0	49 130	9 334	23 035
Rectifying column								
Feed from extract. or purifying col.	544.4	0.2	0.0	394.5	582.17	84.39	16.02	39.71
Heads to extract. or purifying col.	24.7	0.0	0.0	0.0	29.05	0.0	0.0	0.0
Fusel oil draw off to extract. or f.o. col.	24.7	4.9	0.0	8 641	58.12	845	160.5	397.5
Alcohol loss at bottom of col.	1.9	—	—	—	.03	—	—	—
Neutral spirits product	493.1	0.0	0.0	3.4	495	0.0	0.0	0.2

the fusel oil draw-off stream from plate 21 of this column are recycled to the feed stream of the extractive distillation column, it is necessary to calculate the concentration of higher boiling alcohols in this feed stream.

The computed concentrations of higher boiling alcohols in the distilled rum product agree with the actual values, with the exception that actual *iso*-butyl alcohol concentration is appreciably higher (6.1 grams per 100 proof liters) than the computed value (1.4 grams per 100 proof liters). This difference probably indicates an error in the data on volatility of iso-butyl alcohol used in the computer program. It should be noted that very little *n*-propyl alcohol was removed in this operation due to the fact, previously mentioned, that degree of removal of this congener by extractive distillation is relatively poor and because only a samll fraction (0.04 p. 100) of the ethanol fed to this column was removed in the hads stream.

Appendix shows the print-out generated by the computer program for the extractive distillation operation and for the rectification operation.

Comparison of GUILLAUME *and* BARBET *processes for production of neutral spirits*

The question may arise as to which process produces the purest grade of neutral spirits in terms of fusel oil removal, the GUILLAUME system consisting of an extractive distillation colum and a rectifying column or a BARBET system consisting of a heads purifying column, a rectifying column and a fusel oil concentrating column. Computations were performed for both processes in which 1 p. 100 of the ethanol in the feed was removed as heads and tails. The following results represent a hypothetical operation and not an actual one conducted in the distillery.

GUILLAUME *process.*

For the GUILLAUME process, conditions were assumed as shown in figure 9 such that fusel oil removal could be achieved in the extractive distillation column by operating at 13° U.S. proof at the bottom of the column and at a « pinch-proof » of 37° 6 which is optimum for fusel oil removal at this bottom proof. In this operation, feed at a rate of 500 proof gallons per hour is combined with recycled heads and tails from the rectifying colum. Five proof gallons per hour (1 p. 100 of the ethanol in the feed) are removed from the extractive distillation column condenser stream. The product from the bottom of this column is transferred to the rectifying column and neutral spirits at 192° 8 proof are removed from Plate 45 of this column. Heads are removed from the condenser and fusel oils containing 130° proof ethyl alcohol are removed from Plate 21 for recycle to the extractive distillation column.

BARBET *system.*

For the BARBET process, as shown in figure 10, feed at a rate of 500 proof gallons per hour is combined with heads from the rectifying column and heads from the fusel oil concentrating column. This mixture is first distilled on a heads purifying column to strip and concentrate the low-boiling congeners (aldehydes and esters) which are removed together with ethanol from the condenser stream at a rate of 4 proof gallons per hour.

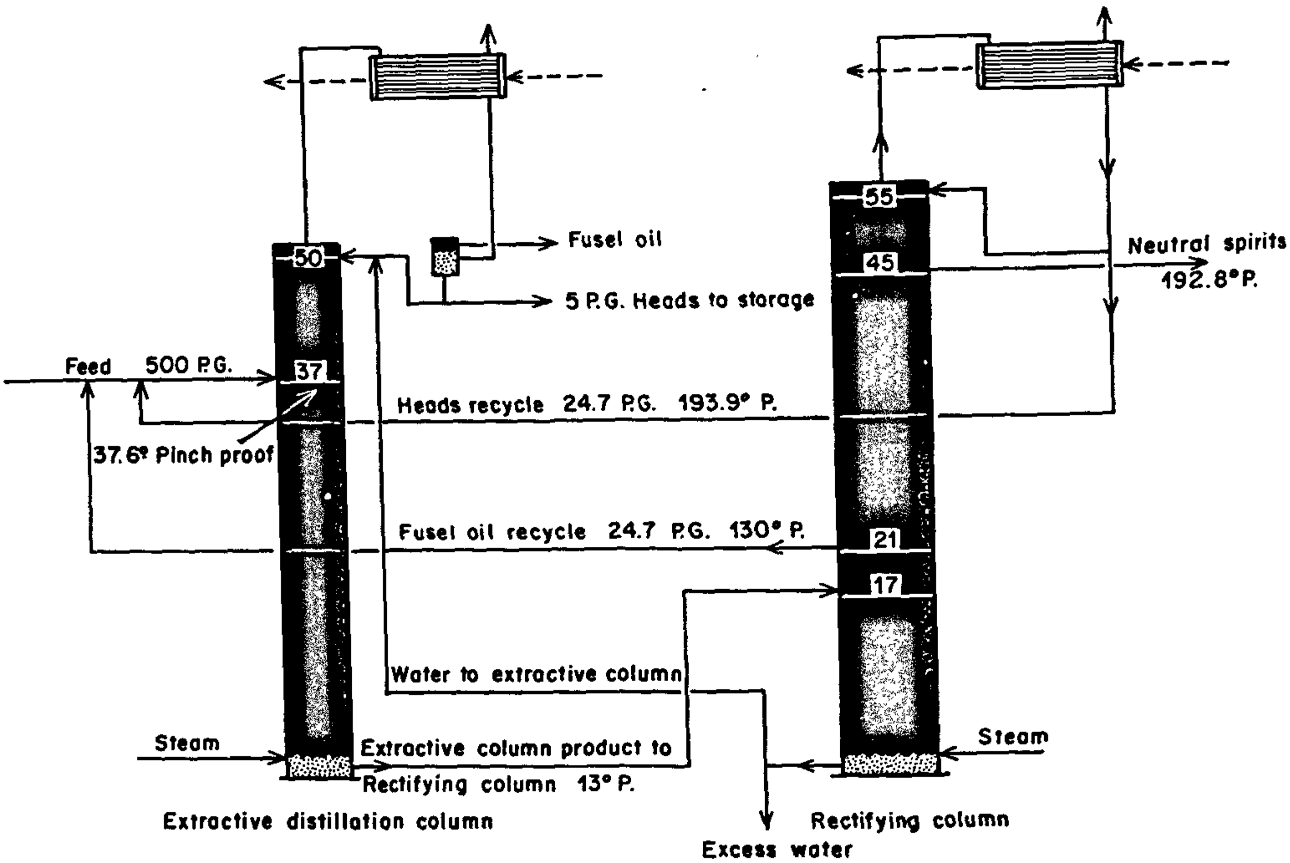

Fig. 9. — *Distillation of neutral spirits by* Guillaume *process*

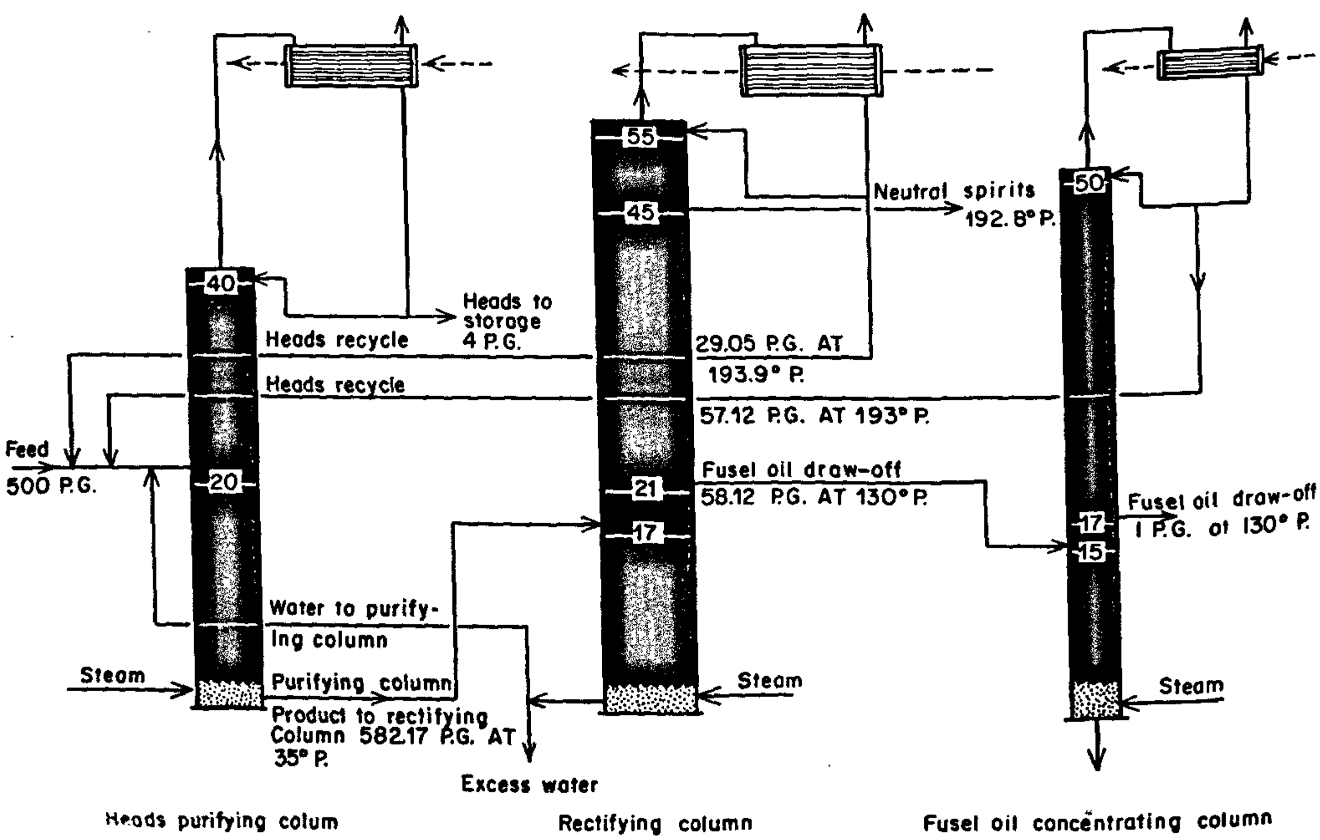

Fig. 10. — *Distillation of neutral spirits by* Barbet *process*

The product from the bottom of this column at 35° proof is then transferred to the rectifying column. In this column, heads are removed from the condenser and recycled to the heads purifying column, neutral spirits are with-drawn from Plate 45 as product and fusel oils containing 130° proof ethanol are withdrawn from Plate 21 and transferred to a fusel oil concentrating column. Heads from the condenser of this column are also transferred to the heads purifying column and fusel oils containing 130° proof ethanol are withdrawn from Plate 17 at a rate of one proof gallon per hour.

In order to compare-fusel oil removal in these two distillation processes, the higher-boiling alcohols in the various streams into and out of the distilling columns for both the GUILLAUME and BARBET systems were computed and are illustrated in table 4. Our results show that the neutral spirits produced by the GUILLAUME process contain no measurable amount of amyl or butyl alcohols, but do contain 3.4 grams per 100 proof liters of *n*-propyl alcohol. The neutral spirits produced by the BARBET process also contain no measurable amount of amyl or butyl alcohols and only 0.2 grams per 100 proof liters of *n*-propyl alcohol.

CONCLUSIONS

Our overall conclusions based upon computations such as these, and also upon actual operations conducted in our distilleries, is that a BARBET system yields a more neutral, more nearly pure spirit than a system based upon the GUILLAUME extractive distillation process. The GUILLAUME system, however, does have an advantage in that only two distilling columns are required while the BARBET process requires at least three columns to produce a neutral spirits.

For producing distillates with intermediate flavor intensity, the extractive distillation and rectification system described in this report is entirely satisfactory and produces light-bodied rum of good quality.

RÉSUMÉ

PRODUCTION DE RHUM LÉGER PAR LA MÉTHODE DE DISTILLATION AVEC EXTRACTION

La distillation avec extraction permet de séparer simultanément des produits de tête et l'huile de fusel du « high wine » (alcool à 60-70 p. 100) du rhum en ajoutant de l'eau sur le plateau supérieur de la colonne de distillation. Ces impuretés sont chassés du condenseur tandis que l'éthanol à 5-10 p. 100 par volume est chassé à la base.

La quantité d'alcool amylique, butylique et propylique éliminée au cours de cette opération est fonction de : 1) la volatilité de l'impureté particulière par rapport à l'éthanol, 2) la concentration d'éthanol à la base, 3) taux de reflux (L/V) dans les plateaux d'épuisement, 4) la quantité de distillat chassée du condenseur. L'effet de ces variables sur le pourcentage d'enlèvement des impuretés est décrit pour une colonne formée de 25 plateaux d'épuisement et 10 plateaux de concentration.

En mettant en série une colonne de distillation avec extraction et une colonne de rectification, on peut produire du rhum léger à 189-190° proof. Grâce à un traitement par ordinateur des performances de ces deux colonnes, on peut prévoir la composition de l'huile de fusel du rhum pour toutes les conditions expérimentales.

Les avantages et inconvénients de cette méthode seront comparés à ceux d'un dispositif de BARBET où l'huile de fusel est chassée à l'aide d'une colonne de concentration d'huile de fuse .

RESUMEN

PRODUCCIÓN DE RON LIGERO, POR EL MÉTODO DE DESTILACIÓN CON EXTRACCIÓN

La destilación con extracción permite separar simultáneamente los productos de cabeza y el aceite de fusel del « high wine » (alcohol de 60-70 p. 100) del ron, por adición de agua sobre el plato superior de la columna de destilación. Estos congéneres son expulsados del condensador mientras que el etanol de 5-10 p. 100 por volumen es expulsado en la base.

La cantidad de alcohol amílico, butílico y propílico eliminado durante el trancurso de esta operación guarda relación con : 1) la volatilidad del congénere particular en relación con el etanol, 2) la concentración de etanol en la base, 3) grado de reflujo (L/V) en los platos de agotamiento y, 4) la cantidad de destilado que se envía hacia el condensador. El efecto de estas variables sobre el porcentaje de eliminación de los congéneres figura descrito para una columna formada por 25 platos de agotamiento y 10 platos de concentración.

Poniendo en serie una columna de destilación con extracción y una columna de rectificación, se puede producir un ron ligero de 189-190°. Mediante procesamiento por computador electrónico de las actuaciones de estas dos columnas, se puede prever la composición del aceite de fusel del ron para la totalidad de condiciones experimentales.

Las ventajas e inconvenientes de este método serán comparados a los de un dispositivo de BARBET, en el cual el aceite de fusel es evacuado por medio de una columna de concentración de aceite de fusel.

RIASSUNTO

PRODUZIONE DEL RUM LEGGERO CON IL METODO DI DISTILLAZIONE CON ESTRAZIONE

La distillazione con estrazione permette di separare simultaneamente i prodotti di testa e l'olio di flemma dell « high wine » (alcool da 60 a 70 p. 100) del rum aggiungendo dell'acqua sul piatto superiore della colonna di distillazione. Questi congeneri sono espulsi dal condensatore mentre l'etanolo a 5-10 p. 100 per volume è espulso alla base.

La quantità di alcool amilico, butilico e propilico eliminata durante questa operazione dipende : 1) dalla volatilità del congenere in particolare rispetto all'etanolo, 2) dalla concentrazione dell'etanolo alla base, 3) dal tasso di riflusso (L/V) nei piatti d'esaurimento, 4) dalla quantità di distillato espulsa dal condensatore. Si ha dunque la descrizione dell' effetto di questi variabili sulla percentuale di ritiro dei congeneri per una colonna formata da 25 piatti di esaurimento e da 10 piatti di concentrazione.

Mettendo in serie una colonna di distillazione con estrazione e una colonna di rettificazione, si puo' produrre del rum leggero a 189-190°. Se le prestazioni di queste due colonne vengono elaborate da un calcolatore elettronico, è possibile prevedere la composizione dell' olio di flemma del rum per tute le condizioni sperimentali.

I vantaggi e gli inconvenienti di questo metodo saranno confrontati con quelli di un dispositivo di BARBET dove l'olio di flemma è espulso mediante una colonna di concentrazione d'olio di flemma.

LITERATURE CITED

ALTSHELER W.B., UNGER E. D., KOLACHOV P., 1954. *Ind. Eng. Chem.*, **43**, 2559.
CAREY J. S., LEWIS W. K., 1932. *Ind. Eng. Chem.*, **24**, 882.
CORNELL L. W., MONTONNA R. E., 1933. *Ind. Eng. Chem.*, **25**, 1331.
DODGE W. B., 1950. Thesis, University of Louisville.
GUILLAUME E., 1911. U.S. Patent no 996328.
JONES C.-A., SCHOENBURN E. M., COLBURN A. P., 1943. *Ind. Eng. Chem.*, **35**, 666.
JOHNS-MANVILLE Technical data catalog, 1939.
KIRK R. E., OTHMER D. F., 1963. *Encyclopedia of Chemical Technology*, **1**, 501.
KIRSCHBAUM E., GERSTNER F., 1939. *Verfahrenstechnik Z.*, **1**, 10.
OTSUKI H., WILLIAMS E.-C. Symposium 6, University of California, Berkeley, Cal.
RICARD E., GUINOT H. M., 1933. U.S. Patent 1, 912, 010.
RIEDER R. M., THOMPSON A. R., 1949. *Ind. Eng. Chem.*, **41**, 2905.
SCHOENBURN E. M., PLANT C. A., WINSLOW C. E., 1959. Final report north Carolina State College, A.E.Ch.E. Research Committee.
SMITH D. A., KUONG J., BROWN G. G., WHITE R. R., 1945. *Petroleum Refiner*, **24**, 296.

APPENDIX

EXTRACTIVE DISTILLATION COLUMN

Production of light-bodied rum computer print-out of extractive distillation column performance

Operating data required for calculations

P.G. feed per HR. = ? 136.22
Total plates = ? 50
Stripping plates = ? 37
Feed proof = ? 159.98
Pinch proof = ? 19.6
Proof at base = ? 12
Iso-amyl alc. in feed (G. per 100 P.L.) = ? 146.86
Iso-butyl alcohol in feed (G. per 100 P.L.) = ? 21.41
n-propyl alc. in feed (G. per 100 P.L.) = ? 73.4
P. 100 of total alc. in feed recovered as prod. = ? 99.96
Type still diameter and plate spacing (inches) = ? 24,10.

Production of light-bodied rum
computer print-out of extractive distillation column performance

Alcohol concentrations, reflux ratio and moles vapor per hour from each plate

Plate n°	Alcohol in liquid		Alcohol in vapor		Reflux ratio above	Moles vapor plate
	Mol (%)	Proof	Mol (%)	Proof		
Calandria	1.9337	12.000	17.2848	83.248		
1	2.9628	18.010	20.6975	94.667	14.9939	36.080
2	3.1889	19.305	22.8729	101.323	15.0291	35.989
3	3.3307	20.113	24.2186	105.224	15.0690	35.887
4	3.4163	20.598	25.0336	107.516	15.1196	35.758
5	3.4653	20.875	25.5147	108.842	15.1776	35.612
6	3.4911	21.021	25.7890	109.589	15.2402	35.455
7	3.5028	21.087	25.9365	109.988	15.3059	35.293
8	3.5057	21.103	26.0068	110.177	15.3735	35.127
9	3.5034	21.090	26.0303	110.240	15.4427	34.958
10	3.4979	21.059	26.0255	110.227	15.5131	34.789
11	3.4905	21.018	26.0036	110.169	15.5844	34.619
12	3.4820	20.970	25.9715	110.082	15.6565	34.448
13	3.4728	20.918	25.9331	109.978	15.7294	34.278
14	3.4632	20.864	25.8910	109.865	15.8031	34.107
15	3.4535	20.809	25.8468	109.745	15.8775	33.937
16	3.4436	20.753	25.8012	109.622	15.9526	33.766
17	3.4336	20.696	25.7549	109.496	16.0284	33.596
18	3.4237	20.640	25.7081	109.369	16.1048	33.426
19	3.4137	20.584	25.6611	109.241	16.1821	33.256
20	3.4038	20.527	25.6140	109.113	16.2600	33.086
21	3.3938	20.471	25.5668	108.984	16.3387	32.916
22	3.3839	20.415	25.5196	108.855	16.4181	32.747
23	3.3741	20.359	25.4725	108.726	16.4982	32.577
24	3.3642	20.303	25.4254	108.597	16.5792	32.408
25	3.3544	20.248	25.3783	108.468	16.6609	32.239
26	3.3447	20.192	25.3313	108.339	16.7434	32.070
27	3.3349	20.137	25.2843	108.210	16.8266	31.901
28	3.3252	20.082	25.2375	108.081	16.9107	31.733
29	3.3155	20.027	25.1906	107.951	16.9956	31.564
30	3.3059	19.972	25.1439	107.822	17.0814	31.396
31	3.2963	19.917	25.0972	107.693	17.1679	31.228
32	3.2867	19.863	25.0505	107.563	17.2554	31.060
33	3.2772	19.809	25.0039	107.434	17.3437	30.892
34	3.2677	19.755	24.9574	107.305	17.4329	30.725
35	3.2582	19.701	24.9110	107.176	17.5230	30.557
36	3.2488	19.647	24.8646	107.046	17.6140	30.390
37	3.2394	19.593	24.8129	106.902	18.9755	27.042
38	1.3069	8.188	18.7565	88.329	19.1837	26.732
39	0.9770	6.159	14.5409	73.076	19.3076	26.551
40	0.7524	4.763	11.4737	60.483	19.4011	26.417
41	0.5906	3.750	9.1699	50.141	19.4864	26.295
42	0.4698	2.990	7.3984	41.648	19.5675	26.180
43	0.3773	2.406	6.0114	34.641	19.6467	26.069
44	0.3052	1.948	4.9104	28.838	19.7261	25.958
45	0.2482	1.586	4.0268	24.017	19.8068	25.847
46	0.2025	1.295	3.3116	20.004	19.8899	25.733
47	0.1657	1.061	2.7288	16.657	19.9758	25.617
48	0.1358	0.870	2.2514	13.863	20.0650	25.497
49	0.1114	0.714	1.8588	11.528	20.1578	25.373
50	0.0914	0.586	1.5767	9.829	17.7682	28.989

Production of light-bodied rum
computer print-out of extractive distillation column performance

Fusel oil concentrations from calandria and plates 1-14

Congeners (Grams per 100 p.l. first row) (mol p. 100 second row)

Plate nº	Amyl alcohol		Butyl alcohol		Propyl alcohol		Colorimetric f.o.	
	liquid	vapor	liquid	vapor	liquid	vapor	liquid product	vapor
Cal	57.10	137.81	5.65	13.52	73.14	95.97	68.37	153.40
Cal	0.0015	0.0314	0.0002	0.0037	0.0027	0.0321		
1	89	183	9	18	82	104	102	201
1	0.0035	0.0500	0.0004	0.0060	0.0047	0.0415		
2	112	231	11	24	86	110	126	251
2	0.0047	0.0697	0.0006	0.0085	0.0053	0.0486		
3	137	283	14	30	90	115	152	306
3	0.0060	0,0904	0.0007	0.0113	0.0058	0.0538		
4	163	339	17	36	93	119	180	366
4	0.0074	0.1121	0.0009	0.0143	0.0061	0.0576		
5	192	400	20	44	95	122	210	431
5	0.0088	0.1348	0.0011	0.0176	0.0064	0.0603		
6	222	467	24	52	97	125	243	501
6	0.0102	0.1588	0.0013	0.0212	0.0065	0.0624		
7	255	537	28	62	98	127	277	577
7	0.0118	0.1840	0.0016	0.0251	0.0067	0.0638		
8	289	613	33	72	99	129	314	659
8	0.0134	0.2104	0.0018	0.0294	0.0067	0.0649		
9	326	694	38	83	100	130	353	745
9	0.0151	0.2383	0.0021	0.0340	0.0068	0.0656		
10	364	779	43	95	101	131	395	838
10	0.0168	0.2674	0.0024	0.0390	0.0068	0.0662		
11	404	868	49	109	101	132	438	936
11	0.0186	0.2979	0.0027	0.0443	0.0068	0.0665		
12	446	962	55	123	101	133	484	1 039
12	0.0205	0.3297	0.0030	0.0501	0.0068	0.0667		
13	489	1 060	62	138	102	133	532	1 147
13	0.0224	0.3628	0.0034	0.0563	0.0068	0.0668		
14	535	1 162	69	155	102	133	582	1 261
14	0.0244	0.3972	0.0037	0.0629	0.0068	0.0668		

Production of light-bodied rum
Computer print-out of extractive distillation column performance

Fusel oil concentrations from plates 15-33

Plate n°	Congeners (Grams per 100 p.l. first row) (mol p. 100 second row)							
	Amyl alcohol		Butyl alcohol		Propyl alcohol		Colorimetric f.o.	
	liquid	vapor	liquid	vapor	liquid	vapor	liquid product	vapor
15	581	1 268	76	172	102	133	634	1 380
15	0.0265	0.4327	0.0041	0.0700	0.0068	0.0667		
16	630	1 378	85	191	102	133	688	1 504
16	0.0286	0.4693	0.0046	0.0774	0.0068	0.0666		
17	679	1 492	93	211	102	133	744	1 632
17	0.0308	0.5070	0.0050	0.0854	0.0067	0.0665		
18	730	1 608	102	232	101	133	802	1 765
18	0.0330	0.5455	0.0055	0.0937	0.0067	0.0663		
19	782	1 727	112	255	101	133	862	1 903
19	0.0352	0.5849	0.0060	0.1025	0.0067	0.0661		
20	835	1 849	122	278	101	133	923	2 044
20	0.375	0.6250	0.0065	0.1117	0.0067	0.0659		
21	8089	1 973	132	302	101	133	985	2 188
21	0.0398	0.6656	0.0070	0.1214	0.0066	0.0656		
22	943	2 098	143	328	101	132	1 049	2 336
22	0.0421	0.7066	0.0076	0.1314	0.0066	0.0654		
23	997	2 225	154	355	100	132	1 113	2 486
23	0.0444	0.7479	0.0082	0.1418	0.0066	0.0652		
24	1 052	2 352	166	382	100	132	1 178	2 639
24	0.0467	0.7892	0.0088	0.1525	0.0065	0.0649		
25	1 106	2 480	178	411	100	132	1 244	2 793
25	0.0490	0.8305	0.0094	0.1636	0.0065	0.0647		
26	1 160	2 607	190	440	100	131	1 309	2 948
26	0.0512	0.8714	0.0100	0.1749	0.0065	0.0644		
27	1 214	2 733	203	470	100	131	1 375	3 103
27	0.0534	0.9119	0.0106	0.1865	0.0064	0.0641		
28	1 266	2 858	215	501	99	131	1 440	3 258
28	0.0556	0.9518	0.0112	0.1983	0.0064	0.0639		
29	1 318	2 980	228	532	99	130	1 504	3 412
29	0.0577	0.9908	0.0119	0.2102	0.0064	0.0636		
30	1 368	3 100	242	563	99	130	1 568	3 564
30	0.0597	1.0287	0.0125	0.2223	0.0063	0.0633		
31	1 416	3 217	255	595	99	130	1 630	3 714
31	0.0616	1.0654	0.0132	0.2344	0.0063	0.0631		
32	1 462	3 329	268	627	98	130	1 690	3 860
32	0.0634	1.1007	0.0138	0.2464	0.0063	0.0628		
33	1 507	3 437	281	659	98	129	1 748	4 003
33	0.0652	1.1343	0.0144	0.2585	0.0062	0.0626		

Production of light-bodied rum
Computer print-out of extractive distillation column performance

Fusel oil concentrations from plates 34-50

Congeners (Grams per 100 p.l. first row) (mol p. 100 second row)

Plate n°	Amyl alcohol		Butyl alcohol		Propyl alcohol		Colorimetric f.o.	
	liquid	vapor	liquid	vapor	liquid	vapor	liquid product	vapor
34	1 548	3 540	294	690	98	129	1 804	4 141
34	0.0668	1.1661	0.0151	0.2704	0.0062	0.0623		
35	1 588	3 638	306	721	98	129	1 858	4 273
35	0.0683	1.1959	0.0157	0.2820	0.0062	0.0621		
36	1 624	3 729	319	752	97	128	1 908	4 399
36	0.0696	1.2235	0.0163	0.2935	0.0061	0.0618		
37	1 657	3 814	331	782	97	128	1 955	4 519
37	0.0708	1.2488	0.0168	0.3046	0.0061	0.0615		
38	3 685	5 482	760	1 115	128	142	4 372	6 476
38	0.0636	1.3570	0.0156	0.3283	0.0032	0.0515		
39	5 311	7 756	1 085	1 563	141	156	6 282	9 131
39	0.0685	1.4884	0.0166	0.3566	0.0027	0.0439		
40	7 536	10 845	1 524	2 161	155	171	8 882	12 725
40	0.0748	1.6422	0.0180	0.3892	0.0023	0.0379		
41	10 569	15 029	2 113	2 961	170	186	12 412	17 573
41	0.0824	1.8188	0.0196	0.4261	0.0019	0.0331		
42	14 688	20 675	2 901	4 025	185	203	17 187	24 093
42	0.0911	2.0187	0.0214	0.4673	0.0017	0.0291		
43	20 263	28 278	3 953	5 439	202	220	23 626	32 842
43	0.1009	2.2435	0.0234	0.5131	0.0015	0.0256		
44	27 787	38 495	5 354	7 313	219	239	32 287	44 559
44	0.1119	2.4946	0.0256	0.5636	0.0013	0.0227		
45	37 922	52 200	7 214	9 795	237	259	43 912	60 225
45	0.1242	2.7741	0.0281	0.6190	0.0011	0.0202		
46	51 549	70 560	9 683	13 076	257	280	59 490	81 143
46	0.1378	3.0838	0.0308	0.6796	0.0010	0.0179		
47	69 849	95 127	12 954	17 409	278	302	80 342	109 044
47	0.1528	3.4258	0.0337	0.7456	0.0009	0.0159		
48	94 399	127 969	17 285	23 127	299	325	108 224	146 226
48	0.1692	3.8024	0.0369	0.8172	0.0008	0.0142		
49	127 307	171 839	23 015	30 667	323	351	145 481	195 739
49	0.1872	4.2154	0.0403	0.8946	0.0007	0.0126		
50	171 399	224 292	30 594	39 526	347	367	195 246	heads 254 698
50	0.2069	4.6671	0.0439	0.9781	0.0006	0.0112		

Computer print-out of extractive distillation column performance

Summary of computed heat balance and required operating conditions

Heat balance in kilo B.T.U. per hour

Heat in	
Feed at 75 F	19.7
Vapor into base	765.5
Water to top plate at 219.3 F	1 639.9
Reflux to top plate at B.P.	93.7
Heat in =	2 518.9
Heat out	
Liq. exit base	1 899.0
Vapor to cond.	603.5
Radiation loss	16.5
Heat out =	2 518.9

LB. moles of feed per hour = 18.7978
LB. moles of product per hour exit base = 504.893
LB. moles vapor per hour into base = 35.7994
LB. Moles vapor per hour to condenser = 28.9891
LB. moles of heads draw-off per HR. from condenser = .248046
LB. moles of condensate per HR. returned as reflux = 28.7411
LB. moles water per hour to top plate = 486.343
Wine gallons of feed per hour = 85.1481 to plate no 37
P.G. of product per hour exit base = 136.166
W.G. of product per hour exit base = 1 134.71
P.G. of heads per hour from condenser = .054488
W.G. of heads per hour from condenser = .554357
W.G. of condensate per hour returned as reflux = 64.2333
Gallons of water per hour (sp. gravity = 1) to top plate = 1 050.99
LBS. steam per hour into calandria = 662.253
P. 100 amyl alcohol in feed removed from product = 61.1
P. 100 butyl alcohol in feed removed from product = 73.63
P. 100 propyl alcohol in feed removed from product = 0.39

RECTIFYING COLUMN

Production of light-bodied rum

Computer print-out of rectifying column performance
Operating data required for calculations and computation of required reflux ratio

For prod. draw-off from condenser, type 1;
For prod. draw-off from side of column, type 2 ? 2

Product proof = ? 189.3
F.O. draw-off proof = ? 135
Feed proof = ? 12
Total plates = ? 55
F.O. draw-off plate = ? 21
Feed plate = ? 17
P.G. product per HR. = ? 123.98
No of plates above product draw-off = ? 24
P. 100 of alc. in feed removed as heads = ? 4.3
Iso-amyl alc in feed (G. per 100 P.L.) = ? 57.1
Iso-butyl alc in feed (G. per 100 P.L.) = ? 5.65
n Propyl alc in feed (G. per 100 P.L.) = ? 73.14
P. 100 of alc. in feed removed at f.o. draw = ? 4.14

Is feed temp. boiling or cold (75 F), type hot or cold? hot

L/V above f.o. draw (D*XD/V) vap. to cond. (XD Calc-XD)
55 .864613 .111083 .888206.888304 — .000014 13

L/V past. section (H*XH/V) L/V Below F.O. draw (H*XH + D*XD + S*XS)/V
.994391 .004983 .851572 .115881

(XS-X calc.) mole p. 100 alc. in stillage
.000011 .011174 14

Production of light-bodied rum
Computer print-out of rectifying column performance

Alcohol concentrations and reflux ratio
from each plate in stripping section

Plate n°	Alcohol in liquid		Alcohol in vapor		Reflux ratio
	Mol (%)	Proof	Mol (%)	Proof	Above plate
Caldria	0.0112	0.07	0.1322	0.85	
1	0.0290	0.19	0.2167	1.39	6.81170
2	0.0414	0.27	0.3260	2.08	6.82485
3	0.0573	0.37	0.4669	2.97	6.83875
4	0.0778	0.50	0.6480	4.11	6.85351
5	0.1041	0.67	0.8799	5.56	6.86929
6	0.1376	0.88	1.1757	7.38	6.88617
7	0.1803	1.15	1.5509	9.67	6.90422
8	0.2342	1.50	2.0240	12.51	6.92342
9	0.3019	1.93	2.6156	16.00	6.94366
10	0.3863	2.46	3.3479	20.21	6.96466
11	0.4903	3.12	4.2429	25.21	6.98602
12	0.6169	3.92	5.3198	31.02	7.00722
13	0.7688	4.87	6.5903	37.61	7.02766
14	0.9473	5.98	8.0545	44.85	7.04679
15	1.1526	7.24	9.6961	52.57	7.06417
16	1.3822	8.65	11.4792	60.51	7.07957

Production of light-bodied rum

Computer print-out of rectifying column performance

Alcohol concentrations from each plate in rectifying section

Plate n°	Alcohol in liquid mol (%)	Alcohol in liquid proof	Alcohol in vapor mol (%)	Alcohol in vapor proof
17	1.6310	10.16	13.3458	68.33
18	2.0641	12.75	15.8670	78.11
19	5.0248	29.45	25.7251	109.42
20	16.6012	80.80	42.9133	146.15
	Alc. in f.o. draw-off			
21	36.7863	135.00	55.2673	164.20
22	51.0737	158.62	62.9868	173.11
23	60.0020	169.86	67.9494	178.04
24	65.7416	175.91	71.5791	181.32
25	69.9397	179.87	74.3254	183.64
26	73.1161	182.63	76.4596	185.35
27	75.5844	184.66	78.1523	186.66
28	77.5422	186.19	79.5533	187.71
29	79.1625	187.42	80.7480	188.58
30	80.5444	188.43	81.7940	189.33
	Alc. in prod. draw-off			
31	81.7541	189.30	82.7311	189.98
32	82.6967	189.96	83.5078	190.52
33	83.4778	190.50	84.1615	190.97
34	84.1352	190.95	84.7189	191.34
35	84.6957	191.33	85.1997	191.66
36	85.1792	191.65	85.6184	191.94
37	85.6003	191.93	85.9863	192.18
38	85.9702	192.17	86.3119	192.39
39	86.2977	192.38	86.6021	192.58
40	86.5895	192.57	86.8623	192.75
41	86.8512	192.74	87.0968	192.90
42	87.0871	192.89	87.3107	193.04
43	87.3021	193.03	87.5046	193.16
44	87.4971	193.16	87.6805	193.27
45	87.6740	193.27	87.8401	193.37
46	87.8345	193.37	87.9851	193.47
47	87.9803	193.46	88.1168	193.55
48	88.1128	193.55	88.2365	193.62
49	88.2332	193.62	88.3454	193.69
50	88.3427	193.69	88.4444	193.75
51	88.4422	193.75	88.5344	193.81
52	88.5327	193.81	88.6163	193.86
53	88.6151	193.86	88.6909	193.91
54	88.6901	193.91	88.7588	193.95
55	88.7584	193.95	88.8206	193.99

Production of light-bodied rum

Computer print-out of rectifying column performance

Fusel oil concentrations from plates 46-55

Congeners (Grams per 100 p.l. first row) (mol p. 100 second row)

Plate nº	Amyl alcohol		Butyl alcohol		Propyl alcohol		Colorimétric f.o.	
	liquid	vapor	liquid	vapor	liquid	vapor	liquid	vapor
							f.o. in heads	
55 55	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0	0.0
54 54	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0	0.0
53 53	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0	0.0
52 52	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0	0.0
51 51	0.00 0.000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0	0.0
50 50	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0	0.0
49 49	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0001	0.0 0.0000	0.0	0.0
48 48	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.1 0.0001	0.0 0.0001	0.0	0.0
47 47	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.1 0.0002	0.1 0.0001	0.0	0.0
46 46	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.0 0.0000	0.1 0.0002	0.1 0.0002	0.0	0.0

Production of light-bodied rum
Computer print-out of rectifying column performance
Fusel oil concentrations from plates 32-45

Congeners (Grams per 100 p.l. first row) (mol p. 100 second row)

Plate nº	Amyl alcohol		Butyl alcohol		Propyl alcohol		Colorimetric f.o.	
	liquid	vapor	liquid	vapor	liquid	vapor	liquid	vapor
45	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0
45	0.0000	0.0000	0.0000	0.0000	0.0003	0.0002		
44	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0
44	0.0000	0.0000	0.0000	0.0000	0.0005	0.0003		
43	0.0	0.0	0.0	0.0	0.4	0.3	0.1	0.0
43	0.0000	0.0000	0.0000	0.0000	0.0007	0.0005		
42	0.0	0.0	0.0	0.0	0.7	0.4	0.1	0.1
42	0.0000	0.0000	0.0000	0.0000	0.0011	0.0007		
41	0.0	0.0	0.0	0.0	1.0	0.7	0.1	0.1
41	0.0000	0.0000	0.0000	0.0000	0.0016	0.0011		
40	0.0	0.0	0.0	0.0	1.4	1.0	0.2	0.1
40	0.0000	0.0000	0.0000	0.0000	0.0024	0.0016		
39	0.0	0.0	0.0	0.0	2.1	1.4	0.3	0.2
39	0.0000	0.0000	0.0000	0.0000	0.0036	0.0024		
38	0.0	0.0	0.0	0.0	3.1	2.1	0.5	0.3
38	0.0000	0.0000	0.0000	0.0000	0.0052	0.0035		
37	0.0	0.0	0.0	0.0	4.6	3.1	0.7	0.5
37	0.0000	0.0000	0.0001	0.0000	0.0077	0.0052		
36	0.0	0.0	0.1	0.0	6.8	4.6	1.1	0.7
36	0.0000	0.0000	0.0000	0.0001	0.0113	0.0076		
35	0.0	0.0	0.1	0.1	10.1	6.8	1.6	1.1
35	0.0000	0.0000	0.0002	0.0001	0.0165	0.0112		
34	0.0	0.0	0.2	0.1	14.8	10.0	2.5	1.6
34	0.0000	0.0000	0.0003	0.0002	0.0240	0.0164		
33	0.0	0.0	0.4	0.2	21.6	14.7	3.8	2.5
33	0.0001	0.0000	0.0006	0.0003	0.0350	0.0239		
32	0.1	0.0	0.8	0.4	31.7	21.5	5.8	3.8
32	0.0001	0.0001	0.0010	0.0006	0.0507	0.0348		

Production of light-bodied rum

Computer print-out of rectifying column performance

Fusel oil concentrations from plates 17-31

Congeners (Grams per 100 p.l. first row) (mol p. 100 second row)

Plate nº	Amyl alcohol		Butyl alcohol		Propyl alcohol		Colorimetric f.o.	
	liquid	vapor	liquid	vapor	liquid	vapor	liquid	vapor
							f.o. in prod	
31 31	0.3 0.0004	0.1 0.0001	1.4 0.0018	0.8 0.0010	46.2 0.0731	31.5 0.0504	9.0	5.8
30 30	0.9 0.0009	0.3 0.0003	2.6 0.0032	1.4 0.0018	68.3 0.1065	45.9 0.0727	14.4	9.0
29 29	2.2 0.0023	0.8 0.0008	4.4 0.0055	2.4 0.0030	97.4 0.1492	65.0 0.1016	22.5	13.6
28 28	5.3 0.0055	1.9 0.0020	7.3 0.0089	4.0 0.0050	135.2 0.2030	90.0 0.1385	35.2	20.6
27 27	12.7 0.0127	4.6 0.0048	11.9 0.0141	6.5 0.0079	184.1 0.2693	122.3 0.1850	55.6	31.4
26 26	30.0 0.0290	10.9 0.0110	19.0 0.0218	10.4 0.0125	246.3 0.3486	163.7 0.2423	90.3	48.8
25 25	69.8 0.0644	25.6 0.0251	29.5 0.0324	16.3 0.0191	324.4 0.4392	216.1 0.3109	152.0	78.1
24 24	158.9 0.1379	59.0 0.0557	44.8 0.0462	25.2 0.0283	419.9 0.5343	280.9 0.3892	266.1	129.8
23 23	352.3 0.2790	133.0 0.1193	65.3 0.0615	37.7 0.0402	532.1 0.6180	358.5 0.4715	480.5	224.0
22 22	747.3 0.5037	290.2 0.2413	89.9 0.0720	54.0 0.0534	657.3 0.6498	446.0 0.5438	876.8	397.3
							f.o. draw	
21 21	1 380.2 0.6701	597.1 0.4355	106.3 0.0613	72.1 0.0625	756.9 0.5390	534.0 0.5713	1 462.0	702.3
20 20	1 428.0 0.3129	1 023.0 0.5794	77.0 0.0200	79.1 0.0533	658.1 0.2115	572.4 0.4755	1 443.7	1 085.8
19 19	481.0 0.0319	810.6 0.2752	23.7 0.0019	44.8 0.0181	370.9 0.0361	394.8 0.1966	504.0	824.3
18 18	99.9 0.0027	171.6 0.0359	5.7 0.0002	10.5 0.0026	151.5 0.0061	153.7 0.0472	116.4	186.1
17 17	34.4 0.0007	63.0 0.0111	3.2 0.0001	5.7 0.0012	71.6 0.0023	83.8 0.0217	44.7	75.0

Production of light-bodied rum

Computer print-out of rectifying column performance

Summary of required operating conditions

LB. moles per HR. — Vapor to condenser = 83.9579
LB. moles per HR. — Heads draw-off = .471
LB. moles per HR. — Alcohol in heads draw off = .418
LB. moles per HR. — Reflux to top plate = 83.4869
LB. moles per HR. — Product = 10.8959
LB. moles per HR. — Alcohol in product = 8.90796
LB. moles per HR. — F.O. draw-off = 1.095
LB. moles per HR. — Alcohol in F.O. draw off = .403
LB. moles per HR. — Feed to still = 504.925
LB. moles per HR. — Alcohol in feed = 9.78413
LB. moles per HR. — Stillage exit base = 492.464
LB. moles per HR. — Alcohol in stillage = .055027
W.G. per HR. — Product = 65.4939 from plate nº 31
P.G. per HR. — Heads draw-off = 5.82
W.G. per HR. — Reflux to top plate = 532.022
W.G. per HR. — F.O. draw-off = 4.15 from plate nº 21
P.G. per HR. — F.O.draw off = 5.61
W.G. per HR. — Feed to plate nº 17 = 1 134.79
LBS. per HR. — Steam to calandria = 1 545.83
W.G. per HR. — Stillage exit base = 1 062.74
P.G. per HR. — Alcohol in stillage = .766