1925

E. AFRICA

302

C.O. 19441 29 APR 25

FROM

ALCOHOL FUEL CORPORATION.

DATE

20th April 1925

FOR CIRCULATION:—

Mr.

Mr.

Mr.

Asst. U.S. of S.

Mr Strachey

Perm. U.S. of S.

Parl. U.S. of S. 8.6.25

Secretary of State.

POWER ALCOHOL. LOCAL PRODUCTION FOR MOTOR TRANSPORT.

Outlines scheme for establishment of local factories for production of power alcohol from Sugar Cane, Cassava, and Maize. The Company already produces the motor spirit "Natalite".

Previous Paper

see [illegible] 62530 Kya

see 9421 [illegible]

22 JUN 1925

8 DEC 1925

Subsequent Paper

see [illegible] 27327 Uga

[illegible] 34083 Uga

MINUTES

(See Mr Ormsby Gore's minute within)

The question of policy was put to Colonial Governments in the Secretary of State's Circular of the 10th of March, 1922, and I attach a note which shows in parallel columns the suggestions in these memoranda and the replies to the circular from Kenya, Uganda, Tanganyika and Nyasaland. Sir C. Bedford saw those replies at the time as he had been appointed Adviser to the Colonial Office in these matters — as to his appointment see [illegible] letter from Mr. Frank Heath to Sir [illegible] Smith of the 22nd of October, 1921. It will be seen from the enclosure to that letter/No. 2434/22 General that the Fuel Research Board and Sir C. Bedford were by no means in agreement. If this memorandum is to be referred to anyone in

this

Mr. Bottomley

I saw Mr. Hobley this morning. He left with me the enclosed papers. He states that Sir Charles Bedford is behind the scheme. He would like the proposal referred in the first instance to the Crown Agents for their comments and then to the 4 local Governments for their comments and cooperation where needed before actually floating a company. It is clear that before a company is floated the attitude of the local Govt & the C.O. should be defined as the production of power alcohol especially from sugar cane involves legislation about denaturants etc.? What action can we take in the matter?

W.? 29.4.25

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WDy 29.4.20

Memorandum

9 copies

22 JUN 1925

Copy to Gov Kya 559, Ugda 225, Nyd 179, 337 — 19444/25

The Secretary's Circular despatch of the 16th March, forwarded to the Governors of Kenya, Uganda, Tanganyika and Nyasaland certain memoranda on fuel/motor transport by the Fuel Research Board, and the Governors were requested to furnish their views as to what facilities and concessions it might be possible to afford to any undertakings or individuals who might be inclined to take up the production of power alcohol, both for local use and for export.

Below are summarised in parallel columns, (a) the suggestions in Mr. Hobley's note as to the assistance which might be given by the East African Governments and (b) the replies of those Governments to the Secretary of State's circular of the 16th March 1922. (The raw materials suggested by Mr. Hobley for the production of pure alcohol are, maize, cassava, molasses, sugar cane, jaggree.)

Mr. Hobley's suggestions

KENYA

The assured consumption is stated sufficient to warrant a plant of [illegible]nomic size to produce say 500,000 [illegible]ons and the supply of raw material [illegible] rapidly becoming sufficient to remove [illegible]xiety on that score. The assistance [illegible]gested is (1) Promise of low railway [illegible]tes on raw material, and (2) Duty of [illegible] 6d. per gallon on imported petrol [illegible]r three years, the Company to give [illegible] undertaking to sell locally [illegible]nufactured spirit at not more than [illegible] stated price.

Replies of Colonial Governments

KENYA.

Writing under date 13th October 1922, (56158/22), the Governor states that at the present stage, information as to prospects is very incomplete and it would be unwise to consider the grant of any special facilities and concessions. He was impressed by the fact that no satisfactory commercial formula had yet been evolved, and he did not think it wise to tie the hands of the Government in any way by granting concessions which may not be used or may be diverted to other purposes. The Victoria Nyanza Sugar Factory was beginning to produce sugar and when these operations were more advanced the Governor promised to investigate further the possibility of interesting this firm in the production of ~~pure~~ power alcohol. The Governor added that he would not lose sight of the matter as he was fully aware of its importance.

UGANDA.

Writing under date of 23rd May 1922, 21880/22, the Governor stated that without specific applications it is not possible to state in detail what shape any concession might take. If, however, occasion should arise, the Government would no doubt be prepared to consider the revision of existing legislation and in a general way afford facilities for the cultivation of any specially suitable crop. The question of the grant of Crown lands would be taken up within the limits ~~proposed~~ imposed by existing undertakings, and the consideration of native interests generally. Transport questions would lie with the Uganda Railway administration.

UGANDA

The consumption of motor spirit
ganda, although increasing, is
present inadequate to warrant the
ablishment of a factory. There is
unlikely however that
a substantial decrease in the
e of fuel ~~which~~ would so increase
sumption as to absorb the whole
put of a distilling plant. At
sent, however, it is impossible
btain the necessary capital in
London market without some
pport, and this difficulty might
overcome by co-operation of the
nda Government and the Empire Cotton
wing Corporation. It is ~~because~~ therefore,
gested that the Colonial Govt. be
ed to select the most suitable
e for a factory, and be asked
ough the Chiefs to make contracts
the landholders around the site
the production of cane over an
area

...al of say 1,000 acres for ten ...ar production, to be jointly ...er the control of the Agricultural ...partment and the Company; the ...ces for cane to be settled ...ween the Government, the land-...ders and the Company; and the ...ire Cotton Growing Corporation ...e asked to underwrite the ...nture issue of the said ...pany at say 7%.

TANGANYIKA

It is suggested that the pro-...ion of a local motor fuel at a ...sonable price would revolutionize ...ditions in the Territory, where ...present motor transport is ...paratively speaking in its ...ancy. Mr. Hobley merely adds ...t some form of Government assistance ...ld have to be mutually devised before ...sal could be obtained.

NYASALAND.

The present consumption is small ...petrol is expensive owing to the ...ence of direct rail communication ...is believed that with a similar ...sure of cooperation between the ...l Government and a manufacturing ...pany, cheap fuel could be locally ...ufactured, particularly as maize

can

TANGANYIKA.

Writing under date of 12th May, 1922, the Acting Governor said that in the event *of any firm being interested in a* practical manner [illegible]ial railway rates *possibly* might be quoted. The local demand for fuel oil is not however sufficient to be likely to induce any firm to invest the necessary capital.

NYASALAND.

Writing under date of 25th May 1922, 30089/22, the Governor said that *if* the production of pure alcohol *were* contemplated, the Government would be willing to grant a long lease of such land as might be necessary, at a very low or nominal rental, and allow

the

n be obtained there at a cheaper te than ~~any~~ in the other colonies referred .

the import, free of duty, of material required, while the project was in an experimental stage. It is, however, very unlikely that such an undertaking would be considered by any local firm, etc., as it would be impossible to compete with the lower cost at which alcohol could be produced from refuse from the sugar factories on the Zambesi.

Import & Export Duties.

	Import	Export
Kenya	30 cts Imp. Gall:	Nil
Uganda	30 cts — " — :	— " —
T. Terr:	30 cts — " — :	— " —
Nyasaland:	2d a gallon:	— " —

Legislation Ordinances have been passed in Kenya (No 9/21 & 17/22) also Rules 4 Aug 1921 – but no denaturants have apparently yet been prescribed under No 19 of the Rules. No legislation passed in Uganda, Tanganyika or Nyasaland.

Railway Rates The Railways have been unable to furnish the rates on the materials mentioned in the memo.

MEMORANDUM

ON

NATALITE

(Reg. Trade Mark)

THE PROVED POWER ALCOHOL MOTOR SPIRIT EQUAL IN EVERY RESPECT TO PETROL

With Notes on its Characteristics, Use and Manufacture, Reports of Tests by the World's leading Motor Fuel Authorities, Automobile Clubs and Associations, Government Departments, Committees, etc.

8TH EDITION.—COPYRIGHT, 1924.

Issued by

THE ALCOHOL FUEL CORPORATION, LIMITED,

Power Alcohol Specialists and owners of "Natalite" Patents,

C. A. H. FAIRBANK, *Secretary*

7, Prince's Street, Westminster, London, S.W.1.

Telegrams and Cables: QUENAN, LONDON. Telephone: VICTORIA [illegible]. Codes: BENTLEY'S

SECTION A.

FOREWORD

on the characteristics of

NATALITE

(Reg. Trade Mark)

THE following pages contain a brief account of the reasons why the motor fuel, known by the Trade Mark NATALITE, will eventually replace Petrol for use in internal combustion engines. Its advantages, method of preparation and cost of production are dealt with.

Long and continuous experience, confirmed by the various reports found in this booklet, has shown conclusively that Natalite can replace petrol in an internal combustion engine with a carburettor designed for petrol, and is then as good as, or even better, than petrol for producing power. In an engine whose compression and carburation have been adjusted for the special use of Natalite—an adjustment which can be readily and inexpensively carried out—Natalite will give, gallon for gallon, results which are actually superior to those obtainable with petrol.

If Natalite catches fire it can be easily extinguished by means of water, whereas with petrol this is not possible. This characteristic places the new fuel at a great advantage, especially for use in ships, motor boats and aeroplanes, and for storage in or near buildings where fire risks have to be specially considered. A few drops of water in petrol will cause misfiring of the engine, but with Natalite this is not the case. This is particularly an advantage in the case of aeroplane engines, where misfiring might be exceedingly dangerous.

Natalite cannot be frozen at any temperature which is likely to be met with either on land or in the air. This is an important consideration in cold climates, and at high altitudes, for both motoring and aviation.

Natalite leaves much less deposit on the walls of the cylinders of an engine than petrol. It is very much easier to start an engine with Natalite than with petrol, and even at extremely low temperatures starting is quite easy.

Engines using Natalite as a fuel are much more easily lubricated, and show a greater economy from the point of view of consumption of lubrication oil, as this fuel does not dissolve oil to the same extent as petrol. Natalite is a better hill climbing fuel than petrol.

A very important point with regard to Natalite is that it is a self-contained fuel. That is to say, its main constituents are obtained from the same raw materials of which the supply is inexhaustible. Natalite is an alcohol motor fuel which does not have a corrosive action on the cylinders or valves of an internal combustion engine. These few facts in themselves at once show that Natalite must be looked upon as a real substitute for petrol, and one for which there is an immense future.

Can be made in unlimited Quantities

NATALITE

(Reg. Trade Mark)

THE MOTOR SPIRIT OF THE FUTURE.

Some of the principal considerations underlying its manufacture and use briefly outlined.

When a particular commodity begins to grow scarce, man seeks for a substitute, and on rare occasions, the substitute, when found, turns out to be of even greater value than the original commodity. An example is the employment of iron as a catalyst in the place of the very expensive metal platinum in certain chemical processes. The iron for certain preparations is even more effective than the metal for which it has been substituted.

The following pages deal with a similar case—the substitute is actually better and cheaper than the original article.

During the last twenty or thirty years one of the most important advances in the progress of civilisation has been the advent of the Internal Combustion Engine. The importance of this means of producing power and its economic value to the community can be gauged by reference to the enormous number of motor vehicles in use to-day both for private and commercial purposes. Every year sees the introduction of new engines designed to burn oil. The leading shipbuilders are gradually replacing coal by oil fuel. The extensive use of petroleum driven war vessels and air craft has revolutionised modern warfare, and there is every reason to believe that the last word has not yet been said on the subject.

The Position of the Internal Combustion Engine at the Present Day.

Broadly speaking, internal combustion engines are designed so as to obtain their power from the rapid expansion of the products of the combustion of a volatile fuel when burnt with the requisite amount of air in a confined space under pressure. Internal combustion engines can be di[illegible] into two classes—(1) those us[illegible]uid fuel-oil; (2) those using a gase[illegible] fuel-gas. The first class can be again sub-divided into those using crude heavy oil fuel and those using petroleum or refined oil.

- Internal Combustion Engines
  - Gas Engines
  - Oil Engines
    - Diesel and semi-Diesel engines (heavy)
    - Petrol Engines (light)

Each of these groups of engines has its own particular advantages, but it is the petrol*-driven, light, internal combustion engine which is most generally used for the production of power for transport purposes. From the point of view of the cost of power, this type is considerably more expensive to operate than the others, but, owing to the exacting conditions of motor car practice, the cost becomes of secondary importance up to a certain limit, in comparison with the advantages obtained from its use. In spite of the ever-increasing cost of petrol, the number of engines requiring this fuel has increased at an enormous rate during the recent years, and there is no prospect of any reduction in this increase; the tendency is all in the other direction.

*Variously termed petrol, gasoline and benzine.

carbons condensed from the Natural Gas has been mixed with the heavier distillates; while spirit low in vapour tension have been obtained by encroaching into the kerosene fraction. The difficulty of starting the engine with such liquids being overcome by admixture with a greater or less amount of petrol. Moreover, a great increase in the proportion of spirit yielded by the distillation of crude petroleum oil has been obtained by the discovery of certain processes for the "cracking" of the heavier fractions. When these heavier fractions (which are high boiling and, therefore, useless by themselves) are heated up to a high temperature and pressure in the absence of air, they are broken down to a certain extent yielding more volatile *i.e.*, lower boiling products. Owing to the absence of oxygen these products are not themselves destroyed, and on cooling can be distilled off and mixed with petrol.

But notwithstanding these efforts the petrol spirit famine remains imminent, and for the reason stated above, namely that the world's supplies of crude petroleum oil from which the petrol is produced are being rapidly depleted.

Another important factor arises when we consider the distribution of the world's oilfields. In the event of war the supply of petrol to some nations might be entirely stopped, and it is therefore practically essential that as far as possible the supply of any petrol substitute should be universally available.

In addition, the present continuous increase in consumption leads one to the inevitable conclusion that most of the oil-producing countries will soon require all they can obtain from their wells for home consumption.

Thus Naramore,* in emphasising the condition of the fuel industry, pointed out that "although each year sees vast increases in the sale and export of oil from America, there has been no increase in production from the actual wells, the aforesaid increase in sale and export being for the most part drawn from storage. The deficit caused by this can never be replaced under existing conditions. The last year or two has seen the working of the last well in the United States which had not been explored; it is in Texas, and is now practically in full working order. Taken as a whole, the oil wells of the United States are producing a prodigious quantity of fuel which is, and for a few years will be, sufficient to quench the thirst of the passenger cars of the United States, but they cannot export enormous quantities to other countries as well."

This is confirmed by a statement made in a recent report on the subject issued by the United States Federal Trade Commission, as follows: "The resources of the United States are being depleted more rapidly than would be the case were the products of these resources applied first to domestic needs, and the diminution of stocks on hand due to export, contributes to an increase in cost to the domestic consumer. We suggest that Congress consider the advisability of restriction on the exportation of domestic crude oil and its products."

Commenting on the above, a Sub-Co[illegible]ee on Motor Fuel appointed by [illegible] British Government in 1921 states "It seems fairly clear from these statements that the domestic fuel position is viewed with extreme seriousness in American official circles."

Substitute for Petrol.

Naturally the next step in the history of this liquid fuel was the search for an efficient substitute.

It is quite obvious from the foregoing remarks that, for a substitute to be of any real value it must be quite independent of petroleum, and must be of such a nature that the supply of it can be maintained in spite of an ever increasing demand.

At this point it may be remarked that the two main desiderata of a suitable fuel to serve as a petrol substitute are :—

(1) That it should have a sufficiently high vapour pressure, *i.e.*, it should be sufficiently volatile to permit the starting of an engine from the cold.

* *The Motor*, Feb. 25th, 1920—page 197.

as a fuel. These may be briefly summarised as follows:—

(1) It would be necessary to design a special engine for use with pure alcohol fuel. When used in internal combustion engines of the existing type, special arrangements for starting on petrol and devices for heating the air intake to the carburettor must be made. Moreover, a higher initial compression than is generally used for petrol or benzol, must be used for economic power production from pure alcohol.

(2) The explosion of the alcohol vapour and air in the cylinder results, essentially, in the combination of the alcohol with the oxygen of the air to form a gaseous mixture of carbon dioxide, and water vapour, but there is always a tendency to give small amounts of acetaldehyde, acetic acid and oxidation products of ethyl alcohol.

$$C_2H_5OH + O \longrightarrow H_2O + CO_2 + CH_3CHO + CO$$

(acetaldehyde)

$$CH_3CHO + O \longrightarrow CH_3COOH$$

(acetic acid)

$$CO + O \longrightarrow CO_2$$

The acetic acid is produced [illegible] es when insufficient air is used fo[r c]arburation, and this product attacks the metal of the cylinders, pistons, valves, etc., and produces corrosion. This in itself would be quite fatal to the adoption of alcohol as a fuel if it were not possible to devise a method by which this can be entirely eliminated. In Natalite this is never found to take place.

(3) Owing to the illicit uses to which alcohol can be applied—resulting in the extremely high excise duties—there is little likelihood of the pure compound ever being available for general use. The pure spirit must therefore be mixed with other products in small amount before it can be retailed to the public.

Natalite.

Providing these three disadvantages could be overcome, alcohol would constitute a very perfect fuel. These facts compel the consideration of the admixture of alcohol with some material capable of overcoming the disadvantages noted above. After many years of experimenting with mixtures of alcohol and naphthalene, acetone, acetylene, ether, etc., it has been definitely established by means of authoritative tests that the most perfect fuel that could be produced on a commercial basis is a mixture consisting of alcohol and ether, combined in suitable proportions with ammonia and castor oil.

This liquid fuel mixture was first produced in Natal, and hence the name "Natilite" or "Natalite," by which it is now very well known. It has been patented in nearly all countries throughout the world, and the names mentioned have been universally registered as trade marks for the product.

It may be of general interest at this point to give some account of the scientific basis upon which the success of Natalite is founded.

In Natalite, the three drawbacks to the use of alcohol as a fuel are overcome in the following manner

(1) The addition of ether

For a motor spirit to give satisfactory starting, it must be sufficiently volatile to yield enough vapour to give an explosive mixture in the cylinder with everything cold, and the measure of its volatility can be obtained by noticing the height of a column of mercury which its vapour will support at any given temperature.

Any reliable brand of petrol, having a specific gravity of about 0.715, can be taken as a standard in judging the performance of other fuels.

The vapour pressures of Natalite, and other fuels, are contrasted in the graph shown on next page.

It will be seen that the vapour pressures of alcohol are uniformly less than those of petrol, and it is very largely this that has caused the starting troubles, and the want of flexibility found with this spirit alone which has militated against its use in high speed vehicles, whilst on the other hand, Natalite is uniformly higher than petrol and will, with the greatest of ease, no matter how low the temperature, give instantaneous

(3) Under the existing Excise regulations, Natalite being an alcohol mixture, must have added to it certain substances to denature, or render unfit to drink. These denaturants vary in almost every country but, excepting Great Britain, form no serious obstacle to the development of the industry. It is hoped that in the future this denaturation process may be simplified but at present there is no immediate prospect of a simpler method. A fuller account of the process known as denaturation is given on pages 34 and 35.

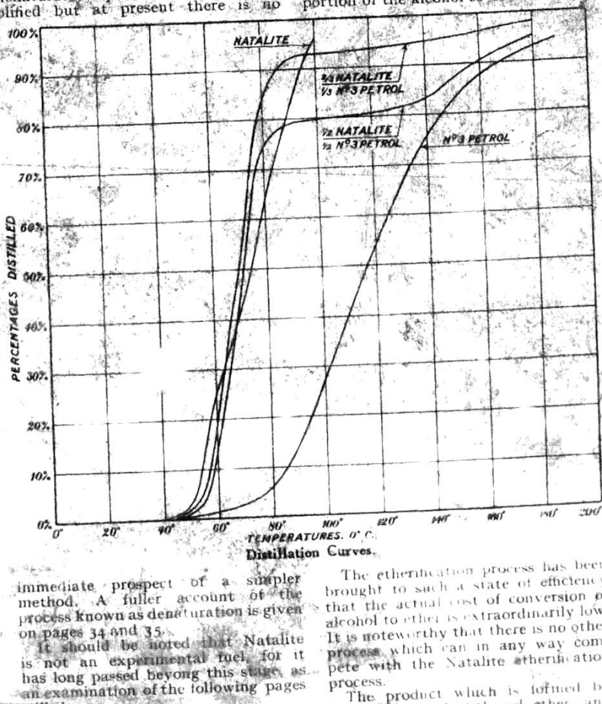
It should be noted that Natalite is not an experimental fuel, for it has long passed beyong this stage, as an examination of the following pages will show.

It consists essentially of a mixture of alcohol and ether, together with small amounts of other substances, which are added for definite purposes.

The manufacturing process is given in detail on pages 25 to 34, but it can be easily summarised as consisting of two main operations:—(a) The production of alcohol from vegetable sources by fermentation methods; and (b) the formation of ether from a portion of the alcohol so obtained.

The etherification process has been brought to such a state of efficiency that the actual cost of conversion of alcohol to ether is extraordinarily low. It is noteworthy that there is no other process which can in any way compete with the Natalite etherification process.

The product which is formed by blending the alcohol and ether, and the chemical substances, is a clear



Distillation Curves.

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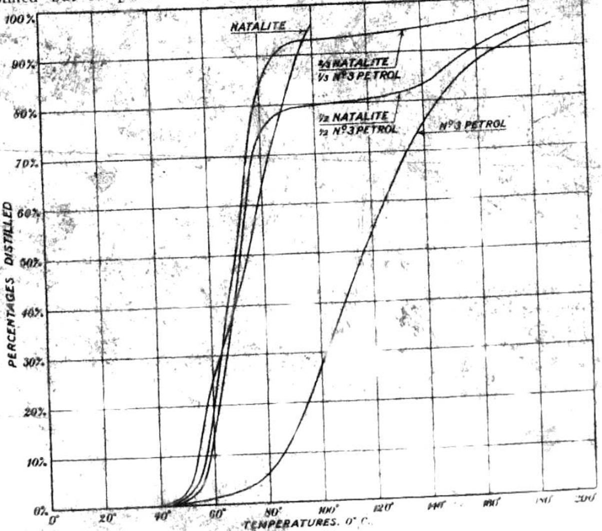

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The product which is formed by blending the alcohol and ether and the chemical substances, is a clear and benzol; that its commercial exploitation is capable of realising very large profits. There should be no technical difficulties or practical difficulties in the way of the establishment of Natalite factories in any part of the world where the raw materials named above are found in sufficient quantity. Another factor of importance is that the handling, storage, transport and distribution can be accomplished without difficulty in any country.

Sources of Alcohol.

Since 99.9 per cent. of the constituents of Natalite are obtained from alcohol, it will be as well to consider the sources from which this substance can be derived.

The suitability of any particular raw material for the production of power alcohol on a large scale is primarily dependent upon cost.

Many potential sources of alcohol—whilst ideal on paper—are not practicable on a large scale owing to such factors as time, labour, expensive and complicated plant, etc.

In this section only the most promising sources will be dealt with. These are three in number :—

(1) Production from ethylene—a by-product in coal gas manufacture, etc.
(2) Production from calcium carbide
(3) Production from fermentable carbohydrates.

I. Production from Ethylene.

Ethylene is a gaseous hydrocarbon of the formula C_2H_4, and is produced by the vigorous dehydration of alcohol. The reverse process, the addition of water to ethylene, has been rendered possible in recent years. Henell, in 1828, found that if ethylene is absorbed in concentrated sulphuric acid, and the resulting liquid diluted with water and then heated, alcohol is distilled off. The chemical reactions can be represented as :—

$$C_2H_4 + H_2SO_4 \longrightarrow C_2H_5HSO_4$$

Ethylene and sulphuric acid give ethyl hydrogen sulphate :—

$$C_2H_5 H.SO_4 + H_2O \longrightarrow H_2SO_4 + C_2H_5OH$$

Ethyl hydrogen sulphate, distilled with water, gives sulphuric acid and alcohol.

Ethylene is a constituent of coal gas and of the gases obtained by distilling mineral oils. The purified coke oven or coal gas (containing from 1 to 6 per cent. of ethylene) is passed up lead-lined towers packed with broken fused silica, and there meets a down-coming stream of sulphuric acid, usually containing some catalyst, such as vanadium anhydride, metallic phosphates, sulphates, etc., which accelerate the absorption.

The various processes patented have not met with any marked success, however, owing to the large amount of sulphuric acid required, and the troublesome necessity of again concentrating this acid after use.

The Committee on Power Alcohol, 1921, regard ethylene as a large potential source of alcohol, but considers that much further work is necessary before definite figures as to quantity and price can be given.

Since a coal famine is looming in the distance, it can be safely prophesied that sufficient alcohol can never be obtained from coal and coke oven gases to meet the coming demand.

II. Alcohol from Calcium Carbide.

Where electrical power is cheap—that is, in countries well supplied with natural water-power—processes for the production of alcohol from acetylene *via* calcium carbide will, no doubt, be extensively developed.

Alcohol is obtainable from acetylene in two ways, each of which involves the addition of hydrogen and water.

(1) The acetylene is converted into ethylene by the action of hydrogen in presence of platinum black :

$$H.C \vdots C.H + H_2 \longrightarrow CH_2 : CH_2.$$

The ethylene can then be absorbed in sulphuric acid, as in the previous process. This process has not yet been successful on a commercial scale.

(2) The acetylene is converted into acetaldehyde by passing the gas through dilute sulphuric acid containing mercury salts as catalysts, or by passing it with steam over catalysts at high temperatures

$$HC \vdots CH + H_2O \longrightarrow CH_3CHO.$$

Natalite is favourably reported on by the Swiss Government

	Galls. per ton.
Cassava	39
Maize	44 to 88
Mangolds	
Oats	65 to 70
Potatoes	21 to 28
Potatoes (sweet)	33 to 35
Rice	68 to 105
Sawdust	18 to 47
Sorghum	85 to 95
Sorghum Stalks	12.5
Sugar Beets	11 to 23
Sugar Cane	19 to 26
Sugar Mangolds	12 to 22
Sugar Molasses	65 to 83
Wheat	75 to 91

The following notes give an indication of the possibilities of some of the sources of alcohol.

MAHUA OR MOWRA FLOWERS.—The Mahua tree is found in various parts of India, and can be grown in most localities. The flowers contain sufficient sugar to produce about 30 per cent. of alcohol, calculated on the dried flowers. It is stated that the trees in India are sufficient to produce 750,000 gallons of alcohol. Alcohol is produced this source in India.

BEET MOLASSES.—This product is the residue from the beet sugar industry and needs very little treatment. Heriot states that the world's supply of beet molasses would yield 100 million gallons of alcohol. This source is largely used in France.

CASSAVA.—This product is extremely easily grown in tropical climates, and contains a large amount of starch, (25 per cent.) and about 5 per cent. of sugars.

MAIZE.—This contains in addition to a large amount of starch a small amount of sugar and gum. It is very largely used in America and France as a source of alcohol.

PEAT.—It is highly probable that this substance will under special treatment yield good results from the point of view of production of alcohol. The Committee on Power Alcohol reported that no satisfactory method had been devised for this purpose, but advised that this product should not be overlooked.

POTATOES.—These are extensively used in Europe and America for log alcohol production. In Germany about 80 per cent. of the alcohol produced in that country is made from this product. In 1914 Germany produced 84 million gallons of alcohol from potatoes. The industry declined during the war, but is rapidly recovering, the production in 1921 being over 40 million gallons.

SAWDUST.—A good deal of experimental work has been done of the production of alcohol from this product as it is so extremely cheap. The object is to convert the cellulosic material present in the sawdust into fermentable sugars. At present the process does not produce alcohol at a price which it can compete with petrol as a fuel, but there is every indication that in time it will be considerably cheapened. In addition to sawdust any cellulosic waste product can be used—such as straws and grasses.

SORGHUM OR DARI.—This product contains sugars and gives a very high yield of alcohol. It is extremely easily grown in an extensive portion of the world.

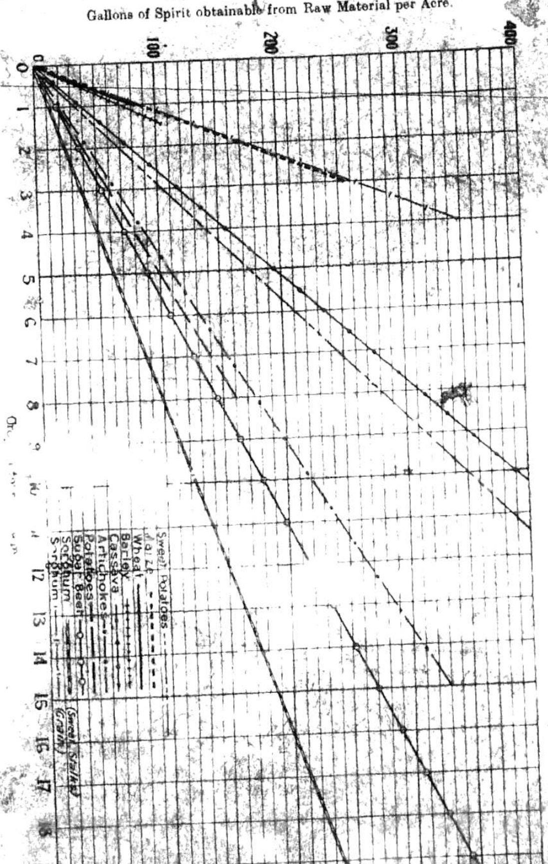
SUGAR BEETS.—Although used for the production of alcohol in France and Ger[illegible] the cost of the process is too h[illegible] render the alcohol so obtained su[illegible]ently cheap to compete with petrol.

SUGAR MOLASSES.—This forms the chief source of alcohol in America. It is stated that the supply of sugar molasses is sufficient to produce 100,000,000 gallons of alcohol. The output from Cuban molasses has been estimated as 40,000,000 gallons. In 1915 it was estimated that the average cost of alcohol from this source was about 5d. per gallon.

SULPHITE LIQUORS. These are a by-product in the manufacture of paper, and by suitable treatment alcohol can be obtained from them. The quantity of alcohol so obtained is limited by the availability of the liquors.

The above short summary indicates the very wide range of vegetable products which are available for the production of alcohol. Some of the products

Natalite supplies unlimited as raw materials are vegetation



to convert unit quantity of the fuel from the liquid to the gaseous state without alteration of temperature. For petrol, where the value of this physical constant is small, the correction is not great, especially as the fuel is drawn into the cylinders of an engine partly vaporised. In the case of alcohol the latent heat is nearly three times that of petrol and consequently the calorific value of alcohol fuels is affected more than that of petrol. Natalite has a latent heat less than that of alcohol, but considerably greater than that of petrol.

(b). The fact that on combustion the ultimate products from every fuel are, theoretically, carbon dioxide CO_2, and water, H_2O, together with the residual nitrogen from the air used in the combustion of the fuel. The water is produced as steam, but if the exhaust gases were cooled it would liquefy. This means that the heat used up to produce the water as steam, *i.e.*, the latent heat of vaporisation of water, together with the heat which is evolved when the exhaust gases cool down to the temperature of the air must be subtracted from the heat which is given out by combustion of the fuel. By making these allowances the net or lower calorific value is arrived at. The effect of cooling the exhaust gases is, however, not very great, but allowance must be made for the cooling down of the liquid water which is produced by the liquefaction of the steam.

The net calorific value represents the actual number of heat units which are available in the engine for producing power.

The following table gives the net calorific values for several fuels. All, with the exception of ether, were determined in our laboratory and are accurate to one-half of one per cent :—

NET CALORIFIC VALUES OF VARIOUS FUELS.

Fuel.	Sp. G.	Calories per CC.	Calories per gram.	B.T.U.S per gallon	B.T.U.S per pound
ALCOHOL—					
Pure ..	[illegible]94	5.204	6,550	93,610	11,790
98.7% Vol	[illegible]0	5.054	6,317	90,906	11,370
95% Vol.	[illegible]16	4.922	6,052	88,590	10,860
ETHER ..	.720	5.871	8,154	105,680	14,080
NATALITE—					
Denatured	.783	5,344	6,825	96,190	12,285
Not denatured	.758	5,146	6,780	92,628	12,220
PETROL—					
Aviation	.734	7.677	10,460	138,186	18,828
No. 1 (a) ..	.752	7,680	10,200	138,240	18,360
No. 1 (b) ..	.718	7.527	10,470	135,486	18,846
BENZENE—					
Pure	.871	8,401	9,646	151,218	17,363
90's (Benzol) ..	.876	8,435	9,630	151,830	17,334

The net calorific value of Natalite, as calculated by two distinct methods, gave as a mean 6,837 calories per gram, and this is in close accordance with the value actually determined in the laboratory, 6,825 cals.

CORROSION.

With many proposed alcohol fuels it has been found extremely difficult to eliminate not only corrosion of the working parts of an engine using such a fuel, but also that of storage and supply tanks, carburettors and fittings.

Natalite is without any corrosive action whatever on the working parts of an engine pistons, cylinders, valves and exhaust, and may be kept in ordinary containers and supply tanks a distillery forming an adjunct to the sugar factory proves at time unremunerative, and may be closed for a period until market conditions make it worth while again to utilise the waste product in this manner. In certain countries in which formerly a greater amount of spirit was produced than at the present day, the question of the disposal of the molasses has become an acute one; and elsewhere it presents a problem which has always awaited a solution.

After what has been previously stated in this book on the imminence of a petrol or gasoline famine, owing to the depletion of the world's supplies of crude petroleum, there appears to be little doubt that the co-operative production of alcohol, for the production of Natalite is a particularly attractive scheme for the establishment of a lucrative branch of the cane sugar industry. Plants for the production of Natalite at suitable centres would result in the absorption of factory waste molasses in modern distilleries, giving a good yield, and showing an excellent margin of profit which in all probability would steadily increase as the price of petrol or gasoline rose, as would seem inevitable in view [illegible]he permanent world famine of [illegible]mmodity, of which, according to [illegible] British Board of Trade there is a grave danger.

Such plants may already exist for the production of rum, and may require little modification for the manufacture of 95 per cent. alcohol spirit and ether. In regard to the preparation of the ether, which is mixed with the alcohol to form Natalite this only necessitates a comparatively inexpensive installation, since the procedure involved is simply to treat the alcohol with concentrated sulphuric acid and distil off the ether that is formed by the dehydrating action of the acid upon the alcohol.

It seems therefore clear that cane sugar manufacturers should find the operation of central Natalite plants at various suitable locations of great interest for the conversion of their waste molasses into motor spirit.

We must, however consider the [illegible] sources of raw materials as the entire amount of molasses available in many countries may be insufficient for the production of the total quantity of spirit demanded, if not at first, at any rate later on.

In the first class of sources mentioned, *i.e.*, the Saccharine or Carbohydrate materials, fermentation is directly effected by the yeast, but in the second the starch must be first converted by suitable means (to be mentioned later) into fermentable sugars.

It is proposed now to give information regarding the production of alcohol from these various materials that will be of service to manufacturers considering the installation of a Natalite central. Space is not available for entering closely into the technical details relating to the operation of fermentation and distillation, nor is this necessary at this time the purpose of this booklet being to present sufficient general data to convince those interested of the desirability of co-operating in the production of industrial alcohol and ether for fuel purposes.

(1). Saccharine Materials.—Cane molasses unquestionably surpasses any other material for the manufacture of alcohol for two reasons, the first being that it is comparatively rich in fermentable sugars, and secondly, that it is a waste product in many countries. Complete statistics regarding the amount produced in different parts of the world do not appear to be available, though figures for certain territories have been published. Factory control figures, however, indicate that the weight of molasses averages about 25 per cent. of the weight of raw sugar produced, being sometimes a few per cent. above or below, depending upon several factors, principally upon the degree of exhaustion of molasses. At any rate, 25 per cent. may be accepted as a sufficiently close figure for calculation of molasses available in any country. Calculated as dextrose the total fermentable sugars (sucrose and glucose or reducing sugars) present in cane molasses vary rather considerably, namely from about 5- to 62 per cent., but the actual composition to serve as a basis of a distillery forming an adjunct to the sugar factory proves at time unremunerative, and may be closed for a period until market conditions make it worth while again to utilise the waste product in this manner. In certain countries in which formerly a greater amount of spirit was produced than at the present day, the question of the disposal of the molasses has become an acute one, and elsewhere it presents a problem which has always awaited a solution.

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Cane cultivated as a raw material for alcohol manufacture would contain 12 to 18 per cent. of total sugars as dextrose, and the juice extracted by a distant mill, perhaps after the sugar manufacturing season had terminated, might be conveyed to the Natalite central by pipe line.

Sorghum stalks contain about 14 to 15 per cent. of total fermentable sugars, and at least 80 per cent. might be extracted in modern mills situated at different points in the territory, the juice obtained being also conveyed to the fermenting vats in the Natalite central by pipe line, a system of transporting which is now in use in several sugar producing countries, and proved to be quite practicable.

Sugar beets might be cultivated in certain countries, and better varieties would contain 12 to 15 per cent. of fermentable sugars, of which it should be possible to extract at least 90 per cent. in a special diffusion apparatus used in distilleries in France and elsewhere.

(2) STARCHY MATERIALS.—Sorghum grain contains about 66 per cent. of starch; rice about 67; maize, about 63; cassava, about 25; sweet potatoes, about 22 per cent., and also 5 to 6 per cent. of fermentable sugars.

All these plants might be intensively cultivated in tropical countries for the purpose in view.

Saccharification of the Starchy Materials.

It has already been pointed out that starch cannot be fermented by yeast directly, but requires preliminarily to be hydrolysed to simpler saccharides. In the production of spirit at the present time this is accomplished largely by the malting process, in which the starchy material after mashing is cooled to 50 to 55 C., and mixed with green malt. In this way, by means of the enzyme diastase, the starch is converted to maltose and malto-dextrins, which are capable of being fermented by the yeast. Another process that is used to some extent, especially on the Continent, is to heat the mash (often under pressure) with a small amount of hydrochloric or sulphuric acid, which later is neutralised. Much work is being done in this direction and extremely promising results have been obtained.

During recent years, however, an improved method of converting starch has developed, and is now successfully used in large distilleries in France and elsewhere. This is the so-called "amylo process," which takes advantage of the fact that certain moulds secrete amylase or diastase. Originally the mould employed was Amylomyces Rouxii, the designation giving rise to the name by which the method is now known, but it is to be noted that a special culture mould has now been put into use, Mucor Boulard No. 5, which effects the conversion of the starch into fermentable sugars both rapidly and efficiently. This process is well suited for use in tropical distilleries, and from the technical point of view offers distinct advantages compared with the acid process in respect of economy both of steam and labour, while, compared with malting, the operation is more certain and more rapid, and generally more suitable for tropical climates. Furthermore, it is claimed that the conversion by means of these cultures is very complete, practically all the starch of the raw materials being converted into fermentable sugars.

Fermentation and Rectification.

Under this heading it may be pointed out that according to modern practice in fermentation the aim is to obviate the growth of any micro-organisms that may cause the formation of products other than ethyl alcohol. This is ensured by the use of pure yeast cultures, the presence of foreign noxious micro-organisms, such as butyric acid bacteria, acetic acid bacteria, mycoderma, etc., causing low yield of alcohol being carefully suppressed. It is unnecessary here to enter into intimate details regarding the use of pure yeast, this being a matter which may well be left to the

Natalite climbs hills better than any petrol

hands of the up-to-date distillery superintendent, but in order to emphasise the importance of conducting operations on these lines, attention may be directed to certain figures given by J. Magne in regard to yield of alcohol, under different conditions of working :-

Method of Fermentation.	Yield of Alcohol per cent. of theoretical.
Spontaneously, in presence of wild yeasts	40 to 60
Using compressed yeasts	[illegible] to 75
Adding antiseptic chemicals	[illegible] 85
Operating with pure yeast	[illegible] 95

Regarding the distillation a[illegible]ctification of the fermented mash, it may be remarked that the purpose of this stage of the manufacture of Natalite is to produce a spirit containing not less than 95 per cent. of alcohol (by volume.) Most of the alcohol nowadays is distilled in the so called "patent still" equipped with a rectifying column, of which the Coffey type is the most prominent example. These apparatus are highly efficient, and are capable of producing spirit continuously, of 96 per cent. strength whereas with the old plant of pot-still type the strongest alcohol obtained is only 92 per cent., even by repeated distillation.

It now remains to s[illegible]rise a few further figures that m[illegible] service to those considering the [illegible]on of a Natalite central, particularly in calculating the yield and profit to be expected. It is impossible in practice to obtain a complete conversion to alcohol of the sugar present in molasses or other raw material, as is well known. Theoretically, the yield of absolute alcohol by weight would be :

	Per Cent.
From dextrose	51.1
From sucrose or maltose	53.8
From starch	56.8

These theoretical values, however, are never reached in practice ; but in efficient plants under careful management a yield of 85 to 90 per cent. of the theoretical amount should be obtainable.

The approximate yield of alcohol that may be expected from [illegible] raw materials is given in a previous table ; some of the figures shown being actually obtained in large scale operations.

A diagram showing the approximate yield per acre of various raw materials is also given.

A Modern "Natalite" Plant.

We have dealt in a general way, *inter alia*, with the "permanent world famine" in petrol,[1] with the advantages of a mixture of alcohol and ether (Natalite) as motor fuel, with the feasibility of the erection of "centrals" for the production of Natilite in cane-growing locations,[3] with the raw material that may supplement the molasses supply,[4] and also with the denaturing of alcohol when used for the purpose of motor fuel.[5] It is now of much interest to give a brief description of a modern Natilite plant, which is conducted with great efficiency in respect both of fermentation and distillation. It is located at Merebank, about eight miles from Durban, Natal (see page 22).

In this factory the only saccharine raw material used is molasses, which is brought from the mills producing it in "treacle tank trucks," and stored in a large reservoir constructed in masonry covered with a suitable roofing. About 45 tons of molasses are fermented in 24 hours. It is pumped from the reservoir to the factory into the diluting tanks, where it is mixed partly with cold water and partly with cold spent wash or vinasse, agitation being effected by means of compressed air. A wort at about 12° Bé. (that is, .9861 sp. gr.) at as low a temperature as possible is thus obtained, and it is allowed to run into several fermentation tanks after the propagation of the pure yeast.

Sterilisation and the Use of Pure Yeast.

Fermentation in the modern industrial alcohol factory, in which a product of high yield and high purity

1 *I.S.J.*, 19[illegible], 147–148.
2 *Ibid.*, 19[illegible], 713–[illegible].
3 *Ibid.* [illegible]
[illegible]
[illegible]

Natalite is a world-wide registered trade mark

is sought, must be conducted under very different conditions from those that obtain in the ordinary run of factory in the West Indies, in which the object in view is the production of spirit of special flavour, the yield being, generally speaking, a secondary consideration. In order to realise the highest yield possible of pure alcohol, pure yeast cultures under aseptic conditions must be employed, a point which has already been mentioned,[1] and in the Natalite factory this is done in a certain and automatic manner by means of the apparatus depicted in these pages. Some of the wash going into the fermentation tanks is intercepted and sterilised in order to destroy the bacteria, foreign yeasts and other micro-organisms present, which if permitted to propagate, would undoubtedly lead to the formation of a certain amount of by-products, and thus decrease both the yield and quality of the product. A special steriliser,[2] which functions automatically and definitely, and controls both the temperature and time of heating, is used. As one may see by reference to page 28, it consists of three parts: (1) the system of tubes in which the wort entering is heated by means of the sterilised wort leaving, another series of tubes completing the cooling effect; (2) the pump for circulating the wort through the tubes, the exhaust steam from which is used for sterilising; and (3) the sterilising vat, in which the wort is raised to the temperature chosen, and maintained at this degree, its discharge being effected by means of a suitable regulating device. This sterilising apparatus, besides being automatic, works very economically from the point of view of cost of fuel, owing to the method of heat exchange in heating which is adopted.

Having sterilised a sufficient quantity of the wort, it is now possible to proceed with the propagation of the pure culture of yeast (supplied by a bacteriological laboratory in Europe), the apparatus (pages 28 and 33) being used for this purpose. In this particular Natalite factory, however, the upper vessel is not included in the yeast apparatus, since it is a steriliser, used only when the special automatic steriliser just described has not been installed. There are, therefore, two vessels, each of about 110 gallons capacity, which preliminarily are sterilised by means of steam. In each are placed 25 gallons of the sterilised wort, preferably at 30° C. (86° F.), and then the pure yeast is added through a tubulure in the cover.

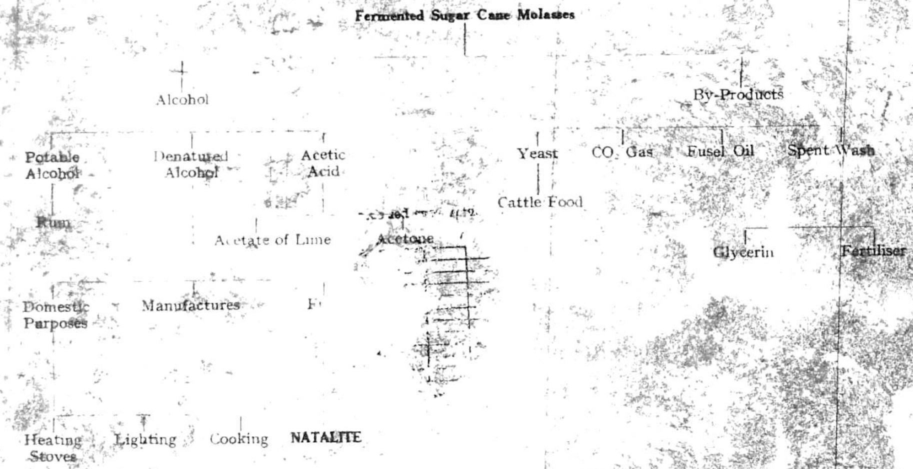
Fermentation develops rapidly, as one may observe by the liberation of the gas through a small tube dipping into an antiseptic solution contained in a small recipient. After a suitable interval of time, a fresh quantity of sterilised wort is added to that already in fermentation, and later yet another, until the vessels are nearly full. So this mixture of wort and yeast is in full fermentation, and some can then be sent to the yeast vats, the volume of liquid thus abstracted being replaced by fresh sterilised wort.

These yeast vats are four in number, and each holds about 1,000 gallons. First some of the sterilised wort is sent into them, then some of the fermenting wort from the pure yeast apparatus, more sterilised wort being subsequently added from time to time, u[illegible] are full. Fermentation is allow[illegible] proceed for a certain time, at the end of which the cells of the micro-organism have become very numerous, and the yeast is ready to be used in the fermentation vats.

There are ten of these fermentation vats, the capacity of each being 10,000 gallons. In filling them a certain quantity of the ordinary unsterilised wort (that is, the mixture of diluted molasses and spent wash or vinasse) is added, then some of the fermenting wort from the yeast vats. A vigorous and healthy fermentation results, and after a little time more wort may be added to this *pied de cuve*, feeding being continued till the vat is full. The wort will then have a density of about 6 to 7° Bé. (that is 1.045 to 1.050 sp. gr.) and about 24 hours later the fermentation will be finished. These fermentation vats are provided

[1] I.S.J., 1921, 385.

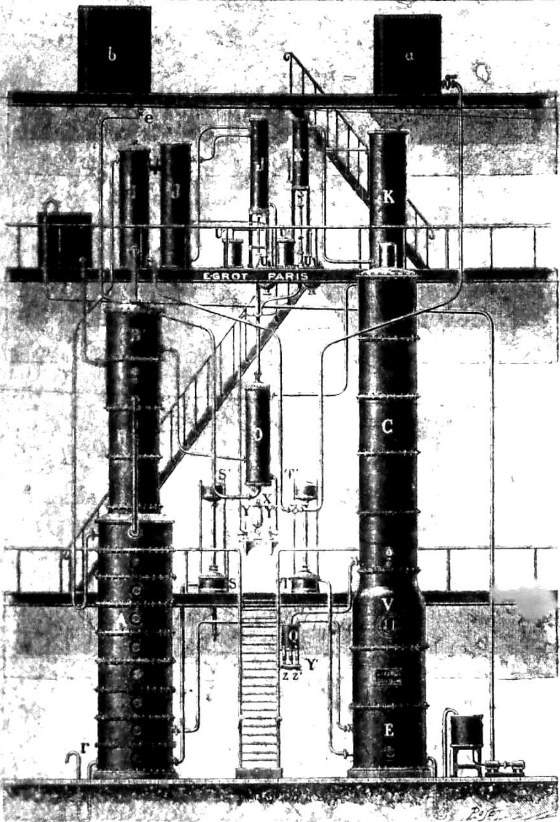
[2] Manufactured by [illegible] of Paris, and termed by them the [illegible] *Réfrigérant*.



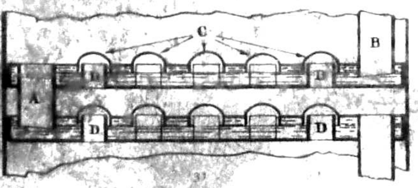
SHOWING THE PRODUCTS OF SUGAR CANE MOLASSES.

(From "*The Manufacture of Sugar from the Cane and Beet,*" by T. H. P. Heriot.)

Natalite distilleries give most valuable by-products

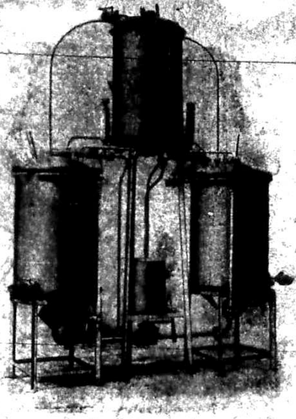


General Lay-out of the Distilling and Rectifying Plant.



One of the "plates" effecting the volatilisation of the alcohol from the wash.

Natalite is the easiest fuel on earth to produce



Pure Yeast Apparatus.

Distribution by
Service Station Pumps.

Ether Plant. General View.

(4) That, while rendering the alcohol unpotable, the denaturant shall not be unduly obnoxious in smell nor highly poisonous.
(5) That the denaturant shall be so effective that the addition of a small percentage shall suffice.
(6) That it shall be readily detectable in small quantities by chemical tests.

The conditions in Great Britain are more severe than any other country, for the duty on potable spirit is so extremely high—72s. 6d. per proof gallon, equal to about 120s. per bulk gallon. As a consequence the temptation to defraud the Excise authorities is correspondingly great. In other countries where the duty on alcohol is very much less the denaturing regulations are not so severe and, as a consequence, the cost of denaturation is much less. Naturally, spirit which has been denatured abroad must be again denatured on entry into this country.

By reason of determined efforts to foster power alcohol the Excise regulations for Great Britain with reference to power alcohol, have been considerably modified, but even so are very complicat[illegible] the Excise regulation with regard [illegible] denaturation of power alcohol stated: "In each operation for the preparation of Power Methylated Spirits the authorised methylator must in the presence of the proper officer mix with and dissolve [illegible] spirits of the proper denomination and strength not less than two and a half per cent. of their bulk of wood naphtha, one-half of one per cent. of crude pyridine, and not less than five per cent. of benzol, and must add to every thousand gallons of the mixture thus obtained three-quarters of an ounce of "Eosin (yellow shade") dye and one-quarter of an ounce of 'Spirit Red 3' dye."

The cost of the chemicals for the denaturing of power alcohol—apart from any labour and overhead charges—amounts to nearly 10 per cent. of the cost of the alcohol, and is a very serious item. It is to be hoped that in the future simpler regulations will come into force.

It may be of interest to say that in addition to the denaturants already mentioned the following are among oth[illegible]s which have been suggested, and in some cases used. Benzol, tar oil distillates, turpentine distillates, bone oil, caoutchoucine, nicotine, etc. None of these is ideal but restricted use has [illegible] found for some. In India the offic[illegible] [illegible] are for the use of one-ha[illegible] [illegible] of crude pyridine bases a[illegible] [illegible] per cent. of caoutchoucine.

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same day as the test with Natalite fuel :—

Fuel.	R.P.M.	I.M.E.P.	I.H.P.	Fuel consumption Unit Vol. ¼ pint. Pint per I.H.P. hr.
Petrol A.	1,500	138.1	32.9	
Natalite	1492	144.2	34.2	.665
	1505	143.8	34.4	.884
	1495	145.3	34.5	.746
	1503	145.3	34.7	.698
	1489	145.3	34.4	.668
	1489	143.5	33.9	.643
	1500	140.3	33.6	.609
	1497	136.7	32.5	.600
	1500	132.0	31.4	.591
	1501	126.6	30.2	.584
	1511	121.5	29.2	.577
	1503	113.6	27.1	.594

Half Power and Consumption Tests.

The following is one of the tables of tests made by Mr. Ricardo at a speed of approximately 750 r.p.m., the first line in the table being the check test on petrol A made on the same engine and on the same day as the test with Natalite fuel :—

Fuel.	R.P.M.	I.M.E.P.	I.H.P.	Fuel Consumption Unit Vol. ¼ pint. Pint per I.H.P. hr.
Petrol A	750	123.8	14.7	
Natalite	749	130.1	15.4	.868
	748	130.8	15.5	.808
	746	130.8	15.4	.783
	748	130.8	15.5	.715
	745	129.3	15.2	.666
	751	125.5	14.9	.631
	743	121.2	14.3	.628
	747	114.7	13.6	.619

With reference to the power and consumption tests, Mr. Ricardo remarks that :—" At 1,500 r.p.m. the average maximum power on Natalite is 4½ per cent. higher than on petrol A under equal conditions, and with detonation completely absent. At 750 r.p.m. the average maximum power on Natalite is four per cent. higher than on petrol A in the same circumstances. Compared with petrol which has a low detonation point, the advantage in power by the use of Natalite will be greater than [illegible] per cent. for the speeds of 1,500 and 750 r.p.m. respectively."

Higher Thermal Efficiency.

Natalite gains in efficiency due to the low specific heat of its weak mixture, while the cooling of the charge, due to the high latent heat keeps the i.m.e.p. up, as compared with the richer petrol mixture. . . . There is a greater effective range of mixture strengths on Natalite than there is on petrol. In a multi-cylinder engine this would be of value, as a given inequality of mixture strength would be less likely to cause the richer cylinders to be working on the steep rich mixture portion curves, thus the gain in efficiency when using Natalite instead of petrol would probably be, in multi-cylinders engines, greater than the above figures indicate. The maximum power obtainable may be as much as eight per cent. higher than with petrol.

Higher Useful Compression.

The tests showed that the maximum useful compression "may be taken as 6.5 : 1 as compared with values for petrol ranging from 4.5 : 1 up to 6 : 1. This shows that as regards detonation, Natalite is superior to petrol, but the same cannot be said as regards preignition." In commenting upon a further maximum compression test with another sample of Natalite, Mr. Ricardo states that :—"The compression ratio was in fact raised as high as 7 : 1 without audible detonation occurring. At this compression it was deemed advisable to discontinue the test since occurrence of preignition at a compression of about 7 : 1 might severely strain or even seriously injure the engine."

" It is clear from the tests we have made that provided suitable sparking plugs are used to prevent preignition, Natalite can be used in engines of the highest compressions at present employed, with the spark advanced to same day as the test with Natalite fuel :—

Fuel.	R.P.M.	I.M.E.P.	I.H.P.	Fuel consumption Unit Vol. ¼ pint. — Pint per I.H.P. hr.
Petrol A.	1,500	138.1	32.9	
Natalite	1492	144.2	34.2	.665
	1505	143.8	34.4	.864
	1495	145.3	34.5	.746
	1503	145.3	34.7	.698
	1489	145.3	34.4	.668
	1489	143.5	33.9	.643
	1500	140.3	33.6	.609
	1497	136.7	32.5	.600
	1500	132.0	31.4	.591
	1501	126.6	30.2	.584
	1511	121.5	29.2	.577
	1503	113.6	27.1	.594

Half Power and Consumption Tests.

The following is one of the tables of tests made by Mr. Ricardo at a speed of approximately 750 r.p.m., the first line in the table being the check test on petrol A made on the same engine and on the same day as the test with Natalite fuel :—

Fuel.	R.P.M.	I.M.E.P.	I.H.P.	Fuel Consumption Unit Vol. ¼ pint. — Pint per I.H.P. hr.
Petrol A.	750	123.8	14.7	
Natalite	749	130.1	15.4	.868
	748	130.8	15.5	.808
	746	130.8	15.4	.783
	748	130.8	15.5	.715
	745	129.3	15.2	.666
	751	125.5	14.9	.631
	743	121.2	14.3	.628
	747	114.7	13.6	.619

With reference to the power and consumption tests, Mr Ricardo remarks that :—" At 1,500 r.p.m. the average maximum power on Natalite is $4\frac{1}{2}$ per cent. higher than on petrol A under equal conditions, and with detonation completely absent. At 750 r.p.m. the average maximum power on Natalite is four per cent. higher than on petrol A in the same circumstances. Compared with petrol which has a low detonation point, the advantage in power by the use of Natalite will be greater than $4\frac{1}{2}$ per cent. for the speeds of 1,500 and 750 r.p.m. respectively."

Higher Thermal Efficiency.

Natalite gains in efficiency due to the low specific heat of its weak mixture, while the cooling of the charge, due to the high latent heat keeps the i.m.e.p. up, as compared with the richer petrol mixture. . . . There is a greater effective range of mixture strengths on Natalite than there is on petrol. In a multi-cylinder engine this would be of value, as a given inequality of mixture strength would be less likely to cause the richer cylinders to be working on the steep rich mixture portion curves, thus the gain in efficiency when using Natalite instead of petrol would probably be, in multi-cylinders engines, greater than the above figures indicate. The maximum power obtainable may be as much as eight per cent. higher than with petrol.

Higher Useful Compression.

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Natalite gives more power than any petrol (Gasoline)

methylated alcohol alone and Natalite are contrasted :—

VAPOUR PRESSURES IN INCHES OF MERCURY.

Temperature of	Pratt's Perfection.	Methylated Alcohol.	Natalite.
60	1.4	1.1	1.9
65	2.6	1.8	3.6
70	3.6	2.7	4.9
75	4.8	3.6	6.8
80	5.9	4.7	8.2
85	7.1	5.7	10.2
90	8.2	6.9	12.3
95	9.3	8.0	14.5
100	10.5	9.2	16.9

It will be seen from this that the vapour pressures of the alcohol are uniformly below those of the petrol, and it is this that has caused the starting troubles found with it and the want of flexibility which has militated against its use in high-speed vehicles, *whilst, on the other hand, Natalite, owing to the volatility of the ether which it contains, is uniformly higher than Pratt's "Perfection," and will, with the greatest ease, no matter how low the temperature, give perfect flexibility in running.*

2. *Bench Tests* with stationary motor car engine, in order to compare the power obtained in the engine by Natalite with that given by Pratt's "Perfection" Spirit. The carburettor was carefully adjusted to give the best result obtainable with Pratt's spirit, and comparative trials were then run with the two fuels—the first at 1,000 revolutions per minute, whilst a second trial was made with the speed accelerated to 1,300 revolutions.

Spirit Used	Pratt's.	Natalite.	Pratt's.	Natalite.
Revolutions	1,000	1,000	1,300	1,300
Horse-power developed ..	12.5	10.5	16.9	15.6
Gallons per hour consumed ..	1.65	1.95	2.36	2.55
Gallons per H.P. hour ..	0.132	0.183	0.140	0.164

This shows that with the normal adjustment of the carburettor for petrol rather more Natalite has to be consumed to give the same power at the lower rate of running, but that as the engine is accelerated the difference in favour of the petrol rapidly grows less, so that at 1,300 revolutions 1.17 gallons of Natalite would give the same results as 1 gallon of the best petrol.

It was then tried if greater power could be developed with the Natalite by adjusting the carburettor to give a richer mixture, and under these conditions the Natalite showed an economy over the petrol :—

Spirit Used	Pratt's.	Natalite.
Revolutions	1,300	1,300
Horse-power developed ..	10.1	18.85
Gallons per hour consumed ..	3.73	3.53
Gallons per H.P. hour ..	0.370	0.187

This shows that when an increase in horse-power is needed it can be obtained more rapidly with the Natalite. Whilst the adjustment of the carburettor on a car is rarely made with delicacy employed in these experiments, *it may be safely said that for all-round practical work Natalite will show much the same results as petrol.*

3. *Exhaust.*—The exhaust given whilst using Natalite was carefully tested and was faintly alkaline throughout, whilst the exhaust gases were in no way offensive, and no signs of corrosion or fouling were found.

These tests show that the Natalite can be used in any engine and carburettor made for petrol without fear of damage to the engine.

4. *Storage, etc.*—Although Natalite

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These tests show that the Natalite can be used in any engine and carburettor made for petrol without fear of damage to the engine.

4. *Storage, etc.*—Although Natalite

an ordinary car with the usual carburettor without any alteration. The inventors of Natalite have solved the difficulty which has been a problem in the motor spirit world for the last twenty years, and have solved the question of corrosion once and for all.

EXTRACT FROM A REPORT BY
Professor Hahn, M.A., Ph.D.
Professor of Chemistry at the South African University, Capetown.

The Natalite mixture can be successfully used wherever petrol is used.

Australian Reports on Comparative Tests of Petrol and "Natalite."

The University of Queensland,
Department of Engineering,
Brisbane,
May 2nd, 1917.

The object of these tests was to ascertain the adaptability of a mixture of ether and alcohol prepared according to the Natalite formula for use in engine designed and adjusted to petrol.

The sample of Natalite was forwarded by the Government Analyst, and was stated to consist of 45 per cent. ether, 54.5 per cent. commercial alcohol, and .5 per cent. ammonia. This was tested against Shell Brand benzine (petrol). The engine was a twin cylinder Crossley rated 13 H.P. at 750 r.p.m., and was loaded by being belted to a dynamo. No alteration was made to the normal adjustment of carburettor or ignition. The output of the dynamo was varied between 2.3 and 5.1 kw., which would correspond to 3.3 and 8.5 B.H.P. respectively if we allow a combined efficiency of 80 per cent. for the dynamo and belt. At each load the engine was run on each fuel alternately, fourteen tests having been made in all. In every instance the consumption of the two kinds of fuel was practically the same, and varied from .14 gallons per brake horse-power per hour at the larger load to .2 gallons at the lower load. Taking a mean of all the observations, the consumption per B.H.P. hour was 3 per cent. lower for Natalite than for benzine (petrol). A Hopkins' optical indicator was attached to the engine, and enabled the indicator diagram to be continually observed. The indicator diagram for the two fuels was practically identical. The engine started with equal facility on either fuel.

My general conclusion was that Natalite spirit gave equally satisfactory results to benzine (petrol) in an engine designed for the latter class of fuel.

In some subsequent runs it was found that in order to form the best mixture less air should be supplied to the carburettor for Natalite than benzine (petrol), as might have been inferred from the chemical compositions of the two fuels.

I have no doubt that better results could be obtained in an engine specially designed for Natalite.

The object of the present tests was, however, merely to note the result of substituting Natalite for benzine in an ordinary petrol engine.

(Sgd.) PERCY L. WESTON, B.Sc.,
B.E. (Mech. and Elec.).
(Lecturer in Electrical Engineering).

The University of Queensland,
Department of Engineering,
Brisbane,
May 21st, 1917.

Having completed further trials of petrol and Natalite, I beg to report on the trials generally.

The object of these trials was to compare the fuel values and general merits of petrol and Natalite in an engine of industrial type designed for petrol. The Natalite was forwarded by the Government Analyst, and was stated to consist of 45 per cent. ether, 54 per cent. commercial alcohol, and efficiency, and the estimated belt efficiency.

The fuel consumption was measured by running it through a graduated glass tube about 18 inches long, the supply from the fuel tank to the tube being shut off when making each run. A separate tube was provided for each fuel. As the object of these trials was to make a comparison under average running conditions, no special attempt was made at exact mixture adjustment for each load.

Discussion of Trials.—When the total fuel consumption is plotted against the B.H.P., the mean graphs for each series are found to be approximately straight lines which are almost identical for the two fuels. Tests Nos. 10 and 11, Series I., lie somewhat below the mean graph, which denotes that the alteration of air adjustment has improved the mixture.

The short series of trials (Service III.) were afterwards made in order to ascertain what improvement in fuel economy could be made with more exact mixture adjustment for each fuel at about three-quarter load, which would per[illegible] a relatively poor mixture being [illegible]d with the throttle full open; these being the conditions under which a maximum economy may be expected. The original carburettor was replaced by a Schebler make, which had a needle adjustment to vary the size of jet. It will be seen that the improvement in economy by exact adjustment was more marked for petrol than for Natalite. In Series I. and II. the Natalite mixture, being relatively weaker than the petrol mixture, was somewhat less throttled by the governor for equal loads, and hence Natalite had the advantage of a somewhat higher compression and less suction losses.

In tests Nos. 4 and 5, Series III., which show the lowest consumption for both fuels, the throttle was wide open, so that the compression was the same for both. If the calorific values of petrol and Natalite be taken as 134,000 and 95,000 B.T.U. per gallon respectively, then the brake thermal efficiencies are 16.5 and 19.1 per cent. respectively.

This result is in agreement with the fact repeatedly noted by other investigators that alcohol gives a consistently higher thermal efficiency than petrol under similar conditions. For instance, an exhaustive series of tests by Strong and Stone (Bulletin 43, U.S. Bureau of Mines, 1912) on hit-and-miss governed engines, showed for similar compression values a brake thermal efficiency of about 22 per cent. for alcohol and 20 per cent. for petrol, and this relative ratio was maintained at other compression values.

Why alcohol should consistently show this inherent superiority has never been satisfactorily explained. The chief respects in which alcohol differs from petrol are:—

(*a*) Alcohol contains some combined oxygen while petrol has none;

(*b*) One pound alcohol required theoretically to 8 lbs. air for perfect combustion, while petrol requires about 15 lbs.;

(*c*) Combustion is propagated much more slowly in an alcohol mixture and a much higher compression can be used before pre-ignition occurs;

(*d*) Latent heat of vaporisation of alcohol is more than double the value for petrol;

(*e*) Alcohol, unlike petrol, is only slightly miscible with lubrication oil;

(*f*) The composition of the products of combustion is different for the two fuels.

Strong and Stone suggest that possibly the different composition of the exhaust gases may cause the rise in the value of the specific heat which is supposed to occur at high temperatures to be greater for alcohol mixtures than for petrol. Another suggestion is that the lower rate of combustion with alcohol mixtures leads to de-

Can be made in unlimited Quantities

Reports of Tests of Natalite Motor Spirit by Governments and Automobile Associations.

Report of Test under the Auspices of the Canterbury Automobile Association.

Headquarters: Christchurch, N.Z.
14th January, 1921.

We hereby Certify that a trial of Natalite Motor Spirit was made under the auspices of the Canterbury Automobile Association on Thursday, the 13th day of January, 1921. The following are the particulars:

Car.—A 1920 Standard Hupmobile car, Model R3, belonging to the N.Z. Farmers' Co-op. Association, which, according to the speedometer, had previously travelled 10,618 miles, and it was stated on behalf of the owners that the engine had not been cleaned or overhauled since the car had been placed on the road. The only adjustment made was to open the jet of the carburettor to the fullest extent.

Driver and Passengers.—The driver was Mr. L. M. Montgomery, the chief engineer for the N.Z. Farmers' Co-op. Garagem, Christchurch, and the passengers were Messrs. W. H. Tisdall (Canterbury Automobile Association), Mr. W. Forrest Marshall, Mr. Dunsterville (Editor, *Dominion Motor Journal*), and Mr. F. W. Johnston (a member of the Council of the Canterbury Automobile Association, and also the President of the South Island Motor Union.)

Weight.—The weight of the car fully loaded, as weighed on the Christchurch City Council weighbridge was 1 ton 12 cwt. 2 qrs.

Spirit.—The petrol tank and vacuum chamber were completely emptied and 6 gallons of what was stated by Mr. Marshall to be Natalite were carefully measured and poured into the petrol tank. Samples of the spirit were also taken for analysis if required.

Route.—The route taken was from Christchurch over Dyer's Pass to Governor's Bay, Charters Bay, Purau, Port Levy, Pigeon Bay and, the Summit Road to Akaroa, and return *via* the Hill Top and Little River. The route driven over was chosen owing to the very severe test it would afford. Several times it went down to sea level and then rose again to heights varying from 700 feet above sea level to 1,925 feet, which was the highest point attained.

Details of running the Car.—The car ran smoothly. The altitude made no difference in running. The engine remained particularly cool during the whole of the journey; no water was added to the radiator during the whole trial. When the car was slowed down to 10 miles an hour on a grade of 1 in 12, there was a total absence of "knock." Coming out of Charters Bay the car was purposely stopped in the middle of a grade of 1 in 5. It was started again, fully loaded, without the slight[illegible]ouble.

Fuel Consum[illegible]—As above stated, the main object o[illegible] test was to test the driving capacity of the spirit, and no attempt was made to conserve the spirit. No extra air supply was fitted to the car, and in descending all hills, with one exception, the car was taken in gear so as to assist the brakes. On the return journey from Akaroa, *via* Little River, the car came to a standstill at Motukarara, with the mileage showing 94 8/10 miles, making an average mileage of 15.8 miles per gallon.

Taking into consideration that there was no tuning up of the car other than the rough adjustment of the carburettors, that there was no extra air, and that the engine was used as a brake in descending hills, coupled with the severity of the road test, we consider the above mileage per gallon an excellent one.

bines greater economy with greater power and more complete combustion.

I am, Gentlemen, yours faithfully,

(Signed) ERIC F. BOULT, A.M.I.A.E.

W. BEAUCHAMP PLATTS,
Secretary and Treasurer, the New Zealand Automobile Union.

W. H. MORTON,
City Engineer, Wellington, N.Z.

C. J. B. NORWOOD,
Dominions Motors, Ltd.

H. T. B. DREW,
Evening Post Representative.

Report of Test of Natalite by the Natal Automobile Club.

Report issued November, 1920.

The following is the full report of a successful test of Natalite, used with the "Jacco" carburettor, held recently by the Natal Automobile Club. The driver of the car was Captain Norton, and he was accompanied by Mr. Jacobson (the inventor of the "Jacco"), Mr. Braby (Chairman of the N.A.C.), Mr. Kyle (Convenor, Technical Committee, N.A.C.), and Mr Strickland (Secretary, N.A.C.) ...

"The run was from Durban to Maritzburg and back, a distance of 105.5 miles. The car used was a Hupmobile, 1920 model, fitted with Jacco carburettor. Total weight of car including driver and other occupants 3,300 lbs., tyres 815 × 105, hood down, windscreen closed.

"The tank was drained dry and refilled with 9 gallons commercial Natalite, purchased at the Natal Motor Industries, and supplied from the Bowser pump. In order to test the accuracy of the Bowser pump, a 1-gallon stamped Imperial measure was used for the first 4 gallons, and, the pumping correct, the balance of 5 gallons was filled direct from the pump. The tank was then sealed. The carburettor was examined with all fuel connections. The speedometer was set at zero.

"The start was made from Durban at 10.26 a.m. The engine, although almost cold, started very easily.

"*Details of Journey Out.*—Speed at Toll Gate, 25 miles per hour.

"Black Hill (gradient, first portion 1 in 7, second portion, 1 in 8, average, 1 in 9½): Speed at bottom on top gear was 21 m.p.h.; the first portion of this hill was taken throughout on top gear; slowest speed, 16 m.p.h., with slight retard. At the foot of the second portion the speed was increased to 25 m.p.h.; at the steepest portion second gear had to be used, but only for a short distance. The actual head of the hill was reached on top gear very easily.

"Huntley's Hill (grades 1 in 7 and 1 in 8, average 1 in 10): Speed at bottom, 25 m.p.h., reduced to 15 m.p.h. in second gear, but the engine picked up wonderfully well, and the top of the hill was reached in high gear at 20 m.p.h.

"Cowie's Hill (gradient 1 in 12): Average speed 20—25 m.h.p., with no change in gears.

"Field's Hill (gradient 1 in 10): Speed at bottom, 21 m.h.p., top, 20 m.p.h. Top gear throughout, with plenty of power to spare. Speed at bottom, 25 m.p.h., at steepest portion.

"Botha's Hill (grade 1 in 8): On second at 14 m.p.h., then to top gear 20 m.p.h. after first rise.

"Drummond Hill (first rise average grade 1 in 14): On top at 25 m.p.h. Second rise on top at 21 m.p.h.; then into second gear 15 m.p.h. on the steepest rise (grade 1 in 7.8, at bottom, and 1 in 8.7 at top).

"Polly Short's Cutting: Taken on top at average 21 m.p.h. until 20 yards from top, when grade is 1 in 9½, on second at 15 m.p.h.

"Arrived Maritzburg (Imperial Hotel) at 12.5 p.m. Time taken outward journey 2 hours 31 minutes, average speed 20.06 m.p.h.

"Examination: Engine examined and found remarkably cool, the water in radiator hardly steaming; no additional water required for return journey. The hood was sealed and fuel sealed, examined, and found in order.

Thousands of motor vehicles use it daily

2,290 lbs., and the distance was 72.8 miles, the ton mileage was 83.356. Two gallons 7½th pints of petrol was used, or 2.975 imperial gallons. Therefore, with petrol, the ton mileage figures at 28 ton miles per gallon, and the car covered 24.5 miles of road per gallon of petrol consumed.

Natalite Test.—The weight of the car was the same, 2,290 lbs., and the distance the same, 72.8 miles, giving a ton mileage of 83.356. In this test 3 gallons 1 pint and 12 oz. of Natalite was used, or 3.192 imperial gallons. This gave a result of 26.114 ton miles per gallon, and the car covered 22.8 miles of road per gallon of Natalite consumed.

From the above the ratio of economy is as follows :—

Natalite in these tests showed 93.264 per cent. of the value of petrol.

General.—With Natalite the engine ran smoothly and strongly, especially at high speed ; the engine performance was all that could be desired. Then, again, it appears to your Committee that in mounting the long grades the engine, when running on Natalite, had the tendency to hang on longer on top gear and pul[illegible] reduced to a low speed.

In conclusion, your Committee consider that Natalite, as supplied to us, is a very satisfactory fuel, and it is our opinion that if the carburettor had been more carefully adjusted, a result as good, or nearly as good, as petrol would have been secured.

Samples of the petrol and the Natalite have been taken and sealed, and are in the possession of the Club officials.

As promised in the last report, a further test has now been completed with Natalite spirit, as follows :—

A Ford car was selected and 40 gallons of Natalite was burnt in 77½ hours on friction load of car only, the back wheels being jacked up.

Prior to starting, the cylinder heads were taken off and all carbon deposits entirely removed, the valves were ground in, and all left showing a perfect surface.

We were constantly in touch with the car during the test, and had samples taken of each tin of Natalite as it was put into the tank. The samples are now in our possession.

At the close of the test we again removed the cylinder heads, which we found less carbonised than would have been the case had the petrol been used. The valves and valve seatings were in no way injured, neither was there any sign of pitting, nor acid deposit. The engine appeared to be in exactly the same condition as when the test started.

The carburettor was removed and dissected to see if any deposit had settled there, but none was found.

The engine throughout the test kept remarkably cool.

(Sgd.) C. H. WILLIAMS, } *Members of*
A. H. BELCOCK } *Committee.*

April 28th, 1916.

Royal Automobile Club Report.

Certificate of Performance (*under the Open Competition Rules of the R.A.C., No. 423*) *in a test of " Natalite " Fuel, May 13th to May 15th, 1915.*

This is to certify that a sample of " Natalite " fuel was entered by Messrs. The Natalite Motor Spirit Company, Limited, of Durban, Natal, for 2,500 miles Consumption Test.

The fuel appeared to consist of alcohol and ether, about 40 per cent. of ether being present ; methyl alcohol was present, probably as a denaturant. The result of a distillation test was as follows :—

10 per cent. distilled below	40° C.
20 „	54° C.
30 „	64° C.
40 „	74° C.
50 „	77° C.
60 „	78° C.
70 „	78° C.
80 „	79° C.
90 „	83° C.

a more extensive road test was decided upon and carried out on June 2nd.

For this purpose a passenger car, Model R II, Pic-Pic, was used, with a Scrieber motor of 16/32 h.p., with four cylinders of 85 mm. bore and 130 mm. stroke, and fitted with a Zenith carburettor.

The diameter of the carburettor for benzine was 1.25 mm. for the benzine jet, and 24 mm. for the air nozzle.

For the "Natalite" the air nozzle was reduced to 20 mm. while the fuel nozzle was kept the same.

The proportion of 20 mm. air nozzle diameter to 1.25 mm. fuel nozzle diameter was found to be the most favourable.

The trial run was 338 kilometres, during which 80 litres of "Natalite" were consumed.

This corresponds to a consumption of 23.6 litres to 100 kilometres, which also corresponds to the benzine consumption of this car.

The motor pulled just as well on up gradients as on the flat, and the car very quickly attained its maximum speed of 80 kilometres per hour. Moreover, on advanced sparking the motor seemed to be less sensitive than with benzine, and evinced a smaller inclination to knock. On these trials it also maintained its normal turning moment with a low number of revolutions.

The analysis of the exhaust gases made showed a content of about 7 per cent. of carbonic oxide. This must be ascribed to the fact that there must have been in the fuel some components which were refractory to combustion, and these probably originated in the denaturing agents.

The motor started up very easily, and it was absolutely impossible to notice any inferior working to benzine.

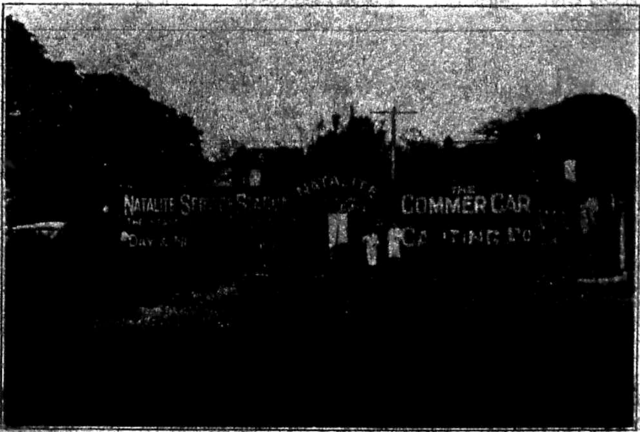
After this trial run the motor was examined, and at the examination the sparking plugs were found to be absolutely clean, nor was there noticeable any fouling of the sparking plugs or of the cylinders. There was no noticeable damage to the cylinders through acids, nor any decomposition of the lubricating oil and the running dry of the cylinders accompanying such, as is noticeable when alcohol is used.

Conclusions.

The trials carried out with "Natalite" have been satisfactory. The reason why this fuel, in spite of its lesser heat content of about 8,000 thermal units, compared with about 10,500 thermal units in benzine, yields approximately equal output of power, lies mainly in the actual difference of explosive power of these two fuels, which must be investigated by further trials. No single disadvantage has been revealed from the use of "Natalite" during the relatively short trial.

Natalite in the German East African Campaign.

As promised, I give you herewith a few particulars of my experience with "NATALITE" Motor Spirit during the campaign in German East Africa. I fear that I can only give you general observations, as much as I would have liked to make some comparative tests, I was far too busy, and in addition the general conditions did not lend themselves to this.



Natalite Service Station in South Africa.

Large quantities of the spirit were used in a great variety of makes of vehicles. These included Napier and Daimler 30 cwt. lorries, 6-cylinder Buick cars, also Dodge, Ford, Overland and Oakland. I did not have any three tonners in my charge.

I was out there between March, 1916, and Nov., 1917, either running convoys or in charge of workshops. During part of this time we used petrol and "NATALITE" alternately in the same vehicles, though we endeavoured so far as possible to keep definite vehicles for "NATALITE" only, having made carburetter adjustments. Latterly we had very little petrol and used practically nothing but "NATALITE."

Being a hot country we never had any difficulties about starting from cold, but I always preferred to run my own car on your spirit, owing to the extremely smooth running obtained.

The spirit was stored in four gallon tins, and so far as that was treated and handled in exactly the same way as petrol.

Storage in bulk would, so far as I

Reports of a Test of Natalite on a "National" 3-cylinder Engine.

13 in. Diameter, by 14 in. Stroke.

With reference to our visit this morning, we wish to place before you the following facts and figures concerning recent trials made with Natalite.

We wish to point out firstly, however, that we used *neither hot air nor heating arrangement of any kind*, and the trials of which we are about to give you the figures, was conducted *entirely on cold air*.

Result of the Degory Carburettors on 3-Cylinder Vertical Engine. 13 in. × 14 in. 350 R.P.M. Maker's Rating, 120 H.P.

Fuel Used ..	Natalite.
Length of time of Test	One hour.
Carburettors ..	3.42 m.m. with 25 20 m.m. multiple choke tubes The carburetto[illegible] chronised and [illegible] terfly throttles controlled by Governor.
B.P.H. Developed	150 Power to which the Makers asked us to tune the engine. Much greater power could have been obtained.
R.P.M.	350. Very steady and constant during whole test.
Consumption .	0,65 pints per hour.
Starting Up ..	Extremely easy from dead cold at first attempt.
Indicator Cards	As per copies enclosed, showing very excellent curves of each cylinder and practically all three exactly alike.

№ 1 CYLINDER

№ 2 CYLINDER

№ 3 CYLINDER

Indicator Diagrams of a 13 in. by 14 in. National Engine, running on Natalite.

Aeroplane Trial of Natalite in Australia.

Mr. H. G. A. Harding, F.T.C., F.C.S., etc., the well known Analytical Chemist of Sydney, was recently taken up in an Avro machine when testing the new motor fuel "Natalite." The engine was a 130 h.p. 9-cylinder Clerget. He states:—

"When starting it was found that the first kick of the propeller set the engine going. Mr. Love, the pilot, at once attained an altitude of 4,000 feet, with a speed of about 112 m.p.h., and they found that the engine ran perfectly—the revolutions did not die off, and there was no misfiring, which frequently happened with petrol. We both agreed that the fuel was superior to petrol for aviation purposes, insomuch that it starts more easily—cannot freeze and should it catch fire can be extinguished by water."

Aeroplane Tests on Alcohol Mixtures in the United States.

Mr. Howard Irving Cole, Chemist, Bureau of Science, Manila, writing on the future of Natalite and such alcohol mixtures, states:—

"That these fuels can even now compete with gasoline for aeroplane engines in the United States, where gasoline costs less than one-half what it does in the Philippines, is demonstrated by the United States Post Office Department* in its aeroplane mail service. Its tests show" a great increase in number of miles per gallon, an increase in power and a very marked saving in the quantity of lubricating oil used.

"Tables 8 and 9 show the amounts of gasoline and alcohol fuel used by aeroplanes at varying speeds, and also the consumption of lubricating oil, the tests covering thirty-one nonstop flights between New York and Washington.

TABLE 8.—COMPARISON OF THE CONSUMPTION OF GASOLINE AND ALCOHOL FUEL IN AEROPLANE ENGINES AT VARYING SPEEDS.

Revolutions per minute.	Gallons per hour.	
	Gasoline.	Alcohol mixture.
1,440 — 1,460 ..	—	15.9
1,475 ..	24	20.1
1,500 ..	24.17	21.5

"These tests also proved that there was much less carbon formation when using alcohol fuel than when using gasoline, and the number of forced landings due to fouled spark plugs was reduced to the minimum.

TABLE 9.—COMPARISON OF THE CONSUMPTION OF LUBRICATING OIL IN AEROPLANE ENGINES WITH GASOLINE AND WITH ALCOHOL FUEL.

Revolutions per minute.	Oil used with	
	Gasoline.	Alcohol.
1,440 — 1,460 ..	—	4.5
1,475 ..	4.65	2.2
1,500 ..	4.95	

* Tunison, B. R., Chem. & Met. Eng. 22 (1920) 297.

Wr Kent arrange appointment 21/4/25 [illegible]

NATALITE AND

C.O. 19441 29 APR 25

339

CABLES: QUENAN, LONDON.
CODE: BENTLEY'S.

TRADE NATILITE MARKS

TELEGRAMS: QUENAN, PARL, LONDON.
TELEPHONE: VICTORIA 9388.

2a

THE ALCOHOL FUEL CORPORATION LIMITED.

POWER ALCOHOL SPECIALISTS.

SECRETARY: C. A. H. FAIRBANK, M.C., F.I.S.A.

REGISTERED OFFICES:
7, PRINCES STREET,
WESTMINSTER, LONDON, S.W.1.

11.15

20th April, 1925.

Sir,

I have the honour to approach you with regard to the following matter.

I am given to understand that during your recent visit to our possessions in East Africa you and the other members of the Commission were greatly impressed with the necessity of improving the internal transport arrangements in the various Colonies.

This matter has been engaging my attention for some time past, and with the assistance of Mr. C. W. Hobley, a retired senior official of Kenya Colony, who has had a long experience of East Africa, a scheme has been worked out, which, if brought into being, would effect great improvement, for it deals with the local production of motor fuel at a reasonable rate.

May I therefore respectfully ask if you would allow Mr. Hobley to call on you and explain the details at your convenience. I may mention that the question has been discussed with your colleague, Major Church.

I have the honour to be, Sir,

Your obedient servant,

[signature]

CHAIRMAN

Hon. W. G. A. Ormsby Gore, M.P.,
Under Secretary of State,
Colonial Office,
S. W. 1.

THE TRANSPORT PROBLEM
in
EASTERN AFRICA

It is a truism to state that the development of motor transport in the Colonies of Kenya and Nyasaland, in the Protectorates of Uganda and Zanzibar, and in the mandated Territory of Tanganyika, is a matter of the greatest importance as regards the growth of prosperity of those dependencies.

It is obvious to all who know these countries that the development of the land on either side of the existing limited railway system depends to a great extent on the increase of motor transport, and this is true not only as regards the products of European activities, but it applies in a greater manner to the native reserves. The provision of transport facilities will enable thousands of natives to grow exportable produce with a prospect of sale, whereas at present they only grow food stuffs for local consumption.

The continual waste of human energy may also be referred to. Very large numbers of natives are at present engaged in bringing produce of various kinds into trading centres in head loads weighing only 30 to 40 lbs. each, often much less, a whole day or more being absorbed in each trip. The waste of human labour in East Africa is incredible. I have seen a column of natives two miles long bringing cotton into ginneries in Kampala each carrying about 20 lbs. of raw cotton. After each harvest thousands of Kikuyu proceed from Fort Hall district towards Nairobi, carrying small head loads of grain for sale, and each man spends at least a week on the round trip. Streams of women come daily into Nairobi carrying firewood for sale. These are examples which can be multiplied indefinitely, and the waste of energy is unbelievable.

This state of affairs grew up in the days when there were no roads suitable for wheeled transport, and consequently wheeled vehicles were non-existent.

Conditions have however greatly changed of recent years; the development of motor transport has proved a stimulus for the construction of roads, and the road mileage is yearly increasing both in native areas and in those occupied by European colonists.

In localities where cattle exists the European and Asiatic traders use a large number of ox carts and wagons, Great regions in Tanganyika Territory, Uganda, and elsewhere are however infested with tsetse fly, and the use of cattle therein is impossible. The position can be summed up by stating that the productive power of the native populations of these territories is crippled by the lack of transport facilities. The numbers of people affected are very considerable for the native population of -

Kenya	is approximately	2,500,000
Uganda	"	3,000,000
Tangan.Terr.	"	4,000,000
Nyasaland	"	1,700,000

Enough has been said to demonstrate the potentiality of these regions as ~~as~~ consumers of ~~native~~ motor fuel.

If motor transport is to supersede human head transport and ox cart transport, the fuel must be cheap. Cheap motor fuel can only be obtained by its local production in each area and from materials locally grown, for unfortunately no oil fields have been as yet discovered in this regi[illegible]

At present the motor users are at the mercy of the petrol distributing companies, who charge as much as they dare irrespective of the distance of the wells and refineries, and in addition the cost of local internal transport is high. For example the cost of petrol in Uganda is at present approximately 5/6d. per gallon, and about 4/- at Mombasa. At the same time the Tanganyika Government are only paying 2/9d. per gallon.

As an example of how high fuel prices react upon the amount paid to natives for their produce it is said that the cotton growers in Uganda outside a certain radius of a lake port receive at least 1d. per lb. less for their cotton than those more favourably situated. But worse than that the financing of the bulk of the cotton crop of Uganda is hampered by the slow rate at which the product reaches the ports of shipment, a situation which could be quickly remedied by the increase of motor transport. With petrol at such a prohibitive figure enterprise is however lacking, and capital for fleets of motor lorries difficult to obtain.

It will be of interest at this stage to examine the statistics of the motor vehicles in these countries.

The last complete returns available are for 1923.

Kenya Colony			In 9 months of 1924 - 850 cars were imported into Kenya and Uganda, 541 motor cycles, and 159 lorries. Full returns for 1924 not available.
	Motor Cars	1,409	
	" Cycles	1,172	
	Lorries	27	
Uganda Protectorate			
	Motor Cars	141	
	" Cycles	322	
	Lorries	43	
Tanganyika Territ.			1924 returns not available
	Motor Cars	128	
	" Cycles	224	
	Lorries	8	
Zanzibar			1924 returns not available
	Motor Cars	120	
	" Cycles	70	
	Lorries	3	

Nyasaland. No figures available.

There are also a number of motor tractors in Kenya, few of which at present pay to work owing to the high price of motor fuel.

It is interesting to examine the actual imports of motor spirit for the same period in the various coun[illegible]. They are as follows:-

	1923	1924
Kenya & Uganda	976,000	738,472 (during 9 months) at the rate of 1,115,000 for year.
Tang. Terr.	59,000	Approx. 100,000
Zanzibar	21,200	Returns not yet available.
Nyasaland	111,200	" " "
	1,167,400 galls	

It will therefore be seen that the present market is very small except in Kenya, but it is obvious to all that the productive capacity of these countries is very great, and the volume of exports is steadily increasing and will continue to do so indefinitely. Moreover it will be greatly stimulated by the improvement of transport services.

Assuming that a market for the output of motor fuel from a factory of commercial size can be assured within a reasonable period, the problem of the manufacture at a reasonable price depends on the availability of adequate supplies of raw material at a favourable rate.

This matter has been extensively explored and three vegetable products stand out - they are sugar cane, maize and cassava.

Sugar Cane stands out as the most suitable, and there are two methods of utilisation. One is to crush the cane and extract the saccharine juice and then convert this into alcohol; the second method presupposes the existence of sugar factories, and in this case the molasses produced at such factories is used. If the molasses supply is inadequate both cane and molasses can be used.

Molasses	yields	65	galls. of alcohol	per	ton.
Sugar Cane	"	23	"	"	"
Sugar Cane Juice	"	40	"	"	"
Jaggree or Native Sugar	"	110	"	"	"

The distillation of spirit from cane juice or molasses is a comparatively simple process, but of course skilled European supervision is essential.

If a comparatively low yield of 30 tons of cane per acre is taken as a basis of calculation and the raw cane is utilised, a yield of 690 gallons per acre may be expected for each of the first two years harvest, falling to about 300 gallons in the third year. After that the area has to be replanted.

Cassava or Manihot utilissema. This well known African plant is ubiquitous in that country from coast land up to about 4,000 feet. It is prolific, resists drought, is not attacked by insect pests, and a crop is obtained every year. An average crop would be 8 to 10 tons per acre. The alcohol yield is approximately 35 galls. per ton of fresh cassava. An acre could be estimated to yield 300 gallons.

Maize flourishes over a great portion of Africa, is cheaply grown and now forms an important export product from those areas which are not too remote from the sea, and which are near a railway line.

It can be estimated to furnish an average yield of 75 gallons of alcohol per ton, and in a normal year about one short ton (2,000 lbs) may be expected per acre. The yield of alcohol per acre is therefore lower than that of the two previous products, but the cost of production of the raw material should be cheaper. The lower grades of maize, which will normally not pay to export, can be used.

The maize has to be malted before it is in a condition for utilisation in a distillation plant, and this necessitates the erection of specially constructed stone or concrete buildings for the malting operation.

Exportable graded maize now commands an exceptionally high price in the European market, and in some of the countries under consideration this has the effect of unduly raising the price of the non-exportable residue to a point which makes maize an uneconomic raw material for the purpose of manufacturing motor spirit. As an approximate estimate the maximum price which could be paid for each of these raw materials in order to produce motor fuel at a reasonable price and to afford a fair return for the investor is:-

Maize	£3. [illegible] 0.	per ton.
Cassava	£1. [illegible]	" "
Molasses	3d. p[illegible]	gallon
Sugar Cane	15/-	per ton.
Jaggree	£4. 0. 0.	per ton.

PROCESS

The best process on the market is that held under patent by the Alcohol Fuel Corporation Ltd., and widely known as "Natalite". It is a mixture of Alcohol and Sulphuric Ether in the proportion of 90% alcohol and 10% ether. There are other constituents, but they are trifling in amount.

This fuel has been exhaustively tested, and is used on a commercial scale with satisfactory results in South Africa and elsewhere. It has the great advantage that none of the main ingredients have to be imported. Alcohol of 95% purity is first produced, a portion of this is then converted into ether and mixed with the alcohol, a small proportion of denaturant is then added, and the fuel is ready for use.

Satisfactory plants for its manufacture are made by both British and French firms.

A plant producing 250,000 gallons of fuel per annum may be considered the smallest unit of commercial size. Such a plant could be purchased and erected for about £26,000. An additional £10,000 would however be needed for working capital.

COMMERCIAL AND FINANCIAL OUTLOOK

Kenya Colony.

The assured consumption in this Colony is now sufficient to warrant a plant of economic size to produce say 500,000 gallons. Further the supply of raw material available in the shape of molasses and sugar cane is rapidly, although still inadequate for a plant of that size, becoming sufficient to remove anxiety on that score. Probably all the assistance which it would be necessary to ask from Government would be a promise of low railway freights on raw material and a duty of say 3d. per gallon on imported [illegible] for a period of three years, the manufacturing company to give an undertaking to sell locally manufactured spirit at not more than a stated price. Protection is already granted to locally produced sugar and wheat.

Uganda Protectorate.

The consumption of motor spirit in Uganda, although increasing, is at present inadequate to warrant the establishment of a factory as an ordinary commercial proposition. There is however no doubt that with a substantial decrease in the price of fuel the local consumption would rapidly increase to such an extent as to absorb the whole output of a distilling plant.

As matters are at present, however, it is considered impossible to obtain the necessary capital in the London market for such a venture without some support.

This difficulty could, however, it is believed be overcome by the cooperation of the Uganda Government and the Empire Cotton Growing Corporation.

It is therefore suggested that the Uganda Government be asked to select the most suitable site for a factory with due regard to the most eligible area for growing sugar cane and also with regard to the distribution of the manufactured product.

It should further be asked through the chiefs to make contracts with the landholders around the factory site for the production of cane over an area of say 1,000 acres in extent for a period of ten years. This production to be jointly under the control of the Government Agricultural Department and the motor fuel company, and the price to be paid for cane delivered at the factory to be mutually settled between the Government, the landholders, and the company. It is further suggested that the Empire Cotton Growing Corporation should be asked to underwrite the Debenture issue of the said company at say 7%.

Under this arrangement a supply of fuel at a reasonable price could be assured, which would enable the cotton, coffee, and other products of Uganda to reach either the Government Railway or steamers at a minimum transport cost.

If assistance was rendered to the Company on the lines indicated the Government would probably insist on limiting the rate of profit, and as the investment with such a backing would be of a high class, this would probably not be objected to.

The 7% Debenture issue should be amortised by a sinking fund spread over 15 years.

Allowing for this the price of the fuel should be so fixed that the holders of the Ordinary shares should receive 10% after the debenture interest and charges were met. If a greater profit than 10% was made, one half of such profit should go to the shareholders and one half to the reduction of the sale price of the fuel.

A reserve fund should however be built up for renewals and expansion. It is estimated that a capital of £10,000 would enable this scheme to be carried out and if the underwriting proposed for one half of this as Debentures could be carried out, the Ordinary share capital could, it is considered, be easily found.

Tanganyika Territory.

Conditions very similar to those of Uganda prevail in much of this Territory and development is unduly retarded. Tanganyika Territory does not however possess such a network of roads as exist in Uganda, and consequently motor transport is comparatively speaking in its infancy. The time has however arrived when the provision of a local motor fuel at a reasonable price would revolutionise conditions in this area. Some form of Government assistance would however have to be mutually devised before capital could be obtained.

Nyasaland.

The present consumption is small and petrol is expensive owing to the absence of direct rail communication. It is believed that with a similar measure of cooperation between the local Government and a manufacturing company, cheap fuel could be locally manufactured, particularly as maize can be obtained there at a cheaper rate than in the other Colonies referred to.

General.

It is claimed that the develop[illegible] of road transport may be considered to be as much the function of Governments, in countries like these, as the development of a railway system. In fact road transport is an essential by which the railways can be fed with traffic.

In order to furnish some idea of the costs of manufacture a tentative estimate is attached hereto.

C. W. H.

ESTIMATED COST OF MANUFACTURING NATALITE IN A PLANT PRODUCING 250,000 - 300,000 GALLONS PER ANNUM.

E S T I M A T E

Raw material Molasses @ 2d per gallon (delivered)

(1) Price of Alcohol per gallon.

To produce 1 gallon of alcohol 2½ gallons of Molasses are required

Molasses - 2½ x 2d (price of 1 gall. molasses)	4.5d
Fuel - wood - 22 lbs. @ 12/- per ton	1.44d
Yeast and Sundries.	.25
	6.19

(2) Price of Ether per Gallon.

It takes 1¼ gallons of alcohol to make 1 gallon of ether

Ether - 1¼ x cost of 1 gall. alcohol 1.25 x 6.19	7.75 d
Fuel - wood - 4 lbs. @ 12/- per ton	.26 d
Sulphuric Acid and Caustic Soda, add 1d	1.00 d
	9.01.

Cost of 1 gallon of Natalite.

40% Ether - 40% of 9.01 - 3.60
60% Alcohol - 60% of 6.19 - 3.75.
Denaturants & other ingredients
approximately - 1.00 — 8.35.

Labour.

1 Charge man @ 20/- per shift
1 Hand " @ 5/-
3 " men @ 6/-

Total 28/- per shift.
or 84/- per day
Output say 800 galls. per day.
Labour cost per gall. 1.26

1.26.

Plant.

Estimated cost with erection, transport and Building

	£25,000
Depreciation 10%	£ 2,500
Upkeep 3%	750
Supervision 4%	1,000
Insurance 1½%	375
	£4, 625 divided among 250,000 galls. say 4. 4 d

Aggregates.

Natalite	8.35 per gall	
Labour	1.26	
Plant etc.	4.4	
Royalty	1.5	1/3/½ Nett cost of production say per gall. from Molasses at 2d per gallon.
	15.41	

E S T I M A T E II
Raw Material Maize @ £3.0.0. per ton

(1) Price of Alcohol per gallon

One ton of maize is estimated to yield 75 galls. alcohol

Maize at £3.0.0. per ton, cost per gall. of alcohol	9.6 d.
Fuel - wood at 12/- per ton	1.44 d.
Yeast and Sundries	25 d.
	11.29 d.

(2) Price of Ether per gallon

It takes 1¼ gallons of alcohol to produce 1 gall. ether

Ether - 1¼ x 11.29	14.11 d.

Cost of 1 gallon of Natalite

40% Ether - 40% of 14.11	- 5.64 d.	
60% Alcohol - 60% of 11.29	- 6.77 d.	
Denaturant & other ingredients approx.	- 1.00 d.	13.41 d.

Labour

1 Chargeman @ 10/- per shift
1 Hand " 5/-
6 " " 1/-

Total 31/- per shift or
93/- per day on an
output of 800 galls. per day
Labour costs per gall approx
1d. — 1.40 d.

Plant

Estimated cost with erection, transport and buildings £27,000
(Note £2,000 is allowed for malt houses)

Depreciation 10%	£2,700
Upkeep 3%	810
Supervision	1,000
Insurance 1½%	400
	£4,910 divided among 250,000 galls. — 4.6 d.

Aggregates

Natalite	1/1.41
Labour	1.40
Plant etc.	4.6
Royalty	1.5
	1/8.01

Nett cost of production 1/9 d. per gall.
from maize at £3.0.0. per ton.

With a 500,000 gallon plant the nett cost would probably be
1d. per gallon cheaper.

ESTIMATE III

Raw Material - Sugar Cane @ 15/- per ton.

(1) Price of alcohol per gallon

To produce 1 gallon of alcohol 53.5 lbs of sugar cane are required

Sugar Cane 1/40 of a ton to 1 gallon	4.5 d.
Fuel - wood at 12/- per ton per gallon	2.5 d.
Yeast & Sundries	.25d.
	7.25d.

(2) Price of ether per gallon

It takes 1¼ gallons of alcohol to make 1 gall. of ether

Ether 1¼ x cost of 1 gall of alcohol 1.25 x 7.25	9.06d.
Fuel - wood 4 lbs. @ 12/- per ton	.26d.
Sulphuric Acid and Caustic Soda add 1d.	1.00d.
	10.32d.

(3) Cost of 1 gallon of Natalite

40% ether -	40% of 10.32	4.03	
60% alcohol -	60% " 7.25	4.35	
Denaturants & other ingredients approx		1.00	9.4 d.

Labour

1 Charge man	@ £1 per shift	Total 26/- per shift or 78/- per day.	
1 Hand	@ 5/- " "	Outpu[illegible] say 800 galls.per day	1.25d.
2 Hands	@ 1/- " "	Labo[illegible]t per gall.say 1¼d.	

Plant

Estimated cost with erection, transport & buildings £25,000

Depreciation	10%	£2,500
Upkeep	3%	750
Supervision	4%	1,000
Insurance	1½	375
		£4,625

£4,625 divided among 250,000 galls. per gall, say 4.4 d.

Aggregates

Natalite	10.32
Labour	1.25
Plant	4.4
Royalty	1.5
	1/5.4[illegible]

Nett cost of production say 1/6 per gallon from Sugar Cane @ 15/- per ton.

An examination of the three preceding estimates gives the following results for various raw materials, and we can from this form an idea of what would be a fair selling price.

Material	Nett cost of production	Sinking Fund Charges per gall.	Profit	Marketing Charges	Sale price per gall.
Molasses	1/3½	2d	2½d	4½d	2/0½d
Sugar Cane.	1/6	2d	2½d	4½d	2/3d
Maize	1/8½	2½d	3d	4½d	2/6½d

The size of plant required for the countries under consideration should to commence with be approx. as follows:-

Kenya	Uganda	Tanganyika	Nyasaland	
500,000	500,000	250,000	250,000	galls. output.

There is little difficulty in increasing the size of a plant as demand grows, for it mainly consists of the addition of another distilling column.

The approximate capital reqiored to instal the above sized plant in each country would be as follows:-

Kenya	Uganda	Tanganyika	Nyasaland
£30,000	£30,000	£25,000	£25,000

Total £110,000

C.W.H.

Allen 8/6 [illegible]

19441/1925 E.Africa

352

Strachey.
Sir J. Shuckburgh.
Sir C. Davis.
Sir G. Grindle.
Sir J. Masterton Smith
Mr. Ormsby-Gore.
Mr. Amery.

Ausd 21896

Downing Street,

DRAFT.

22 June 1925

KENYA

No. 559

Sir,

I have, etc., to transmit to you the accompanying copy of a memorandum received from the Alcohol Fuel Corporation regarding the question of the local production of power alcohol in East Africa.

Memorandum

3d/s.

2. Before considering the proposals in the memorandum, some of which are

Allen 18/6

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Strachey.

J. Shuckburgh.

C. Davis.

G. Grindle.

J. Masterton Smith.

Ormsby-Gore.

Amery.

O. D.
R 18 JUN
D 19

Amd 41791

DRAFT.

UGANDA

225

Downing Street,

22 June 1925.

SIR,

Sir,

I have the honour to transmit to you the accompanying copy of a memorandum received from the Alcohol Fuel Corporation Limited, regarding the question of the local production of power alcohol in East Africa.

2. Before considering the proposals in the memorandum, some of which are clearly open to criticism, I shall be glad to learn whether you have anything to add to the late Sir Robert Coryndon's despatch (31880) No.301 of the 23rd May 1922 on this subject, and also, with reference to Lord Milner's (50508) despatch No.685 of the 21st October 1920, whether any steps are yet in contemplation

for

Allen 16/6
Sonnie 18/6 J.

353

19441/1925 E. Africa.

Strachey.
Shuckburgh.
Davis.
Grindle.
Masterton Smith.
Ormsby-Gore.
Amery

Downing Street,

DRAFT.

22 June 1925

[illegible]IKA TERRITORY 337
[illegible]ALAND 179

Sir,

I have, etc., to transmit to you the accompanying copy of a memorandum received from the Alcohol Fuel Corporation Limited, regarding the question of the local production of power alcohol in East Africa. Before considering the proposals in the memorandum, some of which are clearly open to criticism, I shall be glad to learn whether you have anything to add

Memorandum

(27012) (30899) to (1) Mr. Hollis's despatch No.346 of the 12th May 1922 (2) Sir G. Smith's despatch No. 184 of the 20th May 1922, and also whether any steps are yet in contemplation for introducing in (1) the Tanganyika Ter. (2) Nyasaland legislation to control the local manufacture of industrial alcohol.

In this connection I ~~am~~ have also ~~to~~ invite (To (2) only)

attention to my telegram of the 5th June (205)

last, and the connected corres., ~~regarding~~

on ... 's proposals for the production

of power alcohol from maize.

3 ... es of the Enclosed memorandum are (To both)

... the Governments of

... Tanganyika Territory

... e,

... S. AMERY