THE CHEMICAL CONSTITUTION OF THE

FRUIT-COAT FAT FROM

MYRICA CORDIFOLIA - CAPE BERRY WAX.

THESIS

submitted for the degree of
Master of Science in Engineering
in the Branch of Chemical Engineering
in the Faculty of Engineering.
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by

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GRAPHS AND DIAGRAMS.

INTRODUCTION.

This investigation was undertaken as a result of an observation by Mr. Hawke, namely, that Cape Berry Wax has an acetyl value in the neighbourhood of 70.

The only important vegetable oils showing high acetyl values, thus indicating the presence of an hydroxy acid or acids, are castor oil (Ricinus species of sub-tropical habitat) and ivory wood seed oil, the seed fat of Agonandra brasiliensis. In the former, hydroxy acids comprise about 90 per cent of the total mixed fatty acids,[1,2.] whilst in the latter oil, ricinoleic ac'd is present to the extent of about 47 per cent in the total mixed fatty acids.[3]

In the majority of other cases, the acetyl value is variable and indicates the presence of adventitious alcoholic bodies or the presence of hydroxyl groups due to hydrolytic rancidity, rather than major constituents of natural fats. Thus the presence of ricinoleic acid in the oil of the grape seed[4] (Vitis Vinifera) has been disproved by more recent work, the earlier reports, probably, having been based on acetyl values determined on oils which had undergone partial hydrolysis to yield mono- or diglycerides.[5] Hydroxy acids have been reported as minor constituents of certain other oils namely Ergot oil (Secale cornutum)[6,7] and the oil obtained from Wrightia annamensis.[8]

Although it is generally known that natural waxes give fairly high acetyl values, due to the sterols and higher aliphatic alcohols present, it must be borne in mind that Cape Berry Wax, though commonly referred to as Myrtle Wax or Berry Wax, is strictly speaking not a wax but a fat. It is composed of the glyceryl esters

"of the .....

of the higher fatty acids with a small amount of the
free acids present.

As Hilditch[9] points out, an acetyl value,
showing the presence and proportion of compounds con-
taining free hydroxyl groups, will indicate any of the
following possibilities:

1.   the presence of an hydroxylic fatty acid,
whether saturated or unsaturated, both free and com-
bined.

2.   the presence of free alcohols such as the
higher aliphatic alcohols, sterols, or of some highly
hydroxylated compound such as myricetin. In such
cases, there will be a high proportion of unsaponifiable
matter.

3.   the presence of di- or mono-glycerides in
the product. Care must be taken in such cases where
free fatty acids are present, that the carboxylic hy-
droxyl group is not included when reporting results as
a measure of the mono- or diglycerides present[69]. In
such cases a suitable correction must be applied.

A survey of the literature, in essence,
revealed very little as to the chemical constitution
of the "waxes" from the different Myrica species and
in particular from Myrica Cordifolia.

No acetyl value has yet been reported in
the literature.

A further point borne out by the literature
survey, which caused some confusion, is that although
most of the previous workers conducted their researches
on Myrtle Wax, there exists no uniformity in their re-
ports as to the species of Myrica from which the wax
was obtained.

/Thus.......

Thus Smith and Wade[10] refer to Myrtle Wax, obtained from Myrica Cerifera, also as Laurel Wax which Hilditch[ ] shows to be totally different, being obtained from Laurus nobilis. Hilditch, however, attributes Myrtle Wax to Myrica Mexicana. In other papers Myrtle Wax is referred to generally as Myrica Wax and is stated to have been obtained from various Myrica species such as M. Cerifera, M. Carolinensis or M. Cordifolia whilst Cape Berry Wax is reported to have been obtained from Myrica Cordifolia and also Myrica Quercifolia.[19,21] The result is that the value of comparing the different results reported by different investigators becomes highly doubtful. In certain papers[15,19] it is pointed out, however, that the waxes obtained from Myrica Cerifera and Myrica Carolinensis are very similar to Berry Wax, from Myrica Cordifolia. In this thesis, though, the term Berry Wax always refers to the wax obtained from the seeds of Myrica Cordifolia.

A brief summary of the literature on this subject serves to show the lack of uniformity in the published results regarding the composition of the "Myrica Waxes".

Smith and Wade,[10] summarise all previous work carried out on Myrica Wax and show that the constants and constitution as determined by different investigators are somewhat contradictory. The first to have attempted an analysis of Myrtle Wax are Moore[ ] and Chevreul.[ ] This work was carried out presumably on samples obtained from Myrica Cerifera. Moore and Chevreul both agree that it consists mainly of free palmitic acid with about 20 per cent of tripalmitin. Moore, however, claims that it contains in addition some combined lauric acid whilst Chevreul maintains that

Myrtle Wax, in addition to the Palmitic acid, free and combined, contains myristic, stearic and "margaric" acids.

Benedict[14] states that it is composed mainly of tripalmitin with some trimyristin and tristearin.

Lewkowitsch[15] describes the wax obtained from the different Myrica species to be the same, being the glycerides of stearic, palmitic and myristic acids with a small quantity of oleic acid.

According to van der Riet[16] the above statement of Lewkowitsch holds true for Cape Berry Wax except with regard to the presence of the oleic acid. By the Hübl method, he failed to detect any unsaturation in the material.

Allen[17] whilst omitting to give the composition of Myrtle Wax, states that it contains only 0.12 per cent of free acid as palmitic acid.

Chittenden and Smith[18] merely state that Myrica wax consists mainly of tripalmitin.

Smith and Wade[19] basing their deductions on experimental work carried out on the wax extracted from the berries of Myrica Cerifera with petroleum ether, express themselves in agreement with those investigators who had reported the absence of oleic acid and of volatile acids from the fat. In a table of fat constants they do, however, report an Iodine Value (Hübl) of 3.9 and a Reichert-Meissl Value of 0.5. They further agree with the investigators who consider Myrtle Wax to consist essentially of tripalmitin, some glycerides of lower fatty acids with a small amount of free acids. These authors also claim to have separated tripalmitin from the wax in four crystallisations from petroleum ether. (Melting point 62.5°C, Saponification value 209.4,

/Refractive..

Refractive Index at 80°C 1.4380). Smith and Wade
further made the observation that certain of the
physical constants of Myrtle Wax changed on standing.
The melting point, in particular, was found to have
changed appreciably; in so much that the melting
point of a four year old sample increased from 48° to
57°C. This fact led them to suspect the presence of
tristearin but as they report: "repeated crystalli-
sations from alcohol yielded only practically pure
tripalmitin (Melting point 61.5°C and Saponification
Value 206.7)". These constants are, however, consider-
ably at variance with those reported for the product
by crystallisation from petroleum ether.

Smith and Wade finally proved the absence
of stearic acid by the Hehner and Mitchell method and
they concluded therefore that the high melting point
of the older material was due to some obscure change
which had taken place in the fat on standing. Although
the authors state their intention of continuing further
work on Myrtle Wax with the object of studying the change
which had taken place on standing, no reference could
be found to any subsequent publication.

Abderhalden[19] states that Myrtle Wax is
considered to be obtained from the fruit of different
Myrica species namely M. cerifera, M. carolinensis, M.
cordifolia or M. lacinata and is regarded to be iden-
tical with Cape Berry Wax (stated to be derived from
M. quercifolia). The Myrica fat is said to consist
exclusively of the triglycerides of palmitic acid (70
per cent), myristic acid (8 per cent) and lauric acid
(4.2 per cent). The presence of stearic acid, however,
could not be established.

/Schneider......

Sonneider[20] published a very similar
analysis to the above for the fatty acids from Myrica
Wax obtained presumably from either M. Cordifolia or
M. Quercifolia namely: Palmitic acid 70 per cent.,
Myristic acid 8 per cent. and Lauric acid 10 per cent,
a total of only 88 per cent. He further reported the
glycerine content as 9.4 per cent.

A later publication on Cape Berry Wax,[21]
again stresses the similarity of Berry Wax to Myrtle
Wax obtained from Myrica Cerifera, but its source is
left undecided, as being one or other of the several
species M. Cordifolia, M. Quercifolia, M. Lacinata or
M. Serrata.

Hilditon[22] in discussing fruit-coat fats,
states that the general characteristics are the same:
the main components are palmitic and oleic acids, the
latter, however, being of negligible proportions in
the Myrtle and Rhus "waxes". With the exception of
linoleic acid, the other component acids, it is stated,
rarely form more than 2 - 5 per cent. of the mixed acids.
Among the exceptions to this last statement we have the
fruit-coat fats of the Myrica species which contain a
fair percentage of myristic acid. The values published
for Myrica Mexicana[23] are 61 per cent. myristic acid,
37.5 percent. palmitic acid and 1.4 per cent oleic acid
and a trace of stearic acid. Iodine value (Hanus) -
1.2; Saponification Value 216.7; Unsaponifiable matter
0.85 per cent; Wax content of the berries 28.3 per
cent. Jamieson[20] further mentions that, although
characteristics are published only for Myrtle Wax
(Myrica cerifera), Cape Berry Wax gives constants with-
in the ranges noted.

/From.......

CONSTANTS.	d^{24}	d^{25}	d^{26}	d^{27}	d^{15}	d^{15}	d^{23}	d^{10}
Origin.				M. cordifolia	M. cordifolia	M. Cerifera	M. Cerifera	M. Cerifera
Melting Point.		45°C.	43.2°C.	40.5°C.	41 - 45°C.	40 - 48°C.	40 - 48°C.	46°
Solidifying Point.				—	39 - 40°C.	39 - 45°C.	—	45°
Specific Gravity.	1.005(13°)	1.024(15°C)	0.8765(99°C)	0.8744(99°C)	1.007(15° C)	0.985 - 0.878 (15°C)(99°C).	0.995 - 0.878 (15°C)(99°C).	0.985 - 0.878 (22°/15°) (99°/15°)
Saponification Value.			214.5	211.1	234.5	206 - 217	206 - 212	21.
Iodine Value.			2.38(?)	1.08(?)	Nil(Susi).	1.95 - 3.9(Susi).	1 - 4 (Susi)	3.9 (Susi).
Acid Value.			4.07	4.09	—	—	—	30.7
Mean Mol. Weight of Fatty Acids.			—	236.1	—	241.4 - 243.	—	—
Titer of the Fatty Acids.			—	47.5°C.	—	47.5 - 48.5	46°C.	—
Refractive Index. $n_D^{60°}$			—	—	—	—	1.4363	1.4363.
Reichert-Meissl Value.			—	—	—	—	0.5	0.5
Unsaponifiable Matter.			—	—	—	—	2.5 per cent.	—

Solubility.[19,28]. The wax is insoluble in water, sparingly soluble in cold alcohol, soluble 1.20 parts boiling alcohol, and readily soluble in hot ether and other organic solvents. (Acetone, chloroform, benzol, carbon tetrachloride.).

From the foregoing it would appear that:

(1)   Little or no differentiation is made between the species of Myrica when considering the source of "Myrtle Wax" or with regard to differences in composition and constitution of these waxes.

(2)   Very little data is available regarding the constitution of the Myrica waxes with no data dealing specifically with the wax from Myrica Cordifolia.

All the published data for the different characteristics of the "Myrica Waxes" are tabulated on the opposite page.

Considering the results tabulated, the following points merit discussion:

(1)   Smith and Wade[10] report an acid value of 30.7: they mention, however, that the sample was prepared by extraction with petroleum ether. They were the only investigators that followed this procedure, the others preparing their samples by boiling with water and skimming off the fat.

(2)   Jamieson[23] reports unsaponifiable matter to the extent of 2.5 per cent.

(3)   Except for van der Riet,[16] who claims the absence of unsaturated acids in the fat, (Smith and Wade[10] confirm this, though they report an Iodine Value (Hubl)), the other investigators seem to be in agreement that the fat is unsaturated to a slight extent.

(4)   There appears to be some disagreement in the values published for the Specific gravity at $15^{\circ}C/15^{\circ}C$ namely 0.995 and 1.005.

WAX BERRY.

(MYRICA CORDIFOLIA.)

I.   II.   III.   IV.

1.   Photograph of whole berry covered with wax.

2.   Photograph of berry with wax removed.

3.   Photograph of berry with wax and warts removed.

4.   A section through the whole berry.

GROSS MORPHOLOGY OF MYRICA CORDIFOLIA.

All members of the Myricaceae of which
there are about fifty species, widely distributed in
all temperate climates except Australia are either
shrubs or trees. In South Africa they are all known
as Wax Berry bushes. There are fifteen species in this
country scattered in the south-western and south-eastern
districts of the Cape and also extending from Clanwilliam
to Natal and the Northern Transvaal. The most common
include Myrica Cordifolia, M. Brevifolia, M. Serpifolia
and M. Aethiopica.

Myrica Cordifolia is usually dioecious;
both the male and female flowers being in the axils
of scarious ciliated bracts in oblong or elongated
axillary catkins. The leaves are alternate, ovate or
oblong from a cordate base; they are abruptly pointed
with three to six teeth on each side, firm, numerous,
eight to seventeen millimeters long, and six to thirteen
millimeters wide, very short petioled, glabrous and
pitted on the under surface.

The "berry" or drupe is about four milli-
meters in diameter, warted and closely coated with a
white wax (see fig.1).

The stems of the bush are much-branched,
sometimes erect, three to four feet high and two inches
in diameter, but more frequently they are prostrate,
slender, wide-spreading and buried in the sand sending
up small erect branches. A single plant generally
covers an area ten to twenty feet in diameter and forms
a valuable sand stay on coastal sandhills. When used
for this purpose, it has given excellent results.

/In......

In addition to the value of the wax, the bark of the stem and r ot is of use in tanning owing to its astringent qualities.

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PHYSICAL AND CHEMICAL CONSTANTS.

The present work was carried out on samples
of wax obtained from the berries of Myrica Cordifolia,
through the courtesy of the Forestry Department. The
principal sample was obtained from a firm of wholesale
chemical suppliers during February 1944. The wax is
hard, with a smooth glassy surface. It is greenish-
white to green in colour, but on continued exposure
to light and air, the outer portions become bleached.
The wax has a characteristic herb-like odour.

The large-scale preparation of the wax is
briefly as follows:-
The berries are all hand-picked by coloured labourers
and freed from leaves, twigs etc. before bagging. The
bagged berries must be transported as soon as possible
in order to avoid fermentation, as large quantities of
berries, closely packed, will start fermenting within
four to five days. The wax is separated from the berries
by boiling with water, (one grain bag of berries per 44
gallons of water), when the wax floats to the surface
and can be removed by skimming. The boiling process
is continued for about four hours during which time
practically all the wax is separated. The hot wax is
strained and collected in separate containers and then
allowed to cool and solidify; during this process a
fair amount of water is expelled which can be drained
off. The solid wax is then remelted in clean containers
and strained for a second time. This wax on cooling
and solidifying is substantially free from water and
pure enough for commercial use.

Upon receipt of the principal sample, the
wax was filtered through a hot funnel, using Whatman
No. 4, filter paper, and the following constants deter-
mined.

/Physical:.........

PHYSICAL CONSTANTS.

Melting Range.......... ....40.0°- 40.7°C.

Titer of fatty acids.............. 46°C.

Specific Gravity, D°_t and D^t_{15} for temperatures up to 80°C. (See p.19)

Refractive Index (N) for temperatures from $40.6 - 80^{\circ}$C. (See p.15).

Optical Activity ....Negligible.

Surface Tension at 55°C...... 27.9 dynes per c.n.

Interfacial Tension against water at 55°C...... 7.8 dynes per cn.

Some of these constants merit further discussion and will be treated in detail below:-

1. Melting Point.

The melting point of the original wax sample was very sharp; the fat softened and melted completely within a degree, softening at 40.0°C. and was completely melted at 40.7°C. Such a sharp melting point would seem to indicate a pure compound, thus supporting the view of earlier investigators that Myrica Wax was more or less a pure compound. Smith and Wade stated that the melting point of the sample of fat increased with time. This was confirmed by a determination of the melting point after the sample had been in use for about 18 months when the melting point was found to be 47°C. It is reported that waxes and fats on exposure to air and light become bleached, a process which results in a considerable increase in melting point.

This increase in melting point would seem to indicate that some stereochemical change must have occurred in the fat, either as a result of the atmospheric action or due to the continual heating and

/solidifying......

REFRACTIVE INDEX - TEMPERATURE CURVE

FOR CAPE BERRY WAX.
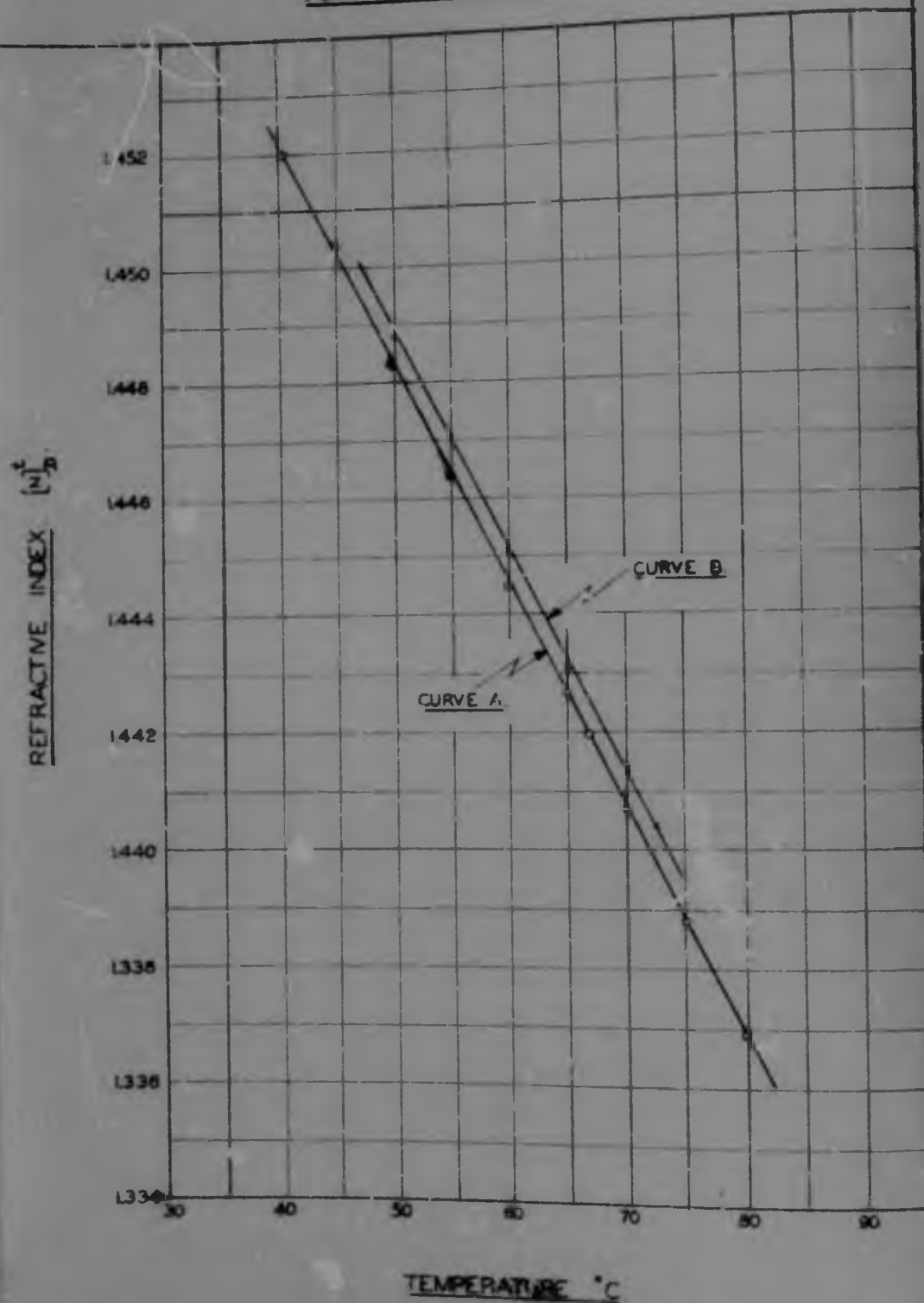
solidifying of the mass or more probably to both.

2. Refractive Index.

The Refractive Index was determined over the temperature range 40 - 80°C. and the values are tabulated below. A graph of Refractive Index against temperature shows a straight line relationship.—Curve A.

Temperature. $t°C$	Refractive Index. (N_D^t)
40.6.	1.4520.
45	1.4504
50	1.4483.
55	1.4464.
60	1.4445.
65	1.4427
67	1.4420.
70	1.4407.
75	1.4398.
80	1.4369.

The Refractive Index, varying inversely as the temperature, can be reduced to any temperature between 40.6 and 80°C., by means of the equation:-

$$R = R' + C (t' - t)$$

where R = Refractive Index reduced to temperature t,

R' = Refractive Index at the operating temperature t', and C = constant correction per degree centigrade.

= 0.00038 as calculated from the slope of the curve. This is the same as the value given by Jamieson for fats in general.

Stereochemical changes in the fat were suspected as a result of the continual heating of the sample so that the Refractive Index determinations were

/repeated......

repeated after about two months. The change was negligible. When, however, after 18 months the melting point was found to have increased, these determinations were repeated once more. A slight increase in the values was observed as indicated by the following results and the accompanying graph - Curve B.

Refractive Index $(N)_t$	Temperature $t°C.$
1.4488	50
1.4470	55.
1.4451	60
1.4431	65.
1.4414	70
1.4404	72.5.

The slopes of the two curves are identical as is to be expected since the constant $C = 0.0003$ is generally accepted to apply for all fats. Thus this increase in Refractive Index together with the increase in melting point indicates that some stereochemical change must have taken place in the fat.

3. Specific Gravity.

The change in specific gravity with temperature was determined and the values obtained plotted. The specific gravities are reported in terms of both D_t^t and D_1^t.

Over the range 40-50°C the values obtained were variable and are not reported. A solid wax-cake did not melt when left in a constant temperature water-bath at 45°C for three hours, though partial fusion around the edges had taken place. Similarly a liquid wax sample could not be maintained liquid in a waterbath at 50°C and solidification slowly set in.

/This.....

This peculiar behaviour of the fat, as well as the increase in melting point and refractive index with time can most probably be explained by assuming polymorphic changes to have taken place in the glycerides.

Malkin[63] first demonstrated that triglycerides can exist in at least four different modifications namely the γ-, α-, β'- and β - phases. (Efremov[64] obtain evidence to show that tripalmitin exists in three polymorphic forms). In so far as they can be applied generally, the main identifying characteristics of the polymorphic forms are listed below:[65]

	γ	α	β'	β
Relative Stability	Least ⟶			Most
Melting Point	Lowest ⟶			Highest
Density	Least ⟶			Greatest
Refractive Index	Lowest ⟶			Highest
Gross Appearance	Vitreous ⟶			Brittle and even powdery.

How obtained

(a) from liquid   Rapid cooling ⟶ Very slow cooling.

(b) from other solids   Not possible ⟶ From the less stable form near the melting point of that form.

Existence of type form in other long-chain compounds   Apparently unique in triglycerides ⟶ Quite general in mono- and diglycerides

From the above table, it follows that the continued melting of the wax, had slowly converted the glycerides into their most stable modifications. Malkin[66] stated that the chilling process in the melting point determination, converted the glycerides from the more stable modifications into the unstable, lowest melting form. This statement will explain the partial

/fusion.......

fusion of the wax-cake in the specific gravity bottle when left in the thermostat at 45°C. The outer layers of the wax, which were more rapidly cooled had changed into the lower melting modifications whilst the glycerides in the central portion still existed in the most stable form.

It was pointed out, however, that the γ - form will slowly revert back to the stable modifications. Joglekar and Watson[66] stated that in the chilling process, numerous nuclei of the β -form were formed in the unstable γ-form. The formation of these nuclei was responsible for the reversion of the γ- into the β -form.

The higher melting point for the sample of wax, extracted with petroleum ether, reported by Smith and Wade[10] can partly be explained by a statement of Duffy[67] that glycerides crystallise from solvents in the more stable modifications i.e. in the higher melting point forms.

Further, the unstable glass-like nature of the low melting modification was from time to time emphasized, especially by Malkin,[] and its slow reversion to the most stable and brittle phase pointed out. A similar change in the physical structure of the wax under investigation was observed over the period of two years. Although the outer surfaces of the wax were still hard and glass-like the core was soft and brittle and even powdery.

In the determination of specific gravities of the wax-cake at various temperatures, concordant results were only obtained provided an air-free sample had been prepared. Various modifications of the general procedure were adopted to ensure that this case.

/The......
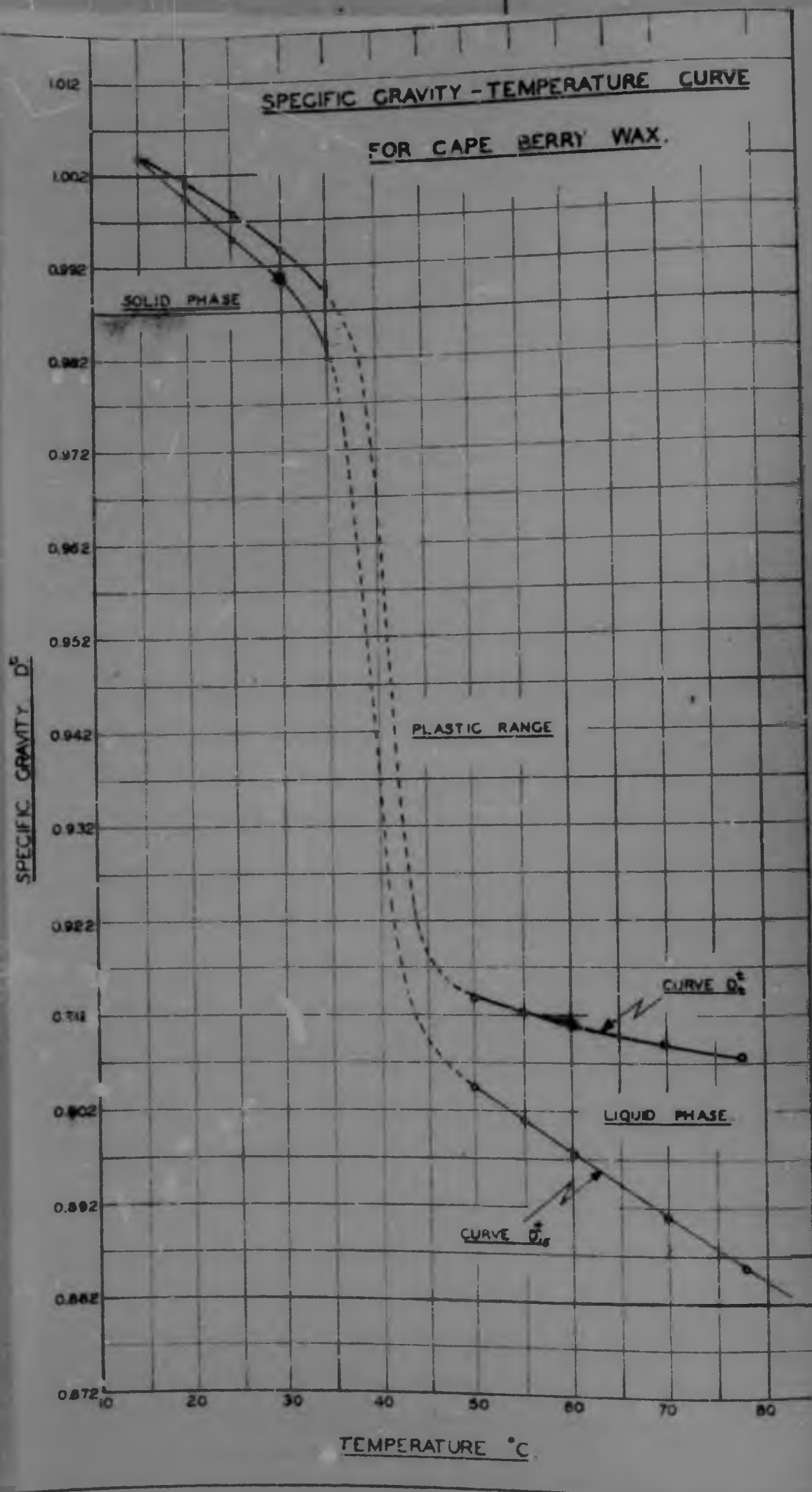
SPECIFIC GRAVITY – TEMPERATURE CURVE

FOR CAPE BERRY WAX.

The values obtained are tabulated below.

Temperature °C.	D^t_t	D^t_{15}
15	1.004	1.004
20	1.001	0.9995
25	0.9977	0.9948
30	0.9937	0.9908
35	0.9895	0.9837
50	0.9136	0.9042
55	0.9121	0.9007
60.4	0.9107	0.8971
70	0.9088	0.8907
78	0.9074	0.8852

From the curves, it would appear that in both the solid ($<35°C$) and liquid ($>50°C$) phases straight-line relationships hold whilst over the plastic range (35-$50°C$) a sudden drop in specific gravity occurs. The slopes of the two straight-line portions of the graph are quite different. Considering curve D^t_{15} the slope of the curve over the solid range is 0.00088 per degree change in temperature, and the equation to the curve:

$$D' = D - 0.00088(t' - t)$$

where D' = specific gravity at temperature t'.

D = specific gravity at temperature t.

Over the liquid range, however, the slope of the curve is 0.0007 per degree change in temperature, and the equation to the curve becomes:

$$D' = D - 0.0007 (t' - t)$$

where D' and D have the same significance as mentioned above.

An important point arising from this investigation is that the value obtained for the specific gravity at

/15°C.......

15°C corresponds to that published by certain of the
previous investigators,[24,25,1] whilst one possible ex-
planation for the low value reported by the other
investigators is that the samples of wax were not air-
free. This is postulated since low values were obtained
in the determinations, before the samples were rendered
air-free.

4. Optical Activity.

The optical activity of the fat as well as
that of the free fatty acids was determined in solutions
in chloroform of five per cent. and ten per cent.
concentration. In all cases the rotation was negligible,
being within the limits of experimental error.

5. Surface - and Interfacial Tensions.

The surface tension of the fat against air
was determined at 55°C, and found to be 27.9 dynes
per cm. Further, an abnormal lowering of the inter-
facial tension against water, also at 55° C, was ex-
perienced, the tension being only 7.8 dynes per cm.
According to Bailey,[72] such a low value is indicative
of the presence of di- or monoglycerides in the fat.

CHEMICAL CONSTANTS.

Acid Value .... 3.58 mgm/gm.

Iodine Value (Wijs)........... 0.60 gm/100 gm.

Saponification Value............. 214.7 mgm/gm.

Acetyl Value.................... 68.2 mgm/gm.

Unsaponifiable Matter.......... 0.12 per cent.

Reichert-Meissl Value.......... 0.5.

Polenske Value................. 2.3.

Fatty Acid Content:-

    a) By Ether Extraction..... 90.3 - 90.6 per cent.

    b) By Wax-cake Method...... 90.1 - 90.5 per cent.

Glycerine Content.............. 15.3 per cent.

Mean molecular weight of the
       fatty acids............ 242.2 - 244.6.

The iodine value (Wijs), though very small, indicates the presence of unsaturation either in the glyceride molecule or in the unsaponifiable matter. The unsaponifiable matter in the fat is practically negligible thus indicating the unsaturation to be confined within the glyceride molecules. This determination tends to disprove the claim made by certain investigators[16,10] to the effect that the fat is completely saturated.

The very low Reichert-Meissl value confirms the absence of any volatile low molecular weight acids whilst the small Polenske value is probably due to the small quantity of lauric acid in the fat.

The acid value is very significant as the low value, as determined indicates that the fat is not rancid and no marked hydrolysis of the glycerides has taken place.

/A discussion......

A discussion of the high acetyl value and its implications will follow under a separate heading.

The fatty acid content of the fat was determined by both the ether extraction and the wax cake methods. The mean value of 90.5 per cent. is much lower than would be expected for a triglyceride (usually of the order of 95 per cent.). With such a low fatty acid content, a high glycerine content was suspected and this was confirmed by an analytical estimation of the glycerine. Both the standard acetin method and the Bertram and Rutges method were employed.[34]

The latter method was standardised against a pure oil of known glycerine content and found to give the theoretical result. For this purpose a pure triglyceride oil was analysed in the usual way. The acid – and saponification values were determined as well as the glycerine and fatty acid contents according to the Bertram and Rutges and other extraction methods respectively.

The pure sample of Maize Oil, gave the following characteristics on analysis:

Acid Value.................... 0.27.

Saponification Value......... 188.8.

Glycerine Content..... ...... 10.23 per cent.

Fatty Acid Content........... 90.5 per cent.

The theoretical fatty acid content, by calculation

= 95.7 per cent.

Using the following formula, (derived below), we can calculate the theoretical glycerine content of any triglyceride fat:

/G.....

$G = 0.05467 E.$

where G = percentage glycerine in the fat.

E = ester value.

Hence, substituting the value of E in the above equation, we obtain:

$G = 0.05467 \times 188.5.$

$= 10.30$ per cent.

These values confirm the applicability of the Bertram and Rutgers method for estimating the glycerol content of a natural fat.

The formula, for calculating the percentage glycerine is derived as follows:-

Let G = percentage glycerine available from the fat.

But 92 mgm. glycerine = M mgm. of triglycerides.

where M = mean molecular weight of the triglyceride molecule.

$\therefore \dfrac{92000}{M}$ mgm. glycerine $\equiv$ 1 gm. of triglycerides.

But 1 gm. of fat contains $1 - 0.01 (a + u)$ gms. of triglycerides,

where a = percentage free fatty acids.

u = percentage unsaponifiable matter in the fat.

$\therefore$ mgm. of glycerine obtained on the hydrolysis of

1 gm. of fat $= \dfrac{92000}{M} \ (1 - 0.01 (a + u))$

or $G = \dfrac{9200}{M} \ (1 - 0.01 (a + u))$

But $M = \dfrac{1.683 \times 10^{5} \ (1 - 0.01 (a + u))}{E}$

and therefore substituting in the above equation, we obtain:

$G = \dfrac{9200(1 - 0.01(a + u)) \times E.}{1.683 \times 10 \ (1 - 0.01 \ (a + u))}$

$= \dfrac{9200}{1.683 \times 10} . \times E.$

$= 0.05467 \ E.$

This formula is only valid if the percentage of free fatty acids, (obtained by hydrolysis of the

glyceride molecules), is low. If the free acid content
is high, indicating partial hydrolysis of the triglycerides,
then the value for G, as calculated, would be incorrect
as G, in this case, would not apply solely to a tri-
glyceride but to a mixture of a diglyceride and triglyceride.
In such a case, the above formula needs modification.

For this reason an oil of low acidity, was
selected for standardising the Bertram and Rutges method.
A further check on the structure of the glyceride
molecule is found in the determination of the total
fatty acids.

Although both methods were used, the Bertram
and Rutges method was finally adopted as it gave fewer
possible sources of loss of glycerine, and appeared to
be more reliable. A brief consideration of the mani-
pulations involved in preparing the glycerine sample for
analysis by the standard acetin method, will suffice to
indicate the complexity of the process and will substan-
tiate the claim made in this paper as to the suitability
of the Bertram and Rutges method for determining the
glycerine contents of the oil samples. A full description
of the process follows later under a separate heading.

Firstly, the double evaporations of the aqueous
solutions are only to be carried to the point of incipient
crystallisation. As this is difficult to judge, evapora-
tions may easily be carried too far, resulting in some
loss of glycerine.

In the extraction processes, where only a small
quantity of glycerine is present, together with a large
proportion of sodium sulphate or barium sulphate, ad-
sorption on the crystal surface becomes of major importance.
Again losses may readily result.

/The........

The removal of the alcohol and water from the
filtered extract by evaporation, even under vacuum, may
result in loss of glycerine due to its volatility in
steam. Also, the rapid method of analysis for glycerine,
as proposed by Hilditch,[36] did not work satisfactorily as
the glycerine residue, finally obtained, always contained
some solid matter which only appeared on concentration
of the solution.

In view of these possible sources of loss of
glycerine, during the preparation of the sample, it was
felt that the methods are not altogether satisfactory and
the method of Bertram and Rutges was therefore used.

The mean molecular weight of the fatty acids,
as determined by direct titration, gave values varying
between 242.2 and 244.6 with a mean value of 243.3.

From a knowledge of the percentage of unsaponifiable
matter, the acid value and the saponification value, the
mean molecular weight of the fatty acids can be calculated
using a formula derived as follows:

Hawke[35] derived the following formula for M, the
mean molecular weight of the glyceride molecule,

$$M = \frac{1.683 \times 10^5(1 - 0.01(a + u))}{\text{Ester value}}$$

and for m = mean molecular weight of the fatty acids

$$= \frac{M - 38}{3}$$

where a = percentage of free fatty acids in the fat.

u - percentage of unsaponifiable matter.

Two important assumptions were made in this
derivation namely:

(1)   All the combined fatty acids are present as
triglycerides.

/(2) The.....

(2)   The mean molecular weight of the free fatty acids is the same as that of the combined or total fatty acids.

Hawke also points out that for free acidities up to 15 per cent. the error in the calculated value of m is practically negligible. It should have been pointed out, however, that this statement only holds true if the free acidity does not result from the hydrolysis of the triglycerides. If that were the case, the weight of glycerides per gram of fat $(1 - 0.01 (a + u))$ though assumed to correspond to triglycerides, would actually constitute a mixture of di- and triglycerides. In such a case the above formula becomes invalid, and has to be modified accordingly.

It will be noticed that to calculate m, the percentage free fatty acids a is required but to calculate a from the acid value V, m is required. Hence to eliminate the factor a from the above equation, another formula can be derived thus:

$$M = \frac{1.683 \times 10^5(1 - 0.01(a + u))}{E} \text{ ----- (1)}$$

Further $m = \frac{M - 38}{3}$

i.e. $M = 3m + 38.$

Substituting this value for M in equation (1), we obtain:

$$3m + 38 = \frac{1.683 \times 10^5(1 - 0.01(a + u))}{E}$$

$$\therefore m = \frac{1.683 \times 10^5(1 - 0.01(a + u)) - 38E}{3E} \text{ ---- (2)}$$

but 1 gm. fat contains 0.01a gms. free fatty acids

or   10a mgm. free fatty acids.

but 10a mgm. free fatty acids $\equiv$ V mgm. KOH.

where V = acid value of the fat.

and m mgm. free fatty acids $\equiv$ 56.1 mgm. KOH.

$$\therefore \quad \frac{56.1}{V} = \frac{m}{10a}$$

$$\therefore \quad a = \frac{mV}{561}$$

Substituting this value in equation (2)

$$m = \frac{1.683 \times 10^5(1 - 0.01(\frac{mV}{561} + u)) - 38E}{3E}$$

$$\therefore \quad 3Em = 1.683 \times 10^5 - 3mV - 1,683 \times 10^3 u - 38E.$$

$$\therefore \quad 3m(E + V) = 1.683 \times 10^3(100 - u) - 38E$$

$$\therefore \quad m = \frac{1.683 \times 10^3(100 - u) - 38E}{3S}$$

From the constants determined on the sample,
a theoretical mean molecular weight of the fatty acids
can be calculated using the above formula.

Thus, u =   0.12 per cent.

S =   214.7 mgm/gm.

E =   214.7 - 3.7 = 211.0 mgm/gm.

and a = $\dfrac{1.683 \times 10^3(100 - 0.12) - 38 \times 211.0}{3 \times 214.7}$

= $\dfrac{168098 - 8018}{644.1}$

= 248.5.

The values for m, found by experiment to be
243.3 by the titration method and 243.1 from the ester
fractionation data, (see later under a separate heading),
show an unexpected divergence from the calculated value
and indicate the presence of a factor or factors un-
accounted for in the formula.

As has been pointed out before, the above
formula is valid only if the free acidity does not
result from the hydrolysis of a triglyceride and also
provided the ester is a triglyceride. If the free
acidity does result from the hydrolysis of the tri-
glyceride, the formula has to be modified to take into
account the fact that the ester present will consist of

/ a mixture......

a mixture of triglycerides and diglycerides. A modified
formula can be derived as follows:

$$
\begin{array}{lll}
CH_2OCOR & + & H_2O \\
CHOCOR & \longrightarrow & CHOCOR + RCOOH \\
CH_2OCOR & & CH_2OCOR \\
M & & M - m + 18 \quad m
\end{array}
$$
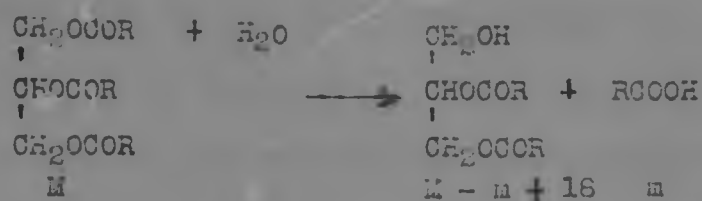
Hence the liberation m grams of fatty acids,
will be accompanied by the formation of $M - m + 18$ grams
of diglycerides.

But the free fatty acid content of the fat = a per cent.

$\therefore$ Per gram of fat,

the weight of free fatty acids = 10a mgm.

and the weight of diglycerides $= \dfrac{10a(M - m + 18)}{m}$ mgm.

Thus if the percentage unsaponifiable matter = u per cent
then the weight of triglyceride per gram of fat will

be $= 1000 - 10a - 10u - \dfrac{10a(M - m + 18)}{m}$ mgm.

$= 1000 - 10a - 10u - \dfrac{10aM}{m} + 10a - \dfrac{180a}{m}$ mgm.

$= 1000 - 10\left(u + \dfrac{aM}{m} + \dfrac{18a}{m}\right)$ mgm.

By or saponification,

M mgm. triglycerides require 3×56.1 mgm. KOH

$\therefore 1000 - 10\left(u + \dfrac{aM}{m} + \dfrac{18a}{m}\right)$ mgm. triglycerides require
X mgm. KOH,

where $X = \dfrac{1000 - 10\left(u + \dfrac{aM}{m} + \dfrac{18a}{m}\right) \times 3 \times 56.1}{M}$ mgm.

Also:

$M - m + 18$ mgm. diglycerides require 2×56.1 mgm. KOH

$\therefore \dfrac{10a(M - m + 18)}{m}$ mgm. diglycerides require X mgm. KOH,

where $X = \dfrac{\dfrac{10a(M - m + 18)}{m} \times 2 \times 56.1}{M - m + 18}$ mgm. KOH.

/Similarly......

Similarly:

m mgm. of free fatty acids require 56.1 mgm. KOH.

∴ 10a mgm. of free fatty acids require $\frac{10a}{m}$ x 56.1 mgm. KOH.

But the saponification value, S, is equivalent to the mgm. KOH required to saponify 1 gram of fat.

∴ $S = \frac{1000 - 10\left(u + \frac{aM}{m} + \frac{13a}{n}\right) \times 3 \times 56.1}{\frac{M}{V}} + \frac{10a}{M} \times 2 \times 56.1$

$+ \frac{10a}{m} \times 56.1.$

$= 56.1\left(\frac{3000}{M} - \frac{30u}{M} - \frac{30a}{u} - \frac{540a}{mM} + \frac{30a}{n}\right)$

$S.M. = 56.1\left(3000 - 30u - \frac{540a}{m}\right)$

But as shown previously,

$M = 3m + 38.$

and $a = \frac{mV}{561}$

Substituting the values for M and a in the above equation gives:

$S(3m + 38) = 56.1\left(3000 - 30u - \frac{540}{m} \times \frac{mV}{561}\right)$

∴ $3Sm + 38S = 1.683 \times 10^{5}(100 - u) - 54V.$

∴ $m = \frac{1.683 \times 10^{3}(100 - u) - 54V - 38S}{3S}$

Substituting the values of u, V and S, as determined, in the above equation, we have:

$m = \frac{1.683 \times 10^{3}(100 - 0.12) - 54 \times 3.7 - 38 \times 214.7}{3 \times 214.7}$

$= \frac{163098 - 199.6 - 8158.6}{644.1}$

$= 245.0.$

Although the value so obtained for m is slightly less than that obtained for a pure triglyceride, it still does not explain the low experimentally determined value. As it would appear that the presence of a diglyceride

lowers the value for m as calculated from the formulae,
a corresponding relationship between m and the oil con-
stants can readily be computed for a pure diglyceride.

Thus: $M = \dfrac{1000 \times 2 \times 56.1(1 - 0.01(a + u))}{\text{Ester Value}}$

$= \dfrac{1.122 \times 10^5(1 - 0.01(a + u))}{E}$

and $m = \dfrac{M - 56}{2}$

or $M = 2m + 56.$

$\therefore 2m + 56 = \dfrac{1.122 \times 10^5\left(1 - 0.01\left(\dfrac{mV}{561} + u\right)\right)}{E}$

$\therefore 2mE = 1.122 \times 10^5 - 2mV - 1.122 \times 10^3 u - 56E$

$\therefore 2m(E + V) = 1.122 \times 10^3(100 - u) - 56E$

and $m = \dfrac{1.122 \times 10^3(100 - u) - 56E}{2S}$

Again using the same values for u, E and S, and
substituting in the above formula, we get:

$m = \dfrac{1.122 \times 10^3(100 - 0.15) - 56 \times 211.0}{2 \times 214.7}$

$= \dfrac{112065 - 11816}{429.4}$

$= 233.4$

These values indicate that the fat under con-
sideration may be a mixture of diglycerides and tri-
glycerides as the experimentally determined mean
molecular weight of the fatty acids is intermediate
between the values calculated for diglycerides and
triglycerides.

CHANGES IN THE CONSTANTS WITH VARIATION IN
TIME OF GATHERING THE BERRIES.

A series of determinations was also carried
out on samples of berries collected at different periods
through-out the season so as to investigate the changes
in the wax during growth of the berry. The berries ripen
at the end of the summer season and are gathered between
April and August. Two samples of berries were used, one
collected at the beginning of the season and the other
very late in the season.

The first of such samples was collected towards
the end of April, 1944. A portion of the batch was ex-
tracted with diethyl ether whilst the main bulk of the
sample was stored in a bottle. Before the wax content
of the berries could be determined, the berries had
started fermenting. The extracted fat sample was very
dark in colour necessitating the use of Alkali Blue 6B
as indicator for all titrations. The unsaponifiable
matter could not be determined because of the stable
emulsions that formed during the extraction process.
Both diethyl ether and petroleum ether were tried for
this extraction. A possible explanation is that some
emulsifying agent may have been extracted from the berry
by the ether.

Since the wax content of the berries could
not be determined for this batch, a further sample
was obtained, which had been collected during May. The
wax was immediately extracted by boiling the berries
with water and skimming off the separated wax. This
was filtered hot, the wax-cake remelted and filtered
again. A small portion of the berries was reserved for
a quantitative determination of the wax content.

/The......

The characteristics of the different fat samples are tabulated below:-

	SAMPLE 1.	SAMPLE 11.	SAMPLE 111.
Period when collected.	April	May.	August.
Separation process.	Extracted with cold diethyl ether,	Boiling with water.	
Acid Value.	6.60.	2.13	2.42
Saponification Value	211.4	216.1	215.0.
Acetyl Value.	66.2	62.3	72.5
Iodine Value	3.74	0.74	0.44
Unsaponifiable Matter.	-	0.30 per cent.	0.30 per cent.

From the results shown in columns 11, and 111, we see that: An increase in acetyl value is accompanied by an increase in the free acidity, but not nearly sufficient to account for the large increase in the former by hydrolysis. The extraction of the first sample with diethyl ether could possibly have resulted in the high acid value, since it is claimed that solvent extraction promotes enzyme activity especially in the presence of a small amount of moisture,[37] On the other hand, the low values for free acidity in the water-boiled samples as compared with the ether-extracted sample might result from a partial solution of the lower molecular weight free fatty acids in the large bulk of water used. Smith and Wade[10] reported an acid value of 30.7 for a petroleum ether extracted sample of Myrtle Wax. This extraordinarily high value can possibly be explained as the result of an enzymatic reaction along the lines mentioned above.

The high iodine value obtained for the ether extracted sample, can be explained by the assumption that some unsaturated body was extracted from the berry. Iodine values were determined on the different wax samples obtained during the quantitative wax content determinations

/of........

of samples 11 and 111.

These samples which were, both, petroleum ether
and chloroform extracted, gave the following results:-

	SAMPLE 11.			SAMPLE 111.	
Solvent.	Petroleum Ether.	Water.	Water.	Chloro- form.	Petroleum Ether.
Iodine value. (Wijs-45 Mins.)	1.27	0.74	0.44.	1.70.	1.02.

These results show that extraction of the
wax with organic solvents results in a product more un-
saturated than is obtained by the water-boiling method
probably due to some unsaturated body extracted from the
berry itself.

The wax content of the berries was quan-
titatively determined by ex.. .cting a weighed sample of
berries in a Soxhlet apparatus with the required solvent.
The results obtained together with the treatment given
each set of determinations are tabulated below:-

SAMPLE.	% FAT CONTENT.	SOLVENT AND TREATMENT.
Sample 11. (May).	20.0 per cent.	Extracted with petro- leum ether for 10 hours; dried for 6 hours at 80°C.
Sample 111.(August)	19.95 per cent.	Extracted with Chloro- form for 5 hours and 10 hours; dried for 6 hours at 80°C.
	19.85 per cent	Extracted with petro- leum ther for 10 hour; dried for 6 hours at 80°C.

These results indicate that the change in
wax content of the berries over the season is negligible.
The wax sample obtained from the chloroform extraction
was brown in colour instead of the usual greenish-white,
had a foul odour and did not solidify very readily. The
extraction of some other volatile, odoriferous compound
from the berry by the chloroform could explain the brown

/colour......

colour and foul odour in the sample and could also
account for the higher Iodine value obtained for this
sample.

It was found that the wax was not readily
soluble in petroleum ether, for after six hours ex-
traction portions of the wax on the berries had not been
recovered. Thus the time of extraction was prolonged to
ten hours when the wax recovery was complete.

———

MOULD ATTACK ON THE BERRIES.
AND THE WAX.

The mould, which had formed on the sample
of fermented berries, was investigated by Mrs. E. Hawke,
of the Botany Department, and was found to belong to
one of the penicillium species.

In order to study the attack of the mould
on the wax-cake, two tests were conducted in which test-
cakes of wax were inocculated in special culture bottles
with the mould obtained from the fermenting berries. A
special nutrient was supplied with the one sample, whilst
in the other case, the mould was left to feed on the wax
alone. After five months the wax-cakes were cleaned
of nutrient and mould and reweighed. In both cases,
the tests showed that the mould had but a negligible
effect on the waxcake, the actual decrease in weight
amounting to less than one per cent. over the test-
period, and which can easily be explained as simply a
loss of surface moisture from the waxcake.

THE FATTY ACID COMPOSITION.

In order to study the fatty acid composition, the methyl esters of the fatty acids were prepared and fractionally distilled in a vacuum through an electrically heated and packed column ("E.H.P. column")[38]. Owing to the absence of any lower volatile acids, no preliminary separation was necessary. Also, because of the very low unsaturation in the fat, there was no need to attempt a lead salt-ether separation of the saturated from the unsaturated members. Consequently the mixed acids were esterified as a whole and the esters distilled directly.

As pointed out by Hilditch[39] and by Norris and Terry[40], the vacuum employed should not be too high, but should be of the order of one to five millimeters at the column head. In all runs, the operating pressure at the head of the column, was consequently maintained at one to two millimeters.

The mixed esters were fractionally distilled at this pressure, through the "E.H.P. column". The apparatus used and the techniques employed are described by Hilditch[41] from the original publication by Longenecker[42]. The only modification applied was in the heating of the packed column; a fine control on the temperature being regulated by a Variac connected in series with an ammeter to the heating coil.

The column head temperatures as recorded, though reported systematically, have little or no absolute significance, but merely afforded, in conjunction with the pot temperature, some indication of the efficiency of the fractionation. The temperature at the midpoint of the column was measured by means of a thermocouple

/inserted......

inserted between the column and the electrically heated
jacket.

An important point noted by Longenecker[42] is that
despite the somewhat prolonged heating period necessary
for fractionating a complex mixture, there is no evidence
that the residual unsaturated esters undergo more profound
decomposition than when a simple Willstätter bulb[43] is
employed. He further points out that for maximum effi-
ciency in fractionation to be obtained, no "flooding" in
the packed column should take place. This requires a
very careful control of the pot and column temperatures.

By regulation of the stopcock in the still head,
the distillation was maintained at a steady rate of five
to six drops per minute. The receivers for the ester
fractions were all stout-walled 6" x 1" test-tubes fitted
to the Perkin triangle through a good quality cork, pro-
viously charred.[44]

In the following tables, the results from duplicate
ester fractionations are set out. The method of calculation
is also illustrated by means of an explicit example.

/Fractional......

1.   Fractional Distillation of the Methyl Esters of

the Fatty Acids of Berry Wax.

(63.5 gms. distilled through "E.H.P. column").

Duration of run — six hours.

Pressure in system — one to two millimeters.

(a)

Samp^	Weight	Oil Bath.	Temperature (°C) of Column		Sap.Val.	Iod. Val.
			Middle	Head		
A	4.44	176 – 184	160 – 167	111 – 110	233.2	0.42
B	4.61	184	167 – 171	110	231.2	0.15
C	7.12	184 – 185	171 – 173	110	231.4	0.07
D	9.40	185 – 190	173 – 181	110.5	231.1	0.00
E	2.01	190 – 194	181 – 184	110.5 – 114	230.2	0.22
F	3.05	194 – 200	184 – 186	114 – 126	223.7	0.27
G	3.42	200 – 215	186 – 200	126 – 130	210.4	0.38
H.	3.03	215 – 230	200 – 208	170 – 130.5	208.2	0.22
I	11.06	230 – 232	208 – 210	130.5 – 131	207.7	0.28
J	9.02	232 – 235	210 – 218	131 – falling	207.3	0.33
K	2.25	Residue from column.			208.3	2.28
R	1.89	Residue in flask.			209.5	7.14
	63.35					

/b. calculated......

(b) Calculated Composition of the Ester Fractions.

Sample	C_{12}	C_{14}	C_{16}	C_{18}	Unsaturated Acids as Palmitoleic.
		Saturated Acids.			
A	0.26	4.16	—	—	0.02
B	—	4.56	0.04	—	0.01
C	—	7.06	0.05	—	0.01
D	—	9.26	0.14	—	0.00
E	—	1.90	0.10	—	0.01
F	—	2.06	0.98	—	0.01
G	—	0.41	3.00	—	0.01
H	—	0.14	4.93	—	0.01
I	—	0.11	10.92	—	0.03
J	—	—	8.86	0.13	0.03
K	—	0.05	2.15	—	0.05
R	—	0.16	1.59	—	0.14
Weights Per cent.	0.26	29.87	32.76	0.13	0.33
Per cent. esters.	0.41	47.15	51.71	0.21	0.53
Per cent. acids.	0.40	46.99	51.88	0.21	0.52
Molal Per cent.	0.49	49.84	49.01	0.18	0.50

Details of the Method of Calculation Involved.

The assumptions made in the following calculations are:

1) that each fraction contains only two saturated esters and one unsaturated ester.

2) that because of the low unsaturation of the fat and because of the predominance of palmitic and myristic acids, the unsaturated acid was taken in every case to be palmitoleic (Δ^{15} 9:10 hexadecenoic acid).

On making these assumptions the calculations are comparatively simple: complete information for each fraction being obtained from the respective saponification

/and......

and iodine values. This is best illustrated by a
definite example e.g. fraction I (11.06 grams, S.V. 207.7,
I.V. 0.28, containing the methyl esters of myristic,
palmitic and palmitoleic acids.

Let m, p, and u represent the respective weights of
myristic, palmitic and palmitoleic acid esters.

The saponification values of the esters are respectively
231.5, 207.5 and 209.0.

The iodine value of palmitoleic acid is 94.8.

The equations, therefore, are:

$$m + p + u = 11.06 \dots\dots\dots \dots\dots (1)$$

$$231.5m + 207.5p + 209.0u = 11.06 \times 207.7 \dots (2)$$

$$94.8 u = 11.06 \times 0.28 \dots (3)$$

From equation (3)

$$u = \frac{11.06 \times 0.28}{94.8}$$

$$= 0.032 \quad (0.03 \text{ gms.})$$

Substituting this value in equations (1) and (2),
we have:

$$m + p = 11.03 \dots\dots\dots\dots\dots (4)$$

$$231.5m + 207.5p = 2297.2 - 6.9$$

$$= 2290.3 \dots\dots\dots\dots\dots (5)$$

(4) x 231.5 - (5)

$$231.5m + 231.5p = 2552.4$$

$$231.5m + 207.5p = 2290.3.$$

$$\therefore 24.0p = 262.1$$

$$p = 10.92 \text{ gms.}$$

whence $m = 0.11$ gm.

From the results shown in table (b) we then
obtain the following percentage composition of the
mixed esters:

Per cent.	C_{12}	C_{14}	C_{16}	C_{18}	Palmitoleic
esters.	0.41	47.15	51.71	0.21	0.53

from which a percentage composition of the mixed
fatty acids can be calculated as follows:

C_{12}	C_{14}	C_{16}	C_{18}	Palmitoleic
$0.41 \times \frac{200.3}{214.3}$	$47.15 \times \frac{228.3}{242.3}$	$51.71 \times \frac{256.4}{270.4}$	$0.21 \times \frac{284.5}{298.5}$	$0.53 \times \frac{254.4}{268.4}$
= 0.38	= 44.41	= 49.04	= 0.20	= 0.49

Per cent. acids.

0.40	46.99	51.88	0.21	0.52
(0.4%)	(47.0%)	(51.9%)	(0.2%)	(0.5%)

From this data the molal percentages of the fatty acids
can readily be calculated.

$\frac{0.40}{200.3}$	$\frac{46.99}{228.3}$	$\frac{51.88}{256.4}$	$\frac{0.21}{288.5}$	$\frac{0.52}{254.4}$
= 0.002027	= 0.2058	= 0.2023	= 0.000727	= 0.002053

Molal
per cent.

0.49	49.84	49.01	0.18	0.50
(0.5%)	(49.8%)	(49.0%)	(0.2%)	(0.5%)

These results show that the total fatty acids
consist of practically an equimolecular mixture of myristic
and palmitic acids with very small amounts of lauric,
stearic and palmitoleic acids.

As a check on the unsaturated acids present,
the total unsaturation in all the fractions can be
balanced against the unsaturation of the mixed esters.

Iodine value of the mixed esters = 0.50

$$x.X = a.A + b.B + c.C + - - - - - -$$

where $a,b,c, - - - - - - - -$ = weights of the fractions.

$A,B,C, - - - - - - - -$ = the corresponding iodine
values of these fractions.

x = weight of mixed esters.

X = iodine value of the mixed
esters.

Thus:

$$/63.35 \times 0.50.........$$

$$63.35 \times 0.50 = (4.44 \times 0.42) + (4.61 \times 0.15) + (7.12 \times 0.07)$$
$$+ (2.01 \times 0.22) + (3.05 \times 0.27) + (3.42 \times 0.38)$$
$$+ (5.08 \times 0.22) + (11.06 \times 0.28) + (9.02 \times 0.33)$$
$$+ (2.25 \times 2.28) + (1.89 \times 7.14).$$
$$\therefore 31.67 = 1.87 + 0.69 + 0.50 + 0.44 + 0.83 + 1.30$$
$$+ 1.12 + 3.10 + 2.98 + 5.12 + 13.50.$$
$$= 31.45.$$

These values agree sufficiently well to confirm the presence of 0.5 per cent. of palmitoleic acid.

In a similar manner, the results can be checked by means of saponification values. A determination of the saponification value of the mixed esters gave a value of 219.4. Therefore applying the above rule:

$$x.X = a.A + b.B + c.C + - - - - -$$
$$63.35 \times 219.4 = (4.44 \times 232.2) + (4.61 \times 231.2)$$
$$+ (7.12 \times 231.4) + (9.40 \times 231.4) + (2.01_x 230.2)$$
$$+ (3.05 \times 223.7) + (3.42 \times 210.4) + (5.08 \times 208.2)$$
$$+ (11.06 \times 207.7) + (9.02 \times 207.3) + (2.25 \times 208.3)$$
$$+ (1.89 \times 209.5)$$
$$\therefore 13898 = 1039 + 1066 + 1648 + 2173 + 463 + 683$$
$$+ 720 + 1058 + 2298 + 1870 + 469 + 396.$$
$$= 13883.$$

The discrepancy of 0.11 per cent. is well within the limits of experimental error. Finally, using the above percentage composition of the fatty acids, the mean molecular weight of the mixed fatty acids can be computed:

Thus mean molecular weight of the fatty acids

$$= \frac{0.40_x 200.3}{100} + \frac{46.99_x 229.3}{100} + \frac{51.88_x 256.4}{100} + \frac{0.21_x 254.5}{100} - - -$$
$$= 0.81 + 107.3 + 133.0 + 0.59 + 1.33 + \frac{0.52_x 254.4}{100}$$
$$= 243.0.$$

Tabulating the above results we got:

Weight Per cent. acids.	C_{12}	C_{14}	C_{16}	C_{18}	Palmitoleic
	0.4%	47.0%	51.9%	0.2%	0.5%
Molal Per cent. acids.	0.5%	49.8%	49.0%	0.2%	0.5%

Mean molecular weight of the fatty acids = 243.0.

	Direct Determination	Fractional Values
Total unsaturation product	31.67	31.45
Total saponification product (i.e. weight x Sap. Value)	13898	13883

11.　　For the duplicate determination a further sample of methyl esters was prepared in a similar manner to the above and a portion of it fractionally distilled through the "E.H.P. column". Both the saponification value and the iodine value of the mixed esters were determined.

Saponification Value = 219.3

Iodine Value = 0.53.

Fractional Distillation of the Methyl Esters of the total Fatty Acids of Berry Wax.

(57.00 gms. distilled through "E.H.P. column").

Duration of run – five-and-a-half hours.

Pressure in system – one to two millimeters.

(a)

Sample	Weight	Oil Bath (Temperature (°C) of)	Column Middle	Head	Sap. Val.	Iod.Val.
A	5.40	174 – 185	161 – 163	112 – 113	232.3	0.23
B	6.33	188	163 – 175	113	230.6	0.14
C	8.13	188 – 198	175 – 180	113 – 114	231.2	0.14
D	4.93	198 – 199	180	114 – 116	230.2	0.11
E	5.64	199 – 207	180 – 184	116 – 132	217.5	0.14
F	6.83	207 – 213	184 – 195	132.5	208.6	0.25
G	8.95	213 – 217	195	132.5 – 133	207.5	0.11
H	6.50	217 – 222	195 – 207	133 – falling	207.4	0.28
I	2.35	Residue in column.			205.1	0.23
R	1.75	Residue in flask.			210.0	0.04
	56.87					

/Calculated.....

(b)   Calculated Composition of the Ester Fractions.

Sample	Saturated Acids.				Unsaturated Acids as Palmitoleic.
	C_{12}	C_{14}	C_{16}	C_{18}	
A	0.16	5.23	–	–	0.01
B	–	6.10	0.22	–	0.01
C	–	8.01	0.11	–	0.01
D	–	4.72	0.26	–	0.01
D	..	2.35	5.28	–	0.01
F	–	0.30	6.51	–	0.02
G	–	–	8.94	–	0.01
H	–	–	6.45	0.03	0.02
I	–	–	2.13	0.16	0.06
R	–	0.14	1.44	–	0.17
Weights.	0.16	26.85	29.34	0.19	0.33
Per cent. esters.	0.28	47.22	51.60	0.33	0.58
Per cent. acids.	0.28 (0.3%)	47.04 (47.0%)	51.76 (51.8%)	0.34 (0.3%)	0.58 (0.6%)
Molal Per cent. acids.	0.34 (0.3%)	49.90 (49.9%)	48.92 (48.9%)	0.29 (0.3%)	0.55 (0.6%)

Again checking the unsaturation and saponification

values of the fractions against that of the mixed esters,

we have:

1. Unsaturation.

$56.87 \times 0.53 = (5.40 \times 0.23) + (6.33 \times 0.14) + (9.13 \times 0.14)$

$+ (4.99 \times 0.11) + (5.64 \times 0.14) + (6.83 \times 0.25)$

$+ (8.95 \times 0.11) + (6.50 \times 0.26) + (2.35 \times 2.23)$

$+ (1.75 \times 9.04)$

$30.14 \quad\quad = 1.24 + 0.88 + 1.14 + 0.55 + 0.79 + 1.71 + 0.98$

$+ 1.32 + 5.24 + 15.82.$

$30.14 \quad\quad = 30.17.$

2.   Saponification Value.

/56.87 x 219.3.......

$$56.97 \times 219.3 = (5.40 \times 232.5) + (6.33 \times 230.5) + (8.13 \times 231.2)$$
$$+ (4.99 \times 230.2) + (5.64 \times 217.5) + (6.83 \times 208.7)$$
$$+ (9.95 \times 207.5) + (6.50 \times 207.4) + (2.35 \times 206.1)$$
$$+ (1.75 \times 209.6).$$
$$= 1255 + 1460 + 1880 + 1149 + 1227 + 1425$$
$$+ 1858 + 1349 + 485 + 368.$$

$$12470 \qquad = 12456$$

Finally calculating the mean molecular weight of the fatty acids from the fatty acid composition, we have:

Mean molecular weight of the fatty acids

$$= \frac{0.28 \times 200.3}{100} + \frac{47.04 \times 228.3}{100} + \frac{51.76 \times 256.4}{100} + \frac{0.34 \times 234.5}{100}$$

$$= 0.56 + 107.4 + 132.7 + 0.96 + 1.48 \qquad + \frac{0.58 \times 254.4}{100}$$

$$= 243.1.$$

These values can be tabulated as follows:

	Direct Determination	Fractional Values.
Total unsaturation product	30.14	30.17
Total saponification product (i.e. weight x sap. val.)	12470	12456

Mean molecular weight of the fatty acids = 243.1

Thus from the data obtained by the duplicate ester fractionations, it can be concluded that the composition of the total fatty acids is:

	Weight Per cent.	Molal Per cent.
Lauric acid..........	0.34 (0.3%)	0.43 (0.4%)
Myristic acid........	47.01 (47.0%)	49.87 (49.9%)
Palmitic acid........	51.82 (51.8%)	48.97 (49.0%)
Stearic acid.........	0.28 (0.3%)	0.22 (0.2%)
Unsaturated acids as Palmitoleic........	0.55 (0.6%)	0.52 (0.5%)
	100.00	100.00

The Mean Molecular Weight of the total Fatty Acids = 243.1.

A PRELIMINARY INVESTIGATION OF THE
GLYCERIDE STRUCTURE.

As has been pointed out in the introduction,
an acetyl value, which is a measure of the hydroxyl
content of the material, may be explained by any one
of the following possibilities:

(1)   the presence of an hydroxy fatty acid, free
or combined. The acid may either be saturated or not.

(2)   the presence of free alcohols (either higher
aliphatic alcohols or sterols) or of some highly hy-
droxylated compound such as myricetin. In all such
cases there will be a high proportion of unsaponifiable
matter.

(3)   the presence of di- or monoglycerides in the
product, either naturally or as a result of hydrolytic
rancidity in the fat.

To investigate the nature of the hydroxylic
body in the material it is necessary to consider each
possibility in detail on the basis of experimental
evidence.

An unsaturated hydroxy fatty acid in the material
would necessarily result in a high iodine value to account
for the high acetyl value. The very low iodine value of
the material (0.6, Wijs - 45 minutes), however, altogether
excludes the presence of such an acid in the material.
The presence of a saturated hydroxy acid e.g. dihydroxy
stearic acid, though possible from the point of view
of unsaturation, was eliminated by the acetyl value of
the total mixed fatty acids. This   .ormination was
first carried out on a sample of the mixed methyl esters,
prepared for the fractional distillation, which gave
the low value of 3.6.   As a check, a repeat determination

/was......

was carried out on a sample of mixed fatty acids to eli-
minate the possibility of removal or reaction of the
hydroxyl group during the drying and esterification
processes. The mixed fatty acids, after removal of the
solvent (diethyl ether) on a waterbath, were consequently
dri d at a relatively low temperature (80°C.) and then
acetylated. Again the acetyl value obtained was 3.8.

From the saponification value and neutralisation
value of the methyl esters and free fatty acids respective-
ly a mean molecular weight of the fatty acids was cal-
culated to be 243.3, which agrees very well with the
values obtained by direct titration and from the ester
fractionation data.

The presence of free saturated higher aliphatic
alcohols, glyceryl-ethers, or sterols can also be eli-
minated. Their general insolubility in water and ready
solubility in ether, would result in a high proportion
of unsaponifiable matter. This determination on the
material, however, gave the negligible value of 0.1 per
cent. Further, the group of saturated alcohols of inter-
mediate molecular weight, occurs mainly in marine-
animal oils, whilst the alcohols f higher molecular
weight, present as the esters of acids of similar molecular
size in certain plant waxes, are eliminated by the low
mean molecular weight of the fatty acids. Myricetin,
an unsaturated hydroxylic compound, known to be present in
the bark of Myrica Nagi, might have been present in the
wax from Myrica Cordifolia, thus accounting for the high
acetyl value. The very low percentage of unsaponifiable
matter together with the very low iodine value of the
fat, eliminates the possibility of Myricetin or of some
similar body being present in the fat under investigation.

/The.....

The most probable explanation, therefore, for the high acetyl value is the presence of diglycerides and possibly monoglycerides in the material either naturally or as a result of hydrolytic rancidity. In the latter instance, a high acetyl value would be accompanied by a high acid value. Experiments showed that with both methods of extraction, namely ether-extraction and water-boiling, the percentage of free fatty acids was low, never exceeding 2.86 per cent. in the samples investigated. Hydrolysis had, therefore, not set in and the abnormally high acetyl value could not be explained in this manner. It is worth noting that Smith and Wade[10] reported an acid value of 30·7 for a sample of wax extracted with petroleum ether from the berries of Myrica Cerifera. Although in the present work, a higher acid value was obtained for an ether-extracted sample than for the water-boiled sample (6.6 as against 2.2), it was still considerably lower than the value reported by the earlier investigators. Their value can probably be ascribed to rancidity in the fat, but no acetyl value was reported to support this supposition.

Thus from the experimental evidence, we can deduce the presence of diglycerides, and, possibly, monoglycerides in the natural fat, from the berries of Myrica Cordifolia. This is indeed a rare occurrence, for no reference has yet been made as to the occurrence of diglycerides in natural fats which are not rancid. This fact is further substantiated by the high glycerine and low fatty acid contents of the fat. Normally for triglycerides, these values approximate to 10 per cent. and 95 per cent. respectively, though in the case under

investigation the values obtained were 1.2 per cent. and 90.5 per cent. respectively.

According to Grün,[46] the difference between the acetyl value of the sample and that of the mixed methyl esters prepared from it, corresponds to the quantity of diglycerides (and of monoglycerides, if present) in the material.

Thus assuming, firstly, that the mixture consists only of triglycerides, diglycerides and free fatty acids, we can calculate the theoretical glycerine and total fatty acid contents from the acetyl value of the fat together with the mean molecular weight of the fatty acids.

Acetyl value of the fat = 68.2

Acetyl value of the mixed esters = 3.8.

Mean molecular weight of the fatty acids = 243.1.

Thus:

$$CH_2OCOR_1 \qquad CH_2OCOR_1$$
$$CHOH \longrightarrow CHOCOCH_3 \longrightarrow CH_3COOH \longrightarrow KOH$$
$$CH_2OCOR_2 \qquad CH_2OCOR_2$$

Mol. Weights: 542.2 584.2 60. 56.1
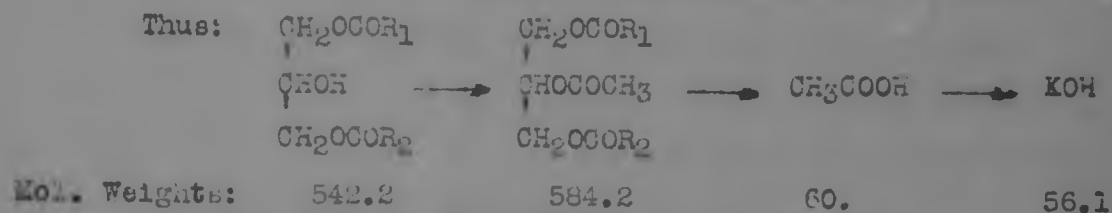
i.e. 584.2 mgm. acetylated product ≡ 56.1 mgm. of KOH.

∴ 1000 mgm. acetylated product ≡ $\dfrac{1000 \times 56.1}{584.2}$ mgm. of KOH.

= 96.05 mgm. KOH.

Thus the acetyl value of the above diglyceride = 96.05

The acid value of the fat = 3.69.

∴ Percentage of free fatty acids = $\dfrac{3.69 \times 243.1 \times 100}{56.1 \times 1000}$

= 1.6 per cent.

Hence the glycerides in 1 gram of fat = 0.984 grams.

Let x = fraction of diglycerides in the fat.

(0.984 - x)= fraction of triglycerides in the fat.

/1 gram.........

$\therefore$ 1 gram unacetylated fat = x gm. diglycerides

$+ (0.984 - x)$ gm. triglycerides $+ 0.016$ gm. free fatty acids.

But on acetylation, 1 gram. of fat will yield:

$x \times \dfrac{554.2}{542.2} + (0.984 - x) + 0.016$ grams acetylated material.

$= 1.078x + 1 - x$

Total weight $= 1 + 0.078x$ grams.

The acetyl value of this mixture would be:

$$A. = \dfrac{1.078x}{1 + 0.078x} \times 96.05$$

Thus for an acetyl value of 64.4, we obtain:

$$64.4 = \dfrac{1.078x}{1 + 0.078x} \times 96.05$$

$64.4(1 + 0.078x) = 1.078x \times 96.05$

$64.4 + 5.03x = 103.5x.$

$\therefore 98.47x = 64.4$

$\therefore x = 0.654$ or 65.4 per cent.

Thus the fat consists of 65.4 per cent. diglycerides

33.0 per cent. triglycerides

1.6 per cent. free fatty acids.

From the above we have that:

542.2 gm. diglycerides will yield 486.2 gm. fatty acids. $+$ 92 gm. glycerine.

and 767.2 gm. triglycerides will yield 729.3 gm. fatty acids. $+$ 92 gm. glycerine.

Thus: 65.4 gm. diglycerides will yield:

$\dfrac{65.4 \times 486.2}{542.2}$ gm. fatty acids. $+ \dfrac{65.4 \times 92}{542.2}$ gm. glycerine.

$= 58.6$ gm. fatty acids. $= 11.09$ gm. glycerine.

Also: 33.0 gm. triglycerides will yield:

$\dfrac{33.0 \times 729.3}{767.3}$ gm. fatty acids. $+ \dfrac{33.0 \times 92}{767.3}$ gm. glycerine.

$= 31.4$ gm. fatty acids. $= 3.96$ gm. glycerine.

$\therefore$ Theoretical fatty acid and glycerine contents are:

/Glycerine........

Glycerine = 11.09 + 3.96 = 15.05 per cent.

Fatty acids = 58.6 + 31.4 + 1.6 = 91.6 per cent.

The experimentally determined values are 15.2 per cent. and 90.5 per cent. respectively. The theoretical saponification value of this mixture would be:

$$\frac{65.4 \times 118.2}{542.2} + \frac{33.0 \times 168.3}{767.3} + \frac{1.6 \times 56.1}{243.1}$$

$$= 135.3 + 72.5 + 3.7.$$

$$= 211.5.$$

The experimentally determined value is 214.7.

A comparison of the values determined experimentally with those calculated above shows that the molecular weights of the diglycerides cannot be equal to values computed from the mean molecular weight of the fatty acids. For, using the mean molecular weight of the fatty acids and the saponification value as bases, would give a percentage composition as follows:

if x = fraction diglycerides in the fat.

$(0.984 - x)$ = fraction triglycerides in the fat.

$$\therefore x \times \frac{112.2}{542.2} + (0.984 - x) \times \frac{168.3}{767.3} = \frac{214.7 - 3.7}{1000}$$

$$\therefore 0.207x + 0.216 - 0.219x = 0.211.$$

$$\therefore 0.012x = 0.005.$$

$$x = 0.417.$$

$\therefore$ Percentage diglyceride = 41.7 per cent.

and Percentage triglyceride = 56.7 per cent.

For this weight of diglycerides to account for the acetyl value, the theoretical acetyl value of the diglyceride would be:

$$64.4 = \frac{1.078 \times 0.417}{1 + 0.078 \times 0.417} \times x$$

$$64.4 \times 1.0326 = 0.449x.$$

$$\therefore x = 148.$$

/This......

This acetyl value is much higher than can be
accounted for in any way by a diglyceride, possible from
the fatty acid resolution data. It would appear, there-
fore, that monoglycerides are present in the material or
that the distribution of the fatty acids on the glyceryl
radicle is specific in the case of the diglycerides (i.e.
the mean molecular weight of the fatty acids in the
diglycerides is not 243.1).

In order to resolve the fat into its constituent
glycerides, systematic crystallisations from organic
solvents were carried out. From the ester fractionation
data, it appears that the total mixed fatty acids con-
sist of a practically equimolecular mixture of myristic
and palmitic acids. Based on Hilditch's "rule of even
distribution", it was considered that the diglycerides
would, most probably, consist essentially of myristo-
palmitin. The fat was, therefore, repeatedly crystal-
lised from the solvents, in an attempt to separate out
pure myristo-palmitin.

Absolute alcohol was first used, as it was con-
sidered that the solubility of the diglyceride in such
a solvent would be increased. Repeated crystallisations
were carried out and the saponification value determined
on each fraction separated. These varied from 217.8,
for the least soluble, down to 209.1 for the most soluble
fraction. (The saponification value of myristo-palmitin
is 207.6). Owing to the low solubility of the material
in absolute alcohol, (a three per cent. solution, only,
could be prepared at 35°C), the quantity of material
separated in each fraction was too small to allow further
determinations to be carried out. This same limitation
existed when methyl alcohol was used as a solvent.

/Acetone.......

Acetone proved to be superior to the lower alcohols as a solvent since twelve per cent. w/v. solutions could be employed (See page 87). Again using the saponification value as the criterion of purity, repeated crystallisations from acetone were performed. The saponification value of the fractions gradually diminished, (with decrease in solubility), to a value of 208.0, which agrees fairly well with that of myristo-palmitin as calculated. An acetyl value determined on this sample, however, gave the low value of 25.7. Determinations on the material recovered by evaporation of the solvent from the first filtrate, i.e. the most soluble fraction, however, gave the following results:

Saponification Value   216.5

Acetyl Value   95.2

These values seem to indicate that the diglycerides are composed essentially of the lower molecular weight acids, such as dimyristin and myristo-palmitin with a small quantity of lauromyristin. Further proof of this statement is found in the previous calculation. The molecular weight of myristo-palmitin is 540 and is practically identical to that calculated for a diglyceride (542) using the mean molecular weight of the fatty acids (243). In the calculation it was shown to be highl improbable for the diglyceride to be only myristo-palmitin. Hence two other possibilities have also to be considered namely dimyristin and dipalmitin. A large quantity of dipalmitin of saponification value 197.2, will give the final product a comparatively low saponification value, and thus not account for the experimental value of 214.7. Thus we may consider the diglycerides present to consist mainly of dimyristin and myristo-palmitin.

Considering the lower molecular weight acids, therefore, to be chiefly ____ined in the diglycerides, the theoretical composition and constants may be computed as follows; assuming all the diglycerides to be composed of lauro-myristin, dimyristin and myristo-palmitin.

$$CH_2OCOC_{11}H_{23}$$
$$CHOH \longrightarrow$$
$$CH_2OCOC_{13}H_{27}$$
484

$$CH_2OCOC_{11}H_{23}$$
$$CHOCOCH_3 \quad \underline{AND}$$
$$CH_2OCOC_{13}H_{27}$$
526

$$CH_2OCOC_{13}H_{27}$$
$$CHOH \longrightarrow$$
$$CH_2OCOC_{13}H_{27}$$
512

$$CH_2OCOC_{13}H_{27}$$
$$CHOCOCH_3$$
$$CH_2OCOC_{13}H_{27}$$
554

$$CH_2OCOC_{13}H_{27}$$
$$CHOH \longrightarrow$$
$$CH_2OCOC_{15}H_{31}$$

$$CH_2OCOC_{13}H_{27}$$
$$CHOCOCH_3$$
$$CH_2OCOC_{15}H_{31}$$

Mol. Weights.   540   582.
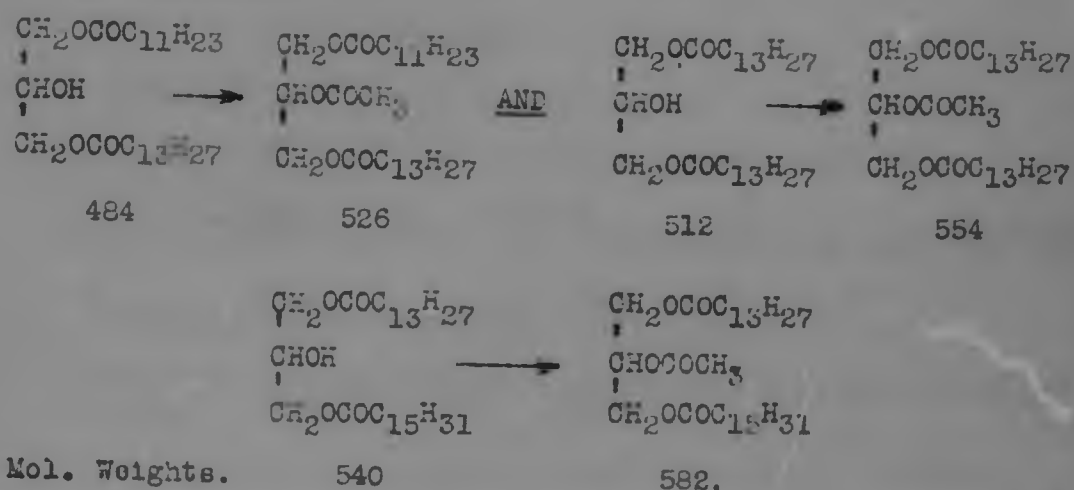
From the ester fractionation data, we have:

Per cent. acids.	C_{12}	C_{14}	C_{16}	C_{18}	Unsaturated acids.
	0.4	47.0	51.8	0.2	0.6

Considering 1000 mgm. of fat yielding 90.5 per cent. of fatty acids:

the weight of lauric acid $= \dfrac{0.4 \times 905}{100} = 3.62$ mgm.

the weight of myristic acid $= \dfrac{47.0 \times 905}{100} = 425.4$ mgm.

and the weight of palmitic acid $= \dfrac{51.8 \times 905}{100} = 468.8$ mgm.

∴ Weight of lauro-myristin present $= \dfrac{3.62 \times 484}{200}$

$= 8.76$ mgm.

and the weight of myristic acid combined $= \dfrac{3.62 \times 228}{200}$

$= 4.13$ mgm.

∴ Weight of myristic acid available for further combination $= 425.4 - 4.1 = 421.3$ mgm.

Let $x =$ weight of dimyristin present.

$y =$ weight of myristo-palmitin present.

/. . x ....

$$\therefore \quad X \times \frac{456}{512} + y \times \frac{228}{540} \quad = \quad 421.3$$

$$0.8900x + 0.4225y \quad = \quad 421.3 \; - - - - - - - (1)$$

But on acetylation, the weight of the acetylated product formed will be:

$$8.76 \times \frac{524}{484} + x \times \frac{554}{512} + y \times \frac{582}{540} + (991.2 - x - y) \quad \text{mgm.}$$

$$= \quad 9.56 + 1.081x + 1.078y + 991.2 - x - y \quad \text{mgm.}$$

$$= \quad 1000.8 + 0.081x + 0.078y \quad \text{mgm.}$$

Thus the acetyl value of this mixture will be:

$$\frac{1000 \times 9.56}{1000.8 + 0.081x + 0.078y} \times \frac{56.1}{524} + \frac{1000}{1000.8 + 0.081x + 0.078y} \times \frac{56.1}{554} \times \frac{554x}{512}$$

$$+ \frac{1000}{1000.8 + 0.081x + 0.078y} \times \frac{582y}{540} \times \frac{56.1}{582} = \quad 64.4$$

$$\therefore \frac{56.1 \times 9.56}{524} + \frac{56.1x}{512} + \frac{56.1y}{540} = \frac{64.4}{1000}(1000.8 + 0.081x + 0.078y)$$

$$1.02 + 0.1095x + 0.1039y = 64.45 + 0.0052x + 0.0050y.$$

$$\therefore \quad 0.1043x + 0.0989y = 63.43. \; - - - - - - - (2)$$

Eliminating x from (1) and (2),

$$0.8900 \times 0.1043x + 0.0441y \quad = \quad 44.00$$

$$0.8900 \times 0.1043x + 0.0880y \quad = \quad 56.90$$

$$\therefore \quad 0.0439v \quad = \quad 12.90$$

$$y \quad = \quad 294 \text{ mgm.}$$

$$\therefore \quad x = \frac{63.43 - 29.0}{0.1043} = \frac{34.43}{0.1043} = \quad \textbf{385. mgm.}$$

i.e. total weight of diglycerides present $= 294 + 352 + 8.8$

$$= \quad \textbf{54.8 mgm.}$$

$\therefore$ Per cent. diglycerides present $= \quad \textbf{5.48}$ per cent. of which

382per cent. is dimyristin.

Weight of palmitic acid in the diglyceride

$$= \frac{256 \times 294}{540} = \quad 139.4 \text{ mgm.}$$

$\therefore$ Weight of palmitic acid in the triglycerides

$$= 468.8 - 139.4 = \quad 329.4 \text{ mgm.}$$

/Mean.......

Mean molecular weight of the fatty acids remaining:

$$= (329.4_x 256.3 + \frac{0.55}{100}x905_x254.3 + \frac{0.2}{100}x905_x234.4) \frac{1}{336.2}$$

$$= (84,500 + 1265 + 515) \frac{1}{336.2}$$

$$= \frac{86280}{336.2} = 256.5.$$

But the percentage free fatty acids (based on a mean molecular weight of 256.5) = 1.637 per cent. This corresponds to a weight in the fat sample of 16.87 mgm.

∴ Weight of triglycerides present = 1000 - 652.8 - 16.9.

$$= 1000 - 651.7$$

$$= 348.3 \text{ mgm.}$$

Hence, to calculate the theoretical glycerine content we have:

(a) from the diglycerides

$$\frac{8.8 \times 92}{484} + \frac{338 \times 92}{512} + \frac{294 \times 92}{540} \text{ mgm. glycerine}$$

$$= 1.68 + 60.05 + 50.05 = 111.78 \text{ mgm glycerine.}$$

(b) from the triglycerides

$$\frac{348.3 \times 92}{807.5} = 39.62 \text{ mgm. glycerine.}$$

∴ Total weight of glycerine = 111.78 + 39.82

$$= 151.6 \text{ mgm.}$$

∴ Percentage glycerine = 15.16 per cent.

Furthermore, the assumption made in the above calculation would necessarily result in a high percentage of tripalmitin. Hilditch,[47] in a discussion of fruit-coat fats, states that in the case of certain fruit-coat fats, tripalmitin forms a definite glyceride constituent; a statement which substantiates the above assumption. The assumption is further supported by saponification values and acetyl values obtained on samples separated from a combined acetone - petroleum ether crystallisation process.

/The......

The fat sample was primarily crystallised from a
1 in 8 acetone solution. The crystallised material
was then repeatedly crystallised from petroleum ether,
whilst the most soluble fraction was separated from the
acetone liquor by a continual partial evaporation of
the solvent.

The values obtained are as follows:

		Saponification Value	Acetyl Value.
Sample	A.	212.4	94.8
Sample	B.	225.5	110.9.

where Sample A = the most insoluble fraction from the
petroleum ether crystallisations.

and Sample B = the most soluble fraction in acetone.

These values can only be explained by assuming
the presence of lower molecular weight diglycerides or
the existence of monoglycerides in the material.

It would, therefore, appear that a fair pro-
portion of the palmitic acid is combined as tripalmitin.
Generally, earlier investigators seem to agree that
"Myrica Wax" contains tripalmitin. An experiment per-
formed by Smith and Wade[10] was repeated by crystallising
the fat successively from petroleum ether. They claim
to have separated tripalmitin after four crystallisations
from petroleum ether. (Melting point- 62.5°C, Saponifica-
tion Value-209.4, Refractive Index $(N)_D^{90°C}$ - 1.4389).

After the fourth crystallisation by the author
a product was separated showing the following constants:
Saponification Value - 209.1;   Melting Point - 63.0°C;
Refractive Index $(N)_D^{90°C}$ - 1.4392:   Acetyl Value - 106.4.

These values are in good agreement with those
reported by Smith and Wade except that it shows the very
high acetyl value of 106.4, indicating quite conclusively

/that.......

that the material separated would not have been tri-
palmitin. Although Smith and Wade worked on the wax
obtained from Myrica Cerifera, it has been pointed out
by several investigators that the constants of Berry
Wax are within the ranges noted for Myrtle Wax, and
the author, therefore, feels that the claim made by
Smith and Wade to have separated tripalmitin from the
fat, is invalid. It would be appropriate at this stage
to note a statement made by Hilditch that "before de-
ciding on the identity of any glyceride as many constants
as possible should be determined on the sample".

Five crystallisations, in all, were carried out
at concentrations varying from 1 in 5 ml. to 1 in 17 ml.
of petroleum ether. The results obtained on all frac-
tions are tabulated below:

The samples are tabulated in the order of their
solubility in petroleum ether.

Sample	Weight	Saponification Value	Acetyl Value
A	20.3 gm.	232.5	56.0
B	11.2 gm.	229.3	44.0
C	17.3 gm.	215.1	33.1
D	20.2 gm.	228.0	51.5
E	5.9 gm.	227.6	56.6
F	2.5 gm.	225.9	73.0
G	9.2 gm.	209.1	106.4
H	2.7 gm.	220.0	105.5
I	37.5 gm.	199.1	106.3
	127.0 gm.		

Since the values obtained on certain fractions,
as tabulated above, are difficult to interpret, a
systematic crystallisation of the fat from anhydrous
acetone was carried out. The general procedure adopted

/was.....

was similar to that previously used (see page 87), the
concentrations of the solutions decreasing from 1 in 6 ml.
to 1 in 25 ml. of acetone. Saponification and acetyl
values were determined on each fraction, as well as the
mean molecular weights by a modification of the Rast
method, (see page 69) and the results obtained are
tabulated below. The fractions are again reported in
the order of their solubility in acetone.

Fraction	Weight	Sap.Val.	*"P.S.V."	Acetyl Val.	†"P.A.V."	Mean Mol. Weight.	%OH.
A	16.2	216.0	3503	102.2	1656	512	3.36
B	8.9	215.8	1922	103.7	923	503	3.42
C	9.5	215.6	2047	88.94	845	522	2.88
D	23.8	216.6	5156	83.83	1997	601	2.71
E	7.4	215.0	1592	92.04	682	548	2.99
F	20.2	217.0	4384	92.15	1865	541	3.00
G	11.1	216.6	2413	80.00	904	582	2.61
H	28.1	217.6	6116	72.52	2040	635	2.32
I	21.3	214.2	4563	68.30	1456	599	2.18
J	11.4	211.3	2409	61.44	701	622	1.95
K	6.5	210.3	1367	54.05	352	650	1.71
L	4.8	210.1	1009	62.44	301	712	1.98
M	41.6	210.0	8740	14.32	600	770	0.44
	210.8 gm.		45221		14320		2.19

* P.S.V. = Product, Sap. Value x Weight.

† P.A.V. = Product, Acetyl Value x Weight.

From the product values, the saponification
and acetyl values of the original fat should be 214.5
and 68.0 respectively. The differences between these
values and those obtained directly on the main sample,
(namely 214.7 and 68.2 respectively), are within the
limits of experimental error.

From the acetyl values, it is obvious that each
fraction must contain a certain proportion of diglycerides
or possibly monoglycerides. Further, the mean molecular
weights obtained, except for the final two fractions, are
all less than can be accounted for by any triglyceride
formed from the acids present. Again, the values ob-
tained for the first two samples are lower than can be
attributed to any diglyceride and would therefore in-
dicate the presence of monoglycerides.

A further check on the proposed diglyceride
constitution of the wax is found in the percentage of
hydroxyl group in the fat as calculated from the values
tabulated. Thus from the fat analysis we have:

			"Mols."	
Per cent. glycerine	=	15.3 per cent.	0.166	1
Per cent. Fatty acids.	=	90.5 per cent.	0.377	2.25
Per cent. hydroxyl group.	=	2.19 per cent.	0.128	0.76

This gives a total number of molecules attached
to the glyceryl radicle as 3.01 molecules, which further
proves the deduction that the wax must contain natural
diglycerides.

The percentage of hydroxyl group in the wax may
be calculated as follows:

$$\text{Hydroxyl Value} = \frac{\text{Acetyl Value}(A) \quad 70}{1 - 0.00075\ A.}$$

Considering the whole wax: Acetyl Value = 68.2.

$$\therefore \text{Hydroxyl Value} = \frac{68.2}{1 - 0.00075 \times 68.2}$$

$$= \frac{68.2}{1 - 0.051}$$

$$= \frac{68.2}{0.949} = 71.9.$$

But the Hydroxyl Value = the number of milligrams
KOH equivalent to the hydroxyl groups in one gram of wax.

/i.e. 71.9.........

i.e. 71.9 mgm. KOH = -OH in 1 gram of wax.

But 56.1 mgm. KOH ≡ 17 mgm. of -OH.

∴ Weight of -OH/gram of wax = $\frac{71.9 \times 17}{56.1}$

= 21.9 mgm. of -OH.

∴ Percentage of -OH = 2.19 per cent.

Thus it seems possible that by using the saponification and acetyl values and the mean molecular weights of the fractions, a probable composition of each fraction may be computed. Further, bearing in mind that the lower molecular weight acids are probably combined, chiefly, in the diglycerides, such a computation may be carried out as follows:

Consider for example fraction G of saponification value 216.6, Acetyl value 80.0 and a mean molecular weight of 582.

In such a calculation, it is assumed that each fraction consists of only two constituent glycerides, one diglyceride and one triglyceride. Although there is no evidence to substantiate this statement, it is obvious from the tabulated results that each fraction must at least contain one diglyceride and one triglyceride. An acetyl value of 80, would indicate approximately 80 per cent. of diglycerides in the fraction since the acetyl values of all the possible diglycerides are about 100. Hence the saponification value of the diglyceride in question must necessarily approximate to 215 - 216, the only glycerides possible being dimyristin at 219.0 and myristo-palmitin at 207.6. Dimyristin, on the one hand, would require a triglyceride of saponification value less than 215, the only possibility being tripalmitin, whilst myristo-palmitin would require a triglyceride of a much higher saponification value than 215 e.g. trimyristin 232.8.

/Thus......

Thus these two possibilities exist which can be considered separately from the saponification value, acetyl value and mean molecular weight determinations.

(a) Considering the fraction to consist of myristo-palmitin and trimyristin.

Let x = weight of myristo-palmitin.

(Sap. Value - 207.6, Acetyl Value - 96.1)

(11.1 - x)= Weight of trimyristin. (Sap. Value - 232.8)

(1) According to the Acetyl Value

$$x = \frac{80 \times 11.1}{96.1} = 9.24 \text{ gm.}$$

(2) According to the Saponification Values.

$$x \times 207.6 + (11.1 - x)232.8 = 11.1 \times 216.6$$
$$25.2x = 11.1 \times 16.2$$
$$x = 7.14 \text{ gm.}$$

These results indicate that it is highly improbable for the fraction to consist of myristo-palmitin and trimyristin. Using palmito-dimyristin in the above calculation will give even a lower value for x when calculated from the saponification values.

(b) Assuming the fraction to consist of dimyristin and tripalmitin.

Let x = weight of dimyristin.

(Sap. Value - 219.0, Acetyl Value - 101)

y = weight of tripalmitin. (Sap. Value - 206.5)

(1) According to the Acetyl value

$$x = \frac{80.0 \times 11.1}{101} = 8.78 \text{ grams.}$$

(2) According to the Saponification values.

$$x \times 219.0 + (11.1 - x)208.5 = 11.1 \times 216.6.$$
$$\therefore 10.5x = 8.1 \times 11.1$$
$$x = 8.56 \text{ grams.}$$

/(3).........

(3)   According to the mean molecular weights.

$$\frac{x}{11.1} \times 512 + \frac{(11.1 - x)807}{11.1} = 580.$$

$$46.2x + 807 - 72.7x = 580$$

$$\therefore 26.5x = 227.$$

$$x = 8.52 \text{ grams.}$$

The small differences in the results can easily be explained in that it is improbable that the fraction consists only of dimyristin and tripalmitin. Other mixed triglycerides will be present but it is quite clear that the major constituents must be dimyristin and tripalmitin.

A complete table is not drawn up in this fashion since calculations indicate the presence of more than two glycerides in/fractions. Although the major constituents in each fraction may be determined, the data at our disposal is not sufficient to warrant the attempt of a complete calculation.

Consideration of the results obtained on fraction M, will show it to be primarily tripalmitin with a small proportion of diglycerides (Acetyl value 14.3). Further the results, as shown, for fractions A and B cannot easily be explained in the above manner, and it would appear that monoglycerides may be present in these fractions to account for the very high acetyl values. This is reinforced by a consideration of the results of the previous table, (see page 58) for the petroleum ether crystallisations. There, three fractions were separated with acetyl values exceeding 105. The only possible explanation that can be given is by assuming monoglycerides to be present.

It, therefore, seems quite definite from the experimental results that the fat under investigation

/consists......

consists of a mixture of diglycerides and triglycerides
together with a small proportion of monoglycerides.
Further it would appear that a fair percentage of tri-
palmitin is present together with dimyristin and myristo-
palmitin as the major diglycerides. The presence of
simple glycerides in natural fats, though contrary to
the "rule of even distribution" has been proved by
recent workers in the case of cottonseed,[48] soybean,[49]
linseed,[50] palm[47] and olive[47] oils.

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USES.

Before concluding the discussion on Berry Wax, it is necessary to consider possible uses for this material.

Chittenden and Smith,[18] stating Berry Wax to consist essentially of tripalmitin, suggested its possible use as a source of palmitic acid.

Another application of Berry Wax repeatedly referred to is its use in the candlemaking industry. Abderhalden[19] merely points to its use in this respect without elaborating on the general efficiency of the candles so produced. It was also suggested as a substitute for beeswax. Jamieson,[23] too, only mentions its use along with other substances in the manufacture of candles. In another publication,[21] it is pointed out, however, that its low melting point might render Berry Wax unsuitable for this purpose, although the candles made from this wax are stated to burn slowly, with very little smoke and to emit an agreeable balsamic odour: they are, however, reported to give a poor light.[51] It is suggested that the wax should be mixed with an equal proportion of tallow in order to make the candles burn more brightly. When used for the adulteration of beeswax, it is stated that the resulting product does not assume the same polish as pure beeswax when rubbed.

A second important application of Berry Wax is as a general soapstock; giving a hard, ivory-white soap with an agreeable odour and of splendid quality.[23,51,52] A firm of soap-makers in Durban, however, reported in 1915 that after investigating the possibilities of Berry Wax in this field, found it to be unsuitable for their use.[52] It seems, however, that it has been used for harden-

/ing......

ing and preserving other soaps. The general impression
would appear to be that its high price largely militates
against its further use in this field.

A third major use for Berry Wax, and one
in which it is still applied today, is in the polishes
industry.[51,52] Although it has been referred to as a
rival for Carnauba Wax in the manufacture of boot-cream,
floor-polish etc., its low melting point renders this
claim extremely improbable. Generally, though, manu-
facturers of floor-polishes, who have tried Berry Wax,
maintain that it lacks certain essential properties
for use in manufacturing polishes. In the Western
Province, Berry Wax appears to have been used by local
house-holders in conjunction with paraffin wax for
floor-polish and to some extent for boot-cream.

The cost of Berry Wax over a period of
about 40 years has fluctuated considerably. In 1906,
it sold at about 27/- per cwt., but in the years fol-
lowing a tremendous interest developed in this product
resulting in a price increase up to 11.4 pennies per
pound in 1915. A marked depreciation in the value of
Berry Wax then took place, dropping to $5\frac{1}{2}$ pennies per
pound in 1922, a price which furnished little induce-
ment to collect the wax. Today, with Berry Wax quoted
at 2/3 per pound, it is used, only to a small extent,
in the polishes industry.

Another industry that might favourably
employ this material is the cosmetics industry, where
its hardness, smoothness and fairly low melting point
would indicate its use in lipsticks and creams. It
has also been found to be an excellent material for use
in oil-baths in chemical laboratories,[16] being prefer ble

/to.......

to paraffin-wax as it can be heated to a much higher
temperature (300°C) without emitting any obnoxious
vapours and because it has a very high flash-point. It
is further suggested by the author, that Berry Wax might
find application, after refining and deodourisation, in
the manufacture of "superglycerinated" shortenings for
manufacturing cakes, sweet yeast doughs and similar
products.[53]   The oil was also found to be an excellent
emulsifying agent.

It seems quite definite, though, that the
Forestry Department would not tolerate unrestricted
exploitation of the berries, as the shrub Myrica Cor-
difolia, abounding on the sandy flats along the South-
western and Southern coasts of the Cape Province, ex-
hibits excellent sand-binding qualities. It thus forms
an important auxiliary in the fixing of the sand-dunes
for when properly established, it puts an end to the
shifting of the sand by constantly pushing new shoots
through the accumulating dunes.[28]

Summarising, we can state that the only
industrial use for Berry Wax today appears to be in the
polishes industry though use in the cosmetics and food
industries indicates definite possibilities. Its high
price excludes its use from the soap industry as well
as from candlemaking, whilst its low melting point ren-
ders it further unsuitable for the latter use and as a
general substitute for Carnauba Wax. Although the melt-
ing point of the wax increases by some 8°C over a
period of about two years, it is considered that this
change proceeds too slowly to be of any industrial
importance.

CONCLUSIONS.

1.   Cape Berry Wax consists of a mixture of diglycerides, triglycerides, a small proportion of free fatty acids, possibly monoglycerides and a trace of unsaponifiable matter.

2.   The fatty acids present consists essentially of approximately equimolecular proportions of myristic (49.9 mol. per cent.) and palmitic (49.0 mol. per cent.) acids. The minor component acids are lauric (0.4 mol. per cent.), stearic (0.2 mol. per cent.) and a monoethenoid acid, probably palmitoleic (0.5 mol. per cent.).

3.   The wax has an abnormally high acetyl value, which was first reported in 1940,[54] and which formed the basis of this investigation.

4.   The specific gravity of air-free samples approximates to that of water at 15°C.

5.   The specific gravity, melting point and refractive index increase with ageing thus indicating the probability of polymorphic changes.

6.   Possible uses for the wax are in the manufacture of "superglycerinated" shortenings, and in the cosmetics industry. It is an excellent emulsifying agent. The wax is not, however, suitable for the manufacture of high-grade polishes.

7.   There seems to be little or no change in the composition of the wax once the berries have ripened.

8.   It has an abnormally low interfacial tension against water at 55°C.

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CALIBRATION OF THE SPECIFIC GRAVITY BOTTLES.
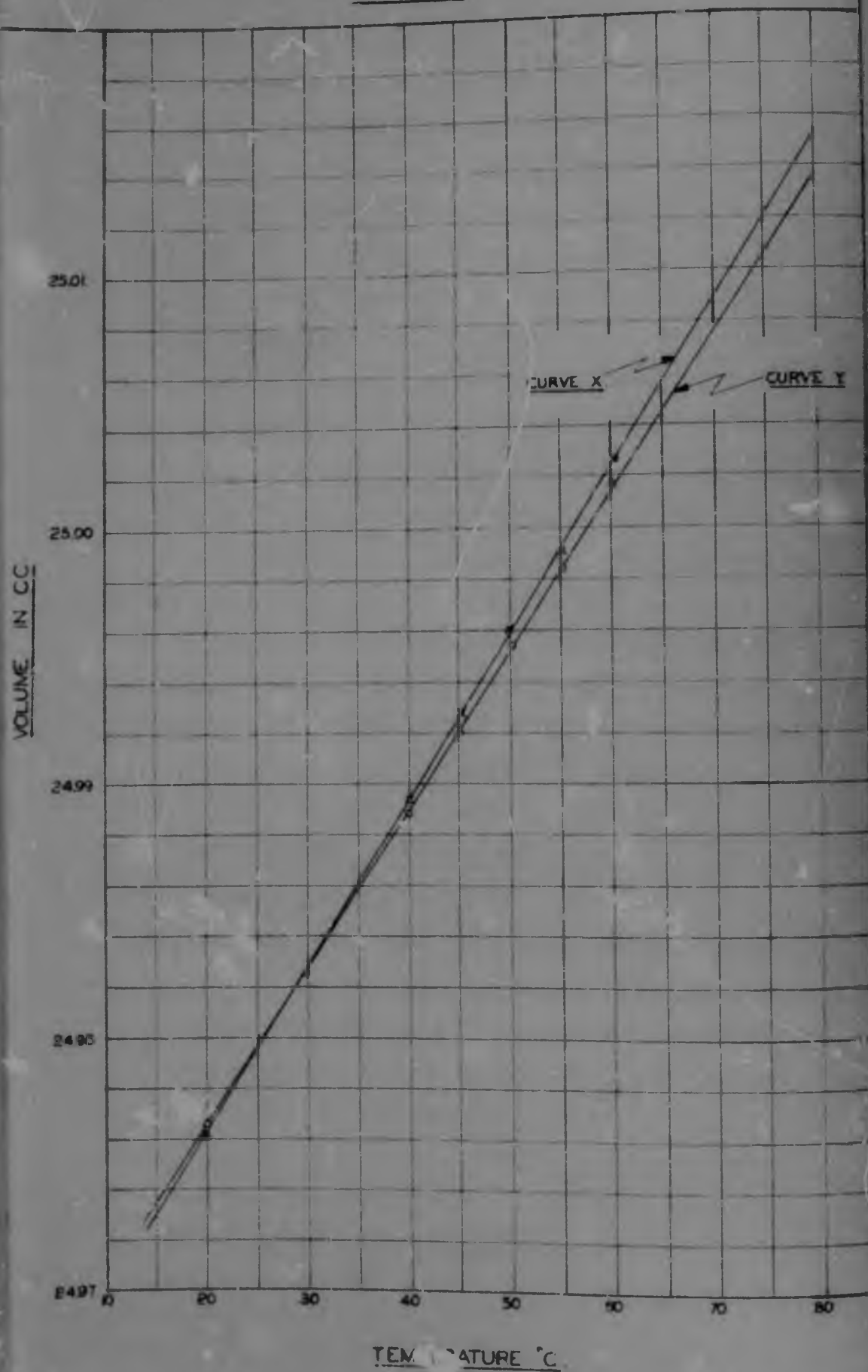
METHODS OF ANALYSIS.

Where the methods used are standard, no comment is made except for giving a reference to that particular method.

A. PHYSICAL CONSTANTS.

1. Specific Gravity.[55]

The specific gravity was determined using a specific gravity bottle. Since the results are reported as D_t^t and D_{15}^t, an accurate measure of the weight of an equivalent volume of water at all temperatures is essential. Distilled water was boiled and then cooled under vacuum. When not in use, the vacuum over the water was maintained to prevent solution of air. Nevertheless, frequent evacuations of the bottle were essential to ensure an air-free sample of water for all determinations. As these water determinations were only carried out at the lower temperatures, immersion in a thermostatically controlled waterbath for half-an-hour proved to be quite sufficient for attaining thermal equilibrium. The bottles were then cooled for twenty minutes in cold water, dried and weighed. An accurate graph, as shown, can thus be plotted of the increase in volume of the specific gravity bottle with temperature. The curve, being a straight line can thus be extrapolated to any temperature up to the boiling point of water.

In all the specific gravity determinations, a maximum deviation in temperature about the required value was maintained at $\pm$ 0.05°C below 60°C and $\pm$ 0.1°C above 60°C.

The wax determinations at 50°C and higher were carried out exactly in a similar manner. The major

/wax.....

wax sample was maintained molten at about $60^{\circ}C$ to exclude as much dissolved air as possible.

The specific gravity bottles, after introducing the samples, were left in an oven, at the same temperature as that at which the determination was being carried out, for one hour. The bottles, after filling them completely, were then transferred to the thermostat and left for one hour. The bottles were then allowed to cool, first in air and then in cold water, for half-an-hour, dried and weighed. After each determination the bottles were left in the oven for at least an hour before the determinations were repeated. Thus having determined the weight of wax at $t^{\circ}C$ and the corresponding weights of water at $t^{\circ}C$ and $15^{\circ}C$, $D_{\frac{t}{t}}$ and L_{15}^{t} could be calculated.

To determine the specific gravity of the solid wax-cake, a different procedure had to be adopted. Briefly the method was as follows: a sample of wax was introduced into the specific gravity bottle, allowed to cool, and weighed. The bottle was then filled with water, evacuated and its weight determined at any particular temperature at $t^{\circ}C$. Hence from the weight of the wax-cake and the corresponding weights of an equivalent volume of water at $t^{\circ}C$ and $15^{\circ}C$, the specific gravity could be calculated.

As has been noted previously, considerable difficulty was experienced before reproducible results were obtained, and various modifications of the general procedure were adopted.

After introducing the samples, the specific gravity bottles were left in an oven at $80^{\circ}C$ for an hour to expel the enclosed air. The samples were then cooled atmospherically and the specific gravity determined.

/In......

In the following series of determinations, the same procedure was adopted except that in the one case, the samples were cooled suddenly by plunging them into cold water and in the other case, very slowly by immersing the bottles in a beaker of water at 80°C and allowing it to cool slowly to room temperature. In each of the above cases, the bottles were evacuated after filling with water so as to remove the trapped air.

The next modification consisted in cooling the wax sample under vacuum. The same preliminary precautions were adopted as before and the cooling was carried out both very slowly and rapidly as described above, though for most reliable results it was found that atmospheric cooling under vacuum was preferable.

The method finally arrived at was as follows. The sample of wax was introduced and the bottle left to stand in an oven at 80°C for at least an hour. This was essential otherwise bubbles formed on the wax surface, through air escaping, whilst cooling under vacuum. Such bubbles immediately introduced an error and the samples had to be discarded. This preliminary heating ensured that the sample had a smooth surface free from pits. The sample was then cooled slowly under vacuum, the cooling being completed in a cold waterbath. The bottle was dried and weighed, about half the required amount of water introduced and the bottle and its contents evacuated until no further air bubbles escaped. (The vacuum was maintained at a sufficiently low value to prevent boiling of the water). The bottle was filled completely and its weight determined after leaving in a thermostat until thermal equilibrium was established. The bottle was then re-evacuated and the weight deter-

/mined.....

mined after leaving in the thermostat as before. This
operation was repeated until concordant results were
obtained - usually two or three times.

For each determination the bottle was left
in the thermostat for an hour and then cooled for half-
an-hour before weighing. In all cases, the samples were
introduced through a long, thin-stemmed funnel to keep
the wax off the upper sides of the bottle as much as
possible, since such a film of wax split off in small
pieces whilst evacuating the sample with a resulting
loss of material.

Over the plastic range 35 - 50°C, considerable
difficulty was experienced due to partial fusion and poly-
morphic changes. The results obtained were unreliable
and are not reported.

2.   Refractive Index.[32]

The Refractive index of the sample was deter-
mined to sodium light using the direct reading Zeiss
Abbé Refractometer with temperature controlled prisms.
The Refractometer was standardised against pure, air-
free distilled water at 20°C. The oil sample, introduced
between the prisms, was allowed ample time to attain the
temperature of the apparatus before a reading was taken.
The temperature control on the instrument was maintained
to within 0.1^{o}C.

The change of refractive index with tempera-
ture was determined over the range 40 - 80°C and plotted
as shown in the graph facing page 15.

3.   Melting Point of Wax.[56]

The wax sample was melted, thoroughly mixed,
and the capillary tubes dipped into the molten material

so that the melted sample rose to a height of one centi-
meter in the tubes. The ends of the capillary tubes
were then carefully fused and allowed to cool. The tubes
were left overnight in a refrigerator at about 5°C, and
the melting point of the wax determined in the usual way.

4.   Optical Activity.[57]

This was determined to sodium light in the
usual manner, using a solution of the wax in chloroform.
The determinations were all made at a temperature of
20°C. The instrument used was a Winkel-Zeiss research
type polarimeter.

5.   Titer of the Fatty Acids.[71]

About 50 grams of fat were saponified with
caustic-glycerine solution; diluted with water and the
acids split by the addition of sulphuric acid solution
(30 per cent. by weight). The acids were then extracted
with ether as described under 7(b).

The apparatus used is described by Jamieson
and consisted of a wide-mouth bottle (450 ml.) fitted
with a stout 6" x 1" test-tube by means of a good
quality cork. The bottle and test-tube containing the
melted fatty acids, were fixed in a two liter beaker
which was filled with water at 20°C to a level one
centimeter above that of the fatty acids. A stirrer
and titer thermometer were then inserted into the tube
and the acids stirred at a steady rate of 100 up-and-
down motions per minute. The stirring was continued
until the temperature remained constant for 30 seconds
or began to rise within the 30-second interval. The
stirring was then discontinued and the maximum temperature
recorded by the thermometer, noted.

/6.........

6.   Surface and Interfacial Tensions.[73]

The surface tension against air and the
interfacial tension against water were both determined
at 55°C using the du Nouy direct reading tensiometer.[74]
A platinum-iridium ring, six centimeters in diameter,
was used in all cases. The instrument was first stan-
dardised by supporting different weights on the ring
to create the pull on the wire. This pull on the in-
strument was balanced by applying a torque to the wire
given by:

$$\gamma = \frac{Mg}{2L}$$

where M   = weight in milligrams used.

g   = acceleration due to gravity.

$= 979.5$ cm./sec.^{2}

L   = 6.001 cm. (mean diameter of the wire).

The lengths of the torsion arms were then
altered until the scale reading corresponded to the above
value. The instrument was then checked against pure
distilled water at 22°C.

For best results, extreme cleanliness of all
apparatus used must be ensured. To this effect all glass-
ware used was boiled with a strong chromic acid solution,
thoroughly washed with distilled water and dried with
filter paper. The ring, after cleaning with chromic
acid solution and rinsing with distilled water, was heated
to bright redness in an alcohol flame. This procedure
was repeated after each determination.

/B. Chemical.......

B.   CHEMICAL CONSTANTS.

1.   Acid Value.

About ten grams of fat were accurately
weighed in a 200 ml. Erlenmeyer flask and dissolved in
50 ml. of boiling neutral ethyl alcohol (95 per cent.).
The mixture was then thoroughly swirled and immediately
titrated with aqueous decinormal caustic potash to
phenol phthalein indicator, swirling the mixture
vigorously throughout the titration. The endpoint was
taken when the pink colour persisted for one minute.

In all cases the acidity was reported as
milligrams KOH per gram of fat.

2.   Saponification Value.

About 2 grams of fat were accurately weighed
in a 200 ml. Erlenmeyer flask, six drops of a one per
cent. alcoholic solution of phenol phthalein indicator
added and the fat saponified under reflux, on a boiling
waterbath for $\frac{1}{4}$ of an hour, with 30 ml. of approximately
seminormal alcoholic caustic potash. - (added from a
burette at a definite rate to ensure constant drainage.)
The flask was swirled at intervals during the saponi-
fication. At the end of the refluxing period, the flask
was raised from the waterbath, the condenser washed down
with 25 ml. of neutral ethyl alcohol (95 per cent.) and
allowed to drain for one minute. The excess alkali was
then back-titrated with seminormal hydrochloric acid
solution.

Two blank determinations were carried out
concurrently with the tests, one treated before the
samples and one after; the agreement in the acid back-
titrations maintained within 0.03 ml., or the deter-
minations rejected. The saponification value, in terms

/of......

of milligrams KOH required to saponify one gram of fat, was then calculated.

3. Acetyl Value.[58]

The method[59] was standardised for five gram samples, though with a suitably modified apparatus, samples as small as one gram were used since comparative determinations showed that the use of one gram samples for acetylation instead of the more usual five to ten gram samples in no way impaired the accuracy of the results.

Using the special flask,[59] the sample was acetylated by refluxing 5 ml. of wax with an equal volume of acetic anhydride in an oil-bath at 140 - 145°C. for two hours. The flask and its contents were allowed to cool to about 100°C, 50ml. of boiling distilled water added and the whole boiled in the oil-bath at 100 - 105°C for 15 minutes, bubbling a slow stream of carbon dioxide through the mixture to prevent oxidation and to minimise bumping.

The water was then siphoned off using a siphon of barometer tubing with the end of the shorter limb ground to fit into the depression at the bottom of the flask. By this means an almost quantitative separation of the two layers was effected. The boiling and siphoning processes were then repeated twice. After the third boiling, the acetylated wax was washed twice with 50 ml. portions of hot distilled water (50°C) in the same vessel. This was done by shaking well with water and allowing the two layers to separate, siphoning off the aqueous layer and removing the droplets of water adhering to the sides of the flask with a spill of filter paper.

/..fter......

After the second washing, a gram of anhydrous sodium sulphate was shaken with the acetylated product which was then allowed to stand for at least an hour and the product filtered in an air-oven at about 90°C using a Whatman No. 4 paper, not greater than 7 cm. in diameter, and a stemless funnel. By this means losses were minimised.

The saponification value of the acetylated product was then determined as in (2) above, and the acetyl value calculated from the formula.[58]

$$A. = \frac{S' - S}{1 - 0.00075 \times S}$$

where A   = acetyl value.

   S'   = saponification value of the acetylated sample.

and S   = saponification value of the original sample.

4.   Unsaponifiable Matter.

About 5 grams of wax, accurately weighed out, were saponified with 5 ml. of a concentrated alkali solution (10 grams KOH in 10 ml. water) added to 30 ml. of ethyl alcohol (95 per cent) for one hour under reflux on a boiling waterbath. The solution was cooled, 50 ml. of petroleum ether (Boiling range 30 - 50°C) added, the flask shaken and the contents transferred to a 250 ml. cylindrical separating funnel. The flask was rinsed with a further two, 25 ml., portions of petroleum ether, each washing being added to the separating funnel which was then well shaken for one minute, rapidly twirled and the layers allowed to separate.

The soap layer was run off and extracted with a further four, 30 ml., portions of petroleum ether, uniting all the extracts. The combined ether extracts were then washed with water until free from alkali to

/phenol.....

phenol phthalein. In the event of an emulsion forming
during washing, it was broken by the addition of a small
quantity of anhydrous sodium sulphate. The extract was
then dried with anhydrous sodium sulphate for two hours
and filtered through fat-free filter paper into a tared
300 ml. Erlenmeyer flask, washing out the separating
funnel and filter with three successive 25 ml. portions
of petroleum ether. The solvent was then carefully dis-
tilled off on a waterbath and the residue dried to con-
stant weight at 95 - 100°C in an air-oven.

It is important that the stopcocks and
stoppers of the separating funnels be lubricated with a
lubricant, insoluble in petroleum ether.

5. Iodine Value.$\overset{60}{}$

All iodine values were determined by the
Wijs method.

About 0.4 - 0.5 gram of wax was accurately
weighed into a clean 1" x $\frac{1}{4}$" sample tube and the tube
transferred to a clean, dry iodine value flask. 10 ml.
of carbon tetrachloride were added to dissolve the wax
and then 15 ml. of Wijs solution run in slowly and at a
constant rate from a burette, taking care not to warm
the solution during handling because of the high coefficient
of expansion of acetic acid. The flask was then tightly
stoppered and sealed with a few drops of potassium iodide
solution. It was thoroughly swirled and allowed to
stand in the dark for exactly 45 minutes, swirling twice
during the first ten minutes.

10ml. of a 10 per cent. potassium iodide
solution were then added to the annular space around
the stopper and the flask carefully opened, allowing the
solution to run down the sides. 50 ml. of cold distilled
water were then added, pouring it over the stopper and

/down......

down the sides of the flask. The liberated iodine was
then titrated immediately with decinormal sodium thio-
sulphate solution to starch indicator in the usual manner.
Two blank determinations were carried out simultaneously,
under exactly the same conditions, with each series of
determinations, one before and one after those containing
the wax samples. This precaution was taken to ensure
the detection of any appreciable temperature change
taking place during the addition of the Wijs solution
to the sample.

From the titration figures the iodine values
were calculated, the results being reported as grams
iodine absorbed per 100 grams of wax.

Wijs Solution.

13 grams of resublimed iodine were dissolved
in one litre of glacial acetic acid (not less than 99.5
per cent.) in a one litre round-bottom flask by warming
on a waterbath, keeping the mouth of the flask loosely
plugged with cottonwool to prevent absorption of moisture.
The solution was cooled to room temperature and 50 ml.
transferred to a glass-stoppered bottle. Pure dry
chlorine gas was then passed through the remainder in the
flask, until the colour just changed from deep-red to
amber. The chlorination was then discontinued, the 50 ml.
of iodine solution added, (the colour changing to a pale
ruby-red) and the resulting solution transferred to a
brown glass-stoppered bottle and stored in the dark.
Any solution more than a month old was rejected

If the titration of 10 ml. of the iodine
solution against decinormal thiosulphate solution was
n ml., then the titration of 10 ml. of the chlorinated
solution (adjusted if necessary), lay between $(2n - 0.5)$

/and.......

and 2n ml. to ensure the absence of iodine trichloride.

6.   Volatile Acids.[81]

About 5 grams of the sample were accurately
weighed into a 300 ml. flat-bottom flask and completely
saponified (indicated by the mixture becoming hom-
geneous) with 20 ml. of glycerine - caustic soda solution
(20 ml. of a 50 per cent. w/w caustic soda solution
added to 180 ml. of pure glycerine) with slight warming.
130 ml. of freshly boiled water were added, followed
by 10 ml. of dilute sulphuric acid solution (20 ml.
sulphuric acid in 100 ml. water) and about one gram of
powdered pumice. Without previously melting the separated
fatty acids, the solution was distilled using the standard
apparatus for the Reichert - Meissl and Polenske values.[81]
The flame was so regulated that 110 ml. of distillate
were collected in 30 minutes. The flame was removed
when the 110 ml. distillate had been collected and a
25 ml. measuring cylinder substituted so as to collect
any drops of distillate that fall later. The contents
of the receiver - flask were thoroughly mixed and the
latter immersed almost completely in cold water for 15
minutes. The distillate was then filtered and 100 ml.
of the filtrate titrated with decinormal caustic potash
solution using six drops of phenol phthalein indicator.
The pink colour persisted for two minutes at the end-
point. A blank determination was carried out to correct
for impurities in the solutions.

Reichert-Meissl Value = ml. of decinormal
caustic potash solution (after correction for the blank
determination)   x 1.1.

The remainder of the soluble acids were
then removed from the insoluble acids upon the filter

/paper......

paper by washing with three successive 15 ml. portions
of water previously passed through the condenser, the
110 ml. receiving flask and the 25 ml. measuring cylinder.
The insoluble acids were then dissolved by passing three
successive 15 ml. portions of neutral ethyl alcohol (95
per cent.), through all the previous containers and the
filter. The combined alcoholic washings were then titrated
with decinormal caustic potash solution in the same
manner as noted for the soluble acids determination.

Polenske Value = ml. decinormal caustic
potash solution required for neutralisation.

7. Total Fatty Acid Content.

This determination was carried out by two
different methods:

(a) Wax-cake Method.

About 8 grams of fat, accurately weighed,
were saponified with 3 grams of caustic potash in 60 ml.
of ethyl alcohol for $1\frac{1}{2}$ hours on a boiling waterbath.
The alkaline soap solution was then quantitatively trans-
ferred to an 800 ml. tall beaker, containing a glass rod,
and the solution dissolved in 500 ml. of hot distilled
water. Several drops of methyl orange indicator were
added and the fatty acids thrown up by the addition of a
slight excess of 1 : 1 sulphuric acid. The beaker was
left on the boiling waterbath, stirring frequently until
the fatty acid layer was clear, when a weighed quantity
(about 20 grams) of good quality beeswax was added. The
heating was continued until this was dissolved in the fatty
acid layer. The mixture was then left to stand overnight.
In the morning it was reheated and stirred to give better
clearing of the aqueous layer. When the two layers had
separated completely, the bubbles on the surface were

/removed.....

removed by blowing air through a heated tube and the
beaker then cooled by surrounding it with cold water.

The wax-cake was removed on the glass rod,
and washed with a fine jet of cold distilled water,
collecting the washings in the aqueous layer which was
subsequently used for the glycerine determination. The
wax-cake and wax adhering to the beaker, were then dried
by standing or wiping lightly with filter paper. The
cake was then removed from the rod, placed on a tared
watch-glass and the rod and beaker scraped with a
spatula, this wax being added to the main cake which
was then weighed.

(b)   The Ether-extraction Method.

About 4 grams of fat, accurately weighed,
were saponified with 40 ml. of seminormal alcoholic
caustic potash solution, for one hour under reflux on
a boiling waterbath. The solution was diluted with
20 ml. of water and the alcohol distilled off. The
alkaline soap solution was then cooled and transferred
to a 250 ml. cylindrical separating funnel. A few drops
of methyl orange indicator were added and the fatty
acids split with 1 : 1 Hydrochloric acid solution. The
flask was rinsed thoroughly with acidified distilled
water and then with 50 ml. of petroleum ether. (Boiling
range 30 - 50°C). The washings were all added to the
contents of the separating funnel, which was gently
shaken for one minute. The layers were allowed to
separate and the aqueous layer run off and extracted
with a further seven, 50 ml., portions of petroleum ether
to ensure complete removal of all the fatty acids.

The combined extracts were then washed with
cold distilled water to remove traces of mineral acids,
the solution dried with anhydrous sodium sulphate for

/four.....

four hours and filtered through fat-free filter paper,
washing the final container and funnel with four successive,
25 ml., portions of petroleum ether. The solvent was
carefully distilled off on a waterbath and the fatty
acids dried to constant weight in an air-oven at 80°C
and under reduced pressure.

Again, as in the determination of unsaponi-
fiable matter, all stopcocks and stoppers were lubricated
with a lubricant insoluble in petroleum ether.

8. Mean Molecular Weight of the Fatty Acids.

This determination could only be done directly
using a titrimetric method. The fatty acids were separated
exactly as described under 7(b) above. The residue was
then titrated with standard alkali (as described under (1)
and the mean molecular weight of the fatty acids calculated.

9. Glycerine Content.[34]

About 25 grams of fat, accurately weighed,
were saponified with 6 grams of caustic soda in 100 ml.
of ethyl alcohol (95 per cent.), for two hours under re-
flux. The solution was diluted with an equal volume of
water, the alcohol distilled off and the fatty acids split
with hydrochloric acid solution (1 : 1). The fatty acids
were then extracted with petroleum ether as described
under 7(b) above, and the aqueous residue and washings
evaporated to a total volume of about 70 ml. The solution
was then filtered into a 100 ml. standard flask, neutralised
with aqueous caustic soda solution and made up to volume
with distilled water.

10 ml. of this glycerol solution were pipetted
into a 100 ml. glass-stoppered standard flask, 10 ml. of
caustic soda solution added (30 grams of caustic soda per

/100 ml......

100 ml. of solution) and 60 ml. of ethyl alcohol (95 per cent.). The contents were mixed thoroughly and alcoholic cupric chloride solution (10 grams of $CuCl_2.2H_2O$ per 100 ml. of solution in ethyl alcohol - 95 per cent.) added gradually in small portions ($\frac{1}{2}$ - 1 ml. at a time) with thorough shaking between additions, until a clearly visible permanent precipitate of cupric hydroxide was formed. The flask was then filled to the mark with 95 per cent. ethyl alcohol, the contents well mixed and about 80 ml. thereof transferred to a 100 ml. centrifuge tube. The suspension was then centrifuged for 20 minutes at 1300 - 1500 r.p.m.

The clear supernatent solution was decanted off and 50 ml. of it pipetted into a 300 ml. Erlenmeyer flask. 100 ml. of cold distilled water were added followed by a small piece of litmus paper, and the contents of the flask made slightly acid to litmus with sulphuric acid solution (1 : 6). 10 grams of potassium iodide were then added and the liberated iodine titrated with decinormal sodium thiosulphate solution until the contents were pure white in colour.

A blank determination was carried out on the reagents using 10 ml. of distilled water instead of the glycerol solution. This is to correct for the solubility of the cupric hydroxide in the alcoholic solution.

1 ml. of 0.1 N Thiosulphate solution

$\equiv$ 9.1975 mgm. of glycerine.[34]

Notes:

The endpoints are more readily observed if the solutions contain 400 mgm. of glycerol or less.

It is important that a considerable excess of cupric hydroxide is present before centrifuging and that the

solution is well centrifuged.

The sulphuric acid solution is preferably added from a burette. It is simple to follow the course of this titration by the changes in colour of the solution and the appearance and disappearance of a precipitate.

10. Preparation of the Glycerine Sample for Analysis by the Acetin Process.

About 8 grams of fat, accurately weighed, were saponified with 3 grams of caustic soda, in 60 ml. of alcohol (95 per cent.) for 1½ hours on a boiling waterbath. The fatty acids were then separated by either method described under (7).

The aqueous acid liquor and washings were then transferred to a large evaporating basin, made slightly alkaline to methyl orange indicator with caustic soda solution, and evaporated on a boiling water-bath to incipient crystallisation of the sodium sulphate. The dish was then removed and cooled in running water, stirring and scratching all the time with a glass rod. Crystallisation started in fine needles, after which stirring and cooling were continued for a short time when the whole mass became pasty. The dish was then left uncovered overnight, when the crystalline mass became quite stiff and dry.

The crystalline mass was then extracted in a Soxhlet extractor with ethyl alcohol (95 per cent.) until the liquid siphoning over was colourless. The thimble was then emptied out into the evaporating dish, the crystals dissolved in water and the solution again evaporated and crystallised as described before. The crystals were again extracted in the same thimble with 95 per cent. ethyl alcohol for a further two hours.

/After.....

After the addition of some pumice, the
alcohol was distilled off on a waterbath and the water
removed by heating the flask in a steam-oven. It is
recommended to complete the evaporation of the alcohol
from the contents in the flask under reduced pressure
to prevent loss of glycerol.

The standard acetin method was then applied
to determine the percentage of glycerine in sample.[33]

A modification of the above procedure,[35]
consisted in neutralising the acid liquor with barium
carbonate instead of caustic soda, resulting in the
precipitation of barium sulphate. Evaporation was con-
tinued until the mass became pasty after which it was
extracted with a mixture of ethyl alcohol and diethyl
ether. The mixed solvent was then carefully distilled
off on a boiling waterbath and the residue dried over
concentrated sulphuric acid in a desiccator. The
glycerine content of the residue was then determined
in the usual manner by the acetin process.

11. Preparation of Mixed Methyl Esters for the er Fractionations.[62]

About 150 grams of wax were saponified
with 60 grams of potassium hydroxide in about 700 ml.
of 95 per cent ethyl alcohol. The solution was boiled
under reflux for about four hours and most of the
alcohol then removed by distillation. The concentrated
soap solution (about 100 ml.) was dissolved in about
400 ml. of water and the soaps split with 1 : 1 hydro-
chloric acid solution. Because of the small amount
of unsaponifiable matter present (0.1 per cent.), no
separation was effected before splitting. The fatty
acids were then extracted with diethyl ether to a total

/bulk......

bulk of 2000 ml., the solvent distilled off and the acids dried at 80°C overnight.

These acids (about 135 grams) were then converted into the neutral methyl esters by esterifying with four times their weight of methyl alcohol in the presence of about two per cent. of concentrated sulphuric acid for four hours. About three-quarters of the methyl alcohol was distilled off and the residue dissolved in diethyl ether to a total bulk of about 600 ml. The unesterified acids were then removed by washing the ethereal solution several (four) times with a dilute (1 per cent.) potassium carbonate solution. (A more concentrated solution of potassium carbonate cannot be used for fear of saponifying some of the esters and because of its tendency to emulsify the whole sample. Such an emulsion can, however, readily be broken by destroying the excess alkalinity with a few drops of dilute hydrochloric acid solution.)

The ethereal solution was then dried overnight with anhydrous sodium sulphate; filtered and the solvent distilled off and the mixed methyl esters left in an oven at 110°C overnight.

12. Fractional Crystallisation from Organic Solvents.

Although the description that follows applies specifically to the acetone crystallisation processes, a similar procedure was adopted for all such experiments. In every case the crystallisation was allowed to proceed overnight at room temperature.

The wax sample was primarily crystallised from anhydrous acetone (dried over and distilled from calcium chloride) in a solution of one gram of wax in

/six.....

six ml. of acetone. The separated material was then
repeatedly crystallised from anhydrous acetone, the
concentration of the solutions gradually diminishing
from 1 : 6 ml. to 1 : 26 ml. of acetone for the major
acetone crystallisation process. The filtrates, in all
cases, were evaporated to dryness and the wax fractions
recovered.

The wax from the primary filtrate was
recovered by partially evaporating the liquor on a
waterbath and allowing it to stand overnight. By this
means several fractions were separated, the most soluble
fraction being obtained by the complete evaporation of
the solvent.

13. Mean Molecular Weight Determination by the Macro-Rast Method.

About 0.01 grams of solute was weighed into
a clean, dry fusion tube. To ensure maximum homogeneity,
each fraction was first melted before the sample was
weighed out. To this about 0.1 gram of camphor, the
solvent, was added and the tube weighed again. The
weights should be very nearly in the proportion of 1 :10.
The tube was then sealed and drawn out into a fine rod,
by means of which it was attached to the thermometer.

The thermometer, with tube attached, was
then suspended, firstly in a small beaker of paraffin.
A lamp was placed behind the beaker, which was then
slowly heated with a small flame until the mixture had
melted. The tube was then shaken to ensure that the
solution would be homogeneous, and allowed to cool when
the mixture solidified.

The beaker was then heated very gently,
stirring the paraffin all the time, and the temperature

/noted.....

noted when all the crystals had molted and the solution
was perfectly clear. Several readings were taken of
this temperature. The melting point of the camphor
was determined in a similar manner.

Due to the low heat transfer through the
comparatively thick-wall of the fusion tube, which
caused a definite time-lag in recording changes in
temperature, the heat capacity of the heating medium
was increased by carrying out further determinations in
a two litre beaker containing about 1500 ml. of paraffin.
The rate of heating was also reduced from 1°C per minute
to 1°C per three minutes. Again several determinations
had to be carried out before concordant results were
obtained. For each determination the sample was allowed
to cool about 10°C below its melting point.

The mean molecular weight was then calculated
from the formula:

$$M = \frac{1000 \times k_b \times w}{W \times \Delta t_f}$$

where w = weight of solute

W = weight of camphor.

Δt_f = depression in melting point.

k_b = freezing point depression constant for
camphor - 40.

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FUEL No. 11

Mixture by volume of:-

60	parts	ETHYL ALCOHOL
20	"	PETROL
20	"	BENZOL

Fuel Data

Composition by weight

Carbon - 66.9 %

Hydrogen- 12.2 %

Oxygen - 20.9 %

Higher Calorific Value

68,120 C.H.U. per gallon.

8,530 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .799

Latent Heat   156 C.H.U. Per lb.

Kinematic Viscosityin abs. cgs. units .01013(1-.0137 T-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	45	83	142

Distillation

Percent Distilled	10%	50%	End point
Temperature	62	69	73.5

Fuel No. 11   60% Alcohol-20% Petrol-20% Benzol
Table 11A

8.30 A.M.   Barometer-24.733 ins Hg   Dry bulb-49.1 F Wet bulb-45.0 F
3.00 P.M.   "   24.801 "   "   "   "   60.5 F "   "   51.9 F

Approximate load 340 lbs.

Initial tyre pressures, lbs/sq ins- front 27, back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH2O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
N 29.2	4-38.2	4.0	350	141	11.9	63	94.3	96.56	22.6
S 28.8	5-46.6	0.2	310	148	14.3		97.33	00.1	27.7
N 28.9	4-47.5	3.5	360	141	11.0		00.24	02.55	23.1
S 28.8	5-51.3	0.3	315	151	14.2		03.18	05.99	28.1
N 28.9	4-48.6	4.8	350	143	11.8		06.2	08.52	23.2
S 28.8	5-50.6	0.5	295	151	14.2		09.11	11.91	28.0
Tyre pressures- front 29 / back 30									
N 38.0	3-21.6	6.2	485	142	10.2	65	12.21	14.34	21.3
S 38.0	4-29.4	0.9	440	152	13.6		15.1	17.94	28.4 ?
N 37.9	3-23.5	4.4	430	142	11.2		18.14	20.28	21.4
S 38.2	4-31.2	0.8	450	149	13.3		21.16	24.04	28.8
N 37.9	3-27.4	5.5	465	144	11.3		24.29	26.47	21.8
S 38.0	4-29.4	0.7	470	149	13.8		27.35	30.19	28.4
Tyre pressures:- front 29 reduced to 29 / back 33 " " 29									
N 46.7	2-21.9	7.0	600	143	9.0	64.5	30.53	32.37	18.4
S 47.3	3-11.9	2.0	560	150	11.4		33.53	36.05	25.2
N 47.0	2-28	6.0	530	145	8.7		36.33	38.26	19.3
S 47.3	3-14.1	2.0	570	150	11.9		39.17	41.72	25.5
N 47.1	2-23.9	6.4	590	147	9.2		42.08	43.9	18.8
S 47.1	3-15	1.6	560	149	12.0		44.85	47.4	25.5
Tyre pressures:- front 32 reduced to 29 / back 30 30									
N 56.6	1-45.6	9.3	640	147	6.5	66	47.84	49.5	16.6
S 56.8	2-17.5	3.2	610	151	9.4		50.6	52.77	21.7
N 57.6	1-45.7	9.0	635	148	6.8		53.45	55.14	16.9
S 57.3	2-18.8	3.5	600	151	9.6		56.25	58.46	22.1
N 56.7	1-43.5	9.7	630	151	6.6		59.13	60.76	16.5
S 58.0	2-17.1	2.9	600	151	9.1		61.89	64.1	22.1
Tyre pressures:- front 30 / back 32									
N 67.9	1-14.2	13.0	710	153	2.3	64.5	65.05	66.45	14.0
S 67.1	1-36	4.7	670	156	5.2		66.65	69.44	17.9
N 67.5	1-14.7	11.5	720	154	1.8		70.8	72.2	14.0
S 66.9	1-35.4	5.2	670	153	4.9		73.48	75.25	17.7
N 66.9	1-14.7	11.8	730	152	1.6		76.49	77.88	13.9
S 67.1	1-33.5	4.8	660	154	5.0	63	79.11	80.85	17.4
Tyre pressures:- Front 31 / Back 33									

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.7	19.1	21.6	19.1

TABLE 11 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.01
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.284

Car Speed in m.p.h.		28.9	38.0	47.1	57.2	67.2
Wind Pressure,	N	4.1	3.4	6.5	9.3	12.1
inches of water.	S	0.3	0.8	1.9	3.2	4.3
Absolute Wind Velocity in direction of motion, m.p.h.		16.5	17.0	14.0	14.9	15.1
Mean Tyre Pressure, lbs/sq ins		28.5	30.2	30	30.2	31.5
Mean Air Temperature °Cent.		17.8	18.5	18.5	18.5	17.8
Miles per gallon	N	23.0	21.5	18.8	16.5	14.0
	S	27.9	28.5	25.4	22.0	17.7
Simple Mean M.P.G.		25.4	25.0	22.1	19.3	15.8
Inlet Manifold Pressure,	N	11.7	12.5	14.2	16.7	21.5
inches of Hg absolute	S	9.0	9.5	11.4	13.8	18.4
Average.		10.5	10.9	12.8	15.2	19.9
Exhaust Gas Temperature	N	392	490	600	636	696
degrees Centigrade.	S	348	477	578	612	660
(above atmospheric) Average.		370	483	589	624	678
Cooling Water Temperature	N	142	143	145	149	153
at entrance to radiator,	S	150	150	150	151	154
degrees Fahrenheit. Average (converted to Cent.)		63.3	63.6	64.2	65.5	67.5
Temperature Difference, water to air. Degrees Cent.		.5	45.3	45.9	47.3	49.7
Acceleration Time (seconds)	N	21.5				
	S	19.1			Average:-	20.3

Exhaust Gas Analysis   12.8 %CO₂   3.0 %O₂   0.3 %CO
—   %H₂ (estimated)   84.1 %N₂ (by diff)

Remarks:-   Starts easily and idles well.

TABLE 11 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.9	38.0	47.1	57.2	67.2
Reciprocal Mean M.P.G. of North & South runs.		25.8	24.5	21.6	18.9	15.6
	a) Wind	8.2	7.2	3.9	3.8	3.0
% Correction for:-	b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
	c) Barometer	–	–	–	–	–
	d) Air Temp.	0.8	0.7	0.7	0.8	1.0
	e) Tyre Press.	-0.8	-0.7	-0.4	-0.1	-0.1
Total correction- %		8.4	6.9	3.9	4.3	3.7
Corrected Miles per Gallon		27.8	26.2	22.4	19.7	16.2

Table 11   D   Volumetric Efficiency & Air/Fuel Ratio

   Ideal Air Fuel Ratio   11.0
   Average Molecular Weight   57
   Mixture Density relative to Air   1.038

Speed in m.p.h.	28.9	38.0	47.1	57.2	67.2
Compression Temperature	382	372	348	328	306
" " Pressure	10.05	10.45	12.0	13.75	17.4
Volumetric Efficiency	.252	.268	.329	.400	.543
Ditto to std. Basis	.232	.251	.317	.384	.524
Theoretical Air/Fuel Ratio	11.2	11.65	12.65	13.5	15.3
Air/Fuel ratio (exh. anal.)	-	-	12.6	-	-
Weight of exhaust gas per gallon of fuel	97.5	101	109	116	130.5

Table 11   E   Heat Balance

Speed in m.p.h.		28.9	38.0	47.1	57.2	67.2
Heat available from fuel	CHU/gal %	68120 100	68120 100	68120 100	68120 100	68120 100
Heat to tractive effort	CHU/gal %	17300 25.4	20200 29.6	20950 30.7	21900 32.1	21250 31.?
Heat to exhaust (a) Sensible	CHU/gal %	9260 13.6	12800 18.8	17150 25.2	19500 28.6	24100 35.3
(b) Latent	CHU/gal %	4300 6.3	4450 6.5	4800 6.9	5100 7.5	5750 8.4
(c) Unburnt gases	CHU/gal %	?	?	670 1.0	-	-
Heat to Cooling water	CHU/gal %	38000 55.7	30900 45.3	23500 34.4	18900 27.7	18350 26.9
Unaccounted for	%	(-1.0)	(-0.2)	1.8	4.1	-1.8

FUEL No. 12.

Mixture by volume of:-

50 parts ETHYL ALCOHOL

20 " PETROL

30 " BENZOL

Fuel Data

Composition by weight	Carbon - 71.1 %
	Hydrogen- 11.7 %
	Oxygen - 17.2 %
Higher Calorific Value	71,280 C.H.U per gallon
	8,830 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .807

Latent Heat   145 C.H.U. per lb.

Kinematic Viscosity in abs, cgs. units   .00914(1-.0141 $\overline{t-20}$)

Vapour pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	45	85	150

Distillation

Percent distilled	20%	50%	End point
Temperature	61	66.5	92

Fuel No. 12   50% Alcohol-20% Petrol-30% Benzol   25th September A.M.

Table 12A.

8.30 A.M. Barometer-24.733 ins Hg dry bulb-49.1 F wet bulb-45.0 F
3.00 P.M.   "   "   24.601 "   "   "   "   60.5 F "   "   51.9 F

Approx. load 380 lbs

Initial tyre pressure, lbs/sq ins- front 27, back 28.

Av. speed mph.	time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins "g	Air temp. F	Mileages:- Begin	End	Diffx10
N 29.5	4-54.1	3.6	360	140	12.3	58	02.49	04.9	24.1
S 28.9	5-41	0.4	300	146	14.1		05.54	08.28	27.4
N 29.4	4-57.1	2.8	340	140	12.8		08.4	10.83	24.3
S 29.3	5-39	0.5	295	145	14.2		11.34	14.1	27.6
N 29.3	4-58.1	3.2	350	141	12.5		14.25	16.68	24.3
S 29.1	5-40	0.3	305	144	14.1		17.16	19.91	27.5
Tyre pressures:- Front 26 Back 26									
N 38.1	3-29.7	5.1	440	140	11.4	57	20.12	22.34	22.2
S 38.0	4-35	1.0	460	146	13.6		23.0	25.9	29.0
N 38.3	3-36.4	4.0	460	141	11.7		26.16	28.46	23.0
S 38.0	4-33.4	1.2	440	144	14.0		29.2	32.08	28.8
N 38.4	3-36.6	4.5	440	141	11.8		32.39	34.7	23.1
S 38.3	4-31.5	0.9	450	144	13.8		35.38	38.27	28.9
Tyre pressures:- Front 27 Pumped up to 27, Back 26.5 ... 28									
N 47.8	2-29.1	6.3	590	141	9.4	57	38.7	40.68	19.8
S 47.5	3-11.8	1.8	(495)	144	12.2		41.64	44.17	25.3 ⊖
N 47.6	2-30.5	5.8	600	141	9.3		44.49	46.48	19.9 ⊖
S 47.5	3-18	2.0	570	144	11.7		47.29	49.9	26.1
N 47.7	2-33.2	6.8	600	143	9.5		50.13	52.16	20.3
S 47.4	3-19.8	2.3	560	145	11.8		52.95	55.58	26.3
Tyre pressures:- Front 27 Back 28									
N -	-	8.7	660	144	6.8	58	55.95	57.7	17.5
S 57.6	2-24.9	2.8	620	147	9.8		58.72	61.04	23.2
N 57.6	1-51.9	8.2	660	144	6.6		61.57	63.36	17.9
S 57.1	2-25.5	3.8	620	147	10.1		64.39	66.7	23.1
N 57.2	1-51.5	9.5	660	146	6.9		67.26	69.03	17.7
S 56.9	2-26.7	2.7	630	148	9.8		70.06	72.38	23.2
Tyre pressures:- Front 28.5 Back 29									
N 67.2	1-16.1	13.3	750	148	2.2	60	73.17	74.59	14.2
S 67.9	1-43.5	4.2	680	153	6.4		75.8	77.75	19.5
N 67.4	1-16.4	12.0	740	146	3.0		78.87	80.3	14.3
S 67.5	1-44.1	5.3	680	151	6.4		81.47	83.42	19.5
N 67.0	1-14.7	13.7	770	150	1.8		84.48	85.87	13.9
S 66.5	1-45.7	4.5	670	154	5.6		87.14	89.09	19.5
Tyre pressures:- Front 29 Back 29									

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.9	18.0	22.4	18.4

TABLE **12** B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   **25.01**
Vapour Pressure of moisture   **0.284**
in atmosphere (Average). Ins of Hg

Car Speed in m.p.h.		29.2	38.2	47.6	57.3	67.2
Wind Pressure,	N	3.2	4.5	6.3	8.8	13.0
inches of water.	S	0.4	1.0	2.0	3.1	4.7
Absolute Wind Velocity in direction of motion, m.p.h.		14.0	13.7	18.3	14.6	15.8
Mean Tyre Pressure, lbs/sq ins		26.8	26.4	27.5	28.1	29.9
Mean Air Temperature °Cent.		13.3	13.9	14.4	15.0	15.6
Miles per gallon	N	24.2	22.8	20.0	17.7	14.1
	S	27.5	28.9	25.9	23.2	19.5
Simple Mean M.P.G.		25.8	25.6	22.9	20.4	16.8
Inlet Manifold Pressure,	N	10.6	11.6	13.8	16.5	21.1
inches of Hg absolute	S	9.0	9.3	11.4	13.3	16.7
Average.		9.8	10.4	12.6	14.9	18.9
Exhaust Gas Temperature	N	390	478	602	652	715
degrees Centigrade.	S	346	480	570	623	665
(above atmospheric)						
Average.		368	479	586	637	690
Cooling Water Temperature	N	140	141	142	145	148
at entrance to radiator,	S	145	145	144	147	153
degrees Fahrenheit.						
Average (converted to Cent.)		61.4	61.7	61.7	63.3	65.8
Temperature Difference, water to air. Degrees Cent.		48.1	47.8	47.3	48.3	50.2
Acceleration Time (seconds)	N	22.1				
	S	18.2		Average:-	20.1	

Exhaust Gas Analysis   13.9 %CO₂   1.7   %O₂   0.5   %CO

    -    %H₂ (estimated)   83.9   %N₂ (by diff)

Remarks:-

TABLE **12** C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	29.2	38.2	47.6	57.3	67.2
Reciprocal Mean M.P.G. of North & South runs.	25.7	25.5	22.6	20.1	16.9
a) Wind	5.9	4.7	6.7	3.7	3.3
% Correction for:- b) Weight	-	-	-	-	-
c) Barometer	-	-	-	-	-
d) Air Temp.	3.3	2.4	2.3	2.2	2.1
e) Tyre Press.	0.6	0.9	0.5	0.5	0.5
Total correction- %	8.8	8.0	9.5	6.4	5.9
Corrected Miles per Gallon	28.0	27.5	24.8	21.4	17.9

Table 12 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   11.5

Average Molecular Weight   60

Mixture Density relative to Air   1.04

Speed in m.p.h.	29.2	38.2	47.6	57.3	67.2
Compression Temperature	380	378	347	329	310
" " Pressure	9.55	10.0	11.5	13.5	16.5
Volumetric Efficiency	.238	.251	.303	.390	.506
Ditto to std. Basis	.219	.232	.292	.366	.478
Theoretical Air/Fuel Ratio	10.7	11.15	12.75	13.9	15.3
Air/Fuel ratio (exh. anal.)	-	-	12.3	-	-
Weight of exhaust gas per gallon of fuel	94.2	98.0	111	120.3	131.5

Table 12 E Heat Balance

Speed in m.p.h.		29.2	38.2	47.6	57.3	67.2
Heat available from fuel	CHU/gal %	71280 100	71280 100	71280 100	71280 100	71280 100
Heat to tractive effort	CHU/gal %	17700 24.8	21250 29.7	23200 32.5	23800 33.3	23500 32.9
Heat to exhaust (a) Sensible	CHU/gal %	8900 12.5	12300 17.3	17400 24.4	20700 29.0	24700 34.7
(b) Latent	CHU/gal %	4080 5.7	4250 6.0	4800 6.7	5220 7.3	5700 8.0
(c) Unburnt gases	CHU/gal %	?	?	1150 1.6	?	-
Heat to Cooling water	CHU/gal %	41500 58.2	34500 48.3	27000 37.8	21100 29.6	16300 22.9
Unaccounted for	%	(-1.2)	(-1.7)	-3.0	0.8	1.5

FUEL No. 13.

Mixture by volume of:-

        40 parts ETHYL ALCOHOL

        20 "   PETROL

        40 "   BENZOL

Fuel Data

__Composition by weight__   Carbon - 75.2 %

                                 Hydrogen- 11.2 %

                                 Oxygen - 13.6 %

__Higher Calorific Value__   74,440 C.H.U. per gallon

                                 9,130 C.H.U. per lb.

__Specific Gravity__ at 20 degrees Centigrade - .815

__Latent Heat__   134 C.H.U. per lb.

__Kinematic Viscosity__in abs, cgs. units .00637(1-.0137 T-20)

__Vapour Pressure__

        Temperature   10 C   20 C   30 C
        V.P. in mm. of Hg 49   88   160

__Distillation__

        Percent Distilled 10%   50% End point
        Temperature   60   64.5 116

Fuel No.13. 40% Alcohol-20% Petrol-40% Benzol

Table 13A.

8.30. A.M. Barometer 24.745 ins Hg Dry bulb-56.8 F Wet bulb-53.6 F
3.00 P.M.   "   24.670 "   "   "   " 77.2 F "   "   37.0 F

Approx load 380 lbs

Initial tyre pressures, lbs/sq in- front 27, back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH2O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Begin	End	Diff x10
N 28.8	5-15.8	1.5	295	140	13.4	50	26.88	29.4	25.2
S 29.0	5-26.3	1.3	295	141	13.7		29.85	32.18	26.3
N 29.1	5-18.9	1.5	305	141	13.3		32.72	35.3	25.8
S 29.0	5-28.5	1.3	300	141	13.6		35.56	38.21	26.5
N 29.2	5-19.3	1.4	300	142	13.7		38.42	41.01	25.9
S 29.2	5-29.9	1.2	296	142	13.8		41.3	43.97	26.7

Tyre pressures:- Front 26
                  Back 27

N 38.5	2-59.4	2.3	400	143	13.1	63.5	44.21	46.77	25.6
S 37.8	4-20.6	2.1	380	143	12.9		47.17	49.91	27.4
N 38.4	4-5.4	2.4	410	145	13.0		50.17	52.75	26.2
S 38.5	4-17.9	2.1	410	145	12.9		53.15	59.2	27.5
N 37.9	4-6.9	2.2	410	146	13.1		56.09	58.69	26.0
S 38.2	4-23.7	2.4	400	146	13.1		59.01	61.8	27.9

Tyre pressures:- Front 27
                  Back   28

N 47.0	2-58.5	3.5	560	148	11.7	65	62.06	64.39	23.3
S 47.0	3-6.3	3.4	570	147	11.4		65.04	67.47	24.3 @
N 46.9	3-4.1	3.3	565	149	11.7		67.84	72.24	24.0 @
S 47.2	3-9.2	3.7	570	148	11.5		70.67	73.15	24.8
N 47.0	3-2.1	3.2	575	151	11.4		73.52	75.9	23..
S -	-	3.7	565	149	11.6		76.38	78.51	(21.3)

Tyre pressures:- Front 28   @ Sample 1.
                  Back   29.5

N 57.0	2-12.9	5.1	625	152	9.6	68	79.27	81.37	21.0
S 56.9	2-17.3	5.6	620	151	9.6		82.11	84.28	21.7
N 57.3	2-13.8	5.1	625	152	9.5		84.95	87.08	21.3
S 57.0	2-17.8	6.2	630	152	9.3		87.78	89.96	21.8
N 57.4	2-14.3	5.6	630	152	9.0		90.58	92.72	21.4
S 57.6	2-17.6	5.7	630	153	9.2		93.4	95.61	22.1

Tyre pressures:- Front 29
                  Back   31

N 67.1	1-38.2	7.6	720	158	5.7	68	96.45	98.28	18.3
S 67.4	1-37.3	7.9	700	158	5.4		99.18	01.0	18.2
N 66.9	1-37	7.0	700	156	5.6		02.07	03.87	18.0
S 66.9	1-35.2	8.8	695	158	5.5		04.85	06.62	17.7
N 67.6	1-39.5	7.6	700	158	5.7		07.7	09.57	18.7
S 67.1	1-36	9.2	700	158	5.2		10.47	12.26	17.9

Tyre pressures:- Front 29.5
                  Back   32

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	18.9	20.5	18.9	20.7

TABLE 13 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.05
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.319

Car speed in m.p.h.		29.0	38.2	47.0	57.2	67.2
Wind Pressure, N inches of water. S		1.5 1.3	2.3 2.2	3.3 3.6	5.3 5.8	7.4 8.6
Absolute Wind Velocity in direction of motion, m.p.h.		1.0	0.5	0.9	1.2	2.2
Mean Tyre Pressure, lbs/sq ins		27	27	28.1	29.4	30.4
Mean Air Temperature °Cent.		16.1	17.8	18.9	20.0	20.0
Miles per gallon N S		25.6 26.5	25.9 27.6	23.7 24.0	21.2 21.9	18.3 17.9
Simple Mean M.P.G.		26.0	26.7	23.8	21.5	18.1
Inlet Manifold Pressure, N inches of Hg absolute S		9.6 9.4	10.0 10.1	11.6 11.7	13.8 13.8	18.1 18.0
Average.		9.6	10.0	11.6	13.8	18.0
Exhaust Gas Temperature N degrees Centigrade. S (above atmospheric)		340 338	443 438	580 582	625 625	687 680
Average.		339	440	581	625	683
Cooling Water Temperature N at entrance to radiator, S degrees Fahrenheit.		141 141	145 145	149 148	152 152	157 158
Average (converted to Cent.)		60.6	62.6	64.7	66.7	69.7
Temperature Difference, water to air. Degrees Cent.		44.5	45.0	45.8	46.7	49.7
Acceleration Time (seconds) N S		18.9 20.7		Average:- 19.7		

Exhaust Gas Analysis   14.9 %CO$_2$ 1.1 %O$_2$ 0.1 %CO

    -   %H$_2$ (estimated)   83.9 %N$_2$ (by diff)

Remarks:-

TABLE 13 C   M.P.G. converted to Standard Basis.

	29.0	38.2	47.0	57.2	67.2
Car Speed in m.p.h.	29.0	38.2	47.0	57.2	67.2
Reciprocal Mean M.P.G. of North & South runs.	26.0	26.7	23.8	21.5	18.1
% Correction for:- a) Wind	-	-	-	-	-
b) Weight	-	-	-	-	-
c) Barometer	0.1	0.1	0.1	0.1	0.1
d) Air Temp.	1.3	0.9	0.5	-	-
e) Tyre Press.	0.5	0.7	0.3	0.2	0.1
Total correction- %	1.9	1.7	0.9	0.3	0.2
Corrected Miles per Gallon	26.5	27.1	24.0	21.7	18.1

Table **13** D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio

Average Molecular Weight   11.9

Mixture Density relative to Air   63.5

                                         1.042

Speed in m.p.h.	29.0	38.2	47.0	57.2	67.2
Compression Temperature	410	401	374	351	326
" " Pressure	9.3	9.6	10.85	12.5	15.75
Volumetric Efficiency	.216	.228	.276	.339	.460
Ditto to std. Basis	.212	.224	.274	.338	.459
Theoretical Air/Fuel Ratio	9.6	10.45	11.4	12.85	14.7
Air/Fuel ratio (exh. anal.)	-	-	12.5	-	-
Weight of exhaust gas per gallon of fuel	86.2	93.3	101	113	128

Table **13** E   Heat Balance

Speed in m.p.h.		29.0	38.2	47.0	57.2	67.2
Heat available from fuel	CHU/gal %	74440 100	74440 100	74440 100	74440 100	74440 100
Heat to tractive effort	CHU/gal %	16750 22.5	20900 28.1	22450 30.1	24200 32.4	23700 32.4
Heat to exhaust (a) Sensible	CHU/gal %	7450 10.0	10700 14.4	15670 21.0	19000 25.6	23800 32.0
(b) Latent	CHU/gal %	3570 4.7	3820 5.1	4140 5.6	4640 6.2	5250 7.1
(c) Unburnt gases	CHU/gal %	?	?	210 0.3	-	-
Heat to Cooling water	CHU/gal %	35800 48.2	31650 42.5	25100 33.8	20500 27.6	16300 21.9
Unaccounted for	%	(14.6)	(9.5)	9.2	6.2	7.1

FUEL No. 14

Mixture by volume of:-

30 parts		ETHYL ALCOHOL
20	"	PETROL
50	"	BENZOL

Fuel Data

Composition by weight

Carbon - 79.4 %

Hydrogen- 10.6 %

Oxygen - 10.0 %

Higher Calorific Value   77,600 C.H.U. per gallon.

9,430 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .824

Latent Heat   123 C.H.U. per lb.

Kinematic Viscosity in abs. cgs. units .00748(1-.0111 T-70)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	55	102	178

Distillation

Percent Distilled	10%	50%	End point
Temperature	57	62	90

FUEL No. 14

Mixture by volume of:-

30 parts		ETHYL ALCOHOL
20	"	PETROL
50	"	BENZOL

Fuel Data

Composition by weight

Carbon - 79.4 %

Hydrogen- 10.6 %

Oxygen - 10.0 %

Higher Calorific Value

77,600 C.H.U. per gallon.

9,430 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .824

Latent Heat

123 C.H.U. per lb.

Kinematic Viscosity in abs. cgs. units $.00748(1-.0111 \overline{T-20})$

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	55	102	178

Distillation

Percent Distilled	10%	50%	End point
Temperature	57	62	90

Fuel No. 14. 30% Alcohol-20% Pe   .-50% Benzol

Table 14A

8.30. A.M. Barometer-24.761 ins Hg Dry bulb-60.1 F wet bulb-56.3 F
3.00 P.M.   "   24.666 "   "   "   "   74.0 F   "   "   60.9 F

Approx. load 340 lbs

Initial tyre pressures, lbs/sq ins-front 28, back 28.

Av. speed mph.	time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp.z F	Mileages Begin	End	Diffx10
N 28.8	5-9.7	2.4	285	149	13.3	75.5	75.4	77.87	24.7
S 29.9	5-21.3	0.5	270	157	13.9		78.32	80.9	25.8
N 28.9	5-8.7	2.0	280	149	13.4		81.11	83.59	24.8
S 29.4	5-24.5	1.0	275	152	13.7		84.0	86.65	26.5
N 28,7	5-13.8	2.2	280	154	13.2		86.82	89.32	25.0
S 28.9	5-24.6	0.7	260	155	13.8		89.7	92.31	26.1
Tyre pressures:- Front 28 Back 29									
N 38.0	3-52	3.8	440	154	12.9	78	92.57	95.02	24.5
S 38.5	4-23.4	1.6	410	158	13.1		95.46	98.28	28.2
N 37.9	3-53.5	3.5	440	155	12.4		98.59	01.05	24.6
S 38.2	4-27.8	1.5	406	158	13.2		01.56	04.4	28.4
N 37.9	3-55.5	4.0	460	157	12.5		04.71	07.19	24.8
S 38.2	4-31.4	1.5	430	160	13.4		07.67	10.55	28.8
Tyre pressures:- Front 29 Back 29									
N 48.2	2-43.5	5.6	570	157	10.3	77.5	11.08	13.25	21.7
S 47.9	3-6.1	2.5	550	163	12.2		13.93	16.43	25.0
N 47.3	2-49.8	4.9	580	160	10.7		16.78	19.01	22.3 @
S 47.5	3-8.7	2.7	570	162	11.9		19.57	22.0	24.9 @
N 47.6	2-49.5	5.8	585	162	10.9		22.45	24.69	22.4
S 48.1	3-4.0	3.5	570	163	12.0		25.32	27.78	24.6
Tyre pressures:- Front 29 @ Sample 1. Back 29									
N 57.2	2-7.7	7.8	650	165	8.0	79.5	28.24	30.27	20.3
S 56.5	2-29	4.5	620	165	9.8		31.04	33.38	23.4
N 57.1	2-9.4	7.0	640	166	8.7		33.67	35.92	20.5
S 57.0	2-25.3	4.6	640	166	9.7		36.7	39.0	23.0
N 56.3	2-11.6	7.6	650	168	9.0		39.55	41.61	20.6
S 56.3	2-24.9	4.9	625	166	9.9		42.35	44.66	23.1
Tyre pressures:- Front 30.5 Back 31.5									
N 66.5	1-32.6	10.6	720	170	5.5	77	45.44	47.15	17.1
S 67.5	1-45.6	7.2	700	170	6.2		48.1	50.08	19.8
N 66.5	1-35.4	9.2	725	168	5.5		51.05	52.81	17.6
S 66.8	1-51	6.6	690	169	7.2		53.74	55.8	20.6
N 67.6	1-32.7	11.6	725	170	5.2		56.68	58.42	17.4
S 66.5	1-47.1	7.5	710	173	6.6	82	59.45	61.43	19.8
Tyre pressures:- Front 31 Back 32									

Acceleration tests

Direction	N	S	N	S	N
Accel. time in seconds	20.2	19.8	20.5	19.7	20.5

TABLE **14** B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.05
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.418

Car Speed in m.p.h.		28.9	38.1	47.7	56.9	66.9
Wind Pressure,	N	2.2	3.8	5.4	7.5	10.3
inches of water.	S	0.7	1.5	2.9	4.7	7.1
Absolute Wind Velocity in direction of motion, m.p.h.		7.0	8.7	7.3	6.4	6.0
Mean Tyre Pressure, lbs/sq ins		28.2	28.8	29.0	30	31.2
Mean Air Temperature °Cent.		24.4	25.0	25.8	25.8	26.1
Miles per gallon	N	24.8	24.6	22.1	20.5	17.4
	S	26.1	29.5	24.8	23.2	20.1
Simple Mean M.P.G.		25.4	26.5	23.4	21.8	18.7
Inlet Manifold Pressure,	N	9.9	10.6	12.4	14.7	18.0
inches of Hg absolute	S	9.3	9.9	11.2	13.5	16.7
Average.		9.6	10.2	11.8	14.1	17.3
Exhaust Gas Temperature	N	327	477	590	648	696
degrees Centigrade.	S	313	450	577	627	682
(above atmospheric) Average.		320	463	583	638	689
Cooling Water Temperature	N	151	157	160	166	169
at entrance to radiator,	S	155	159	165	166	171
degrees Fahrenheit. Average (converted to Cent.)		67.2	69.4	72.0	74.4	76.7
Temperature Difference, water to air. Degrees Cent.		42.8	44.4	46.2	48.6	50.6
Acceleration Time (seconds)	N	20.4				
	S	19.8		Average:-	20.1	

Exhaust Gas Analysis   13.5 %CO$_2$ 2.1   %O$_2$ 1.5 %CO

0.3 %H$_2$ (estimated)   83.1 %N$_2$ (by diff)

Remarks:-

TABLE **14** C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.9	38.1	47.7	56.9	66.9
Reciprocal Mean M.P.G. of North & South runs.		25.4	27.3	23.4	21.8	18.6
% Correction for:-	a) Wind	1.4	1.9	1.1	0.7	0.5
	b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
	c) Barometer	0.1	0.1	0.1	0.1	0.1
	d) Air Temp.	-1.5	-1.9	-2.4	-2.7	-2.8
	e) Tyre Press.	-0.1	-0.1	-	-	-0.1
Total correction- %		-0.5	-0.3	-0.9	-2.1	-2.5
Corrected Miles per Gallon		25.3	27.2	23.2	21.4	18.1

Table 14 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio	12.4
Average Molecular Weight	67.5
Mixture Density relative to Air	1.044

Speed in m.p.h.	28.9	38.1	47.7	56.9	66.9
Compression Temperature	423	409	382	357	337
" " Pressure	9.4	9.8	11.0	12.8	15.1
Volumetric Efficiency	.212	.229	.275	.342	.428
Ditto to std. Basis	.213	.230	.277	.349	.439
Theoretical Air/Fuel Ratio	9.1	10.7	11.5	12.9	13.8
Air/Fuel ratio (exh. anal.)	-	-	13.0	-	-
Weight of exhaust gas per gallon of fuel	83	96.5	99	114.5	122

Table 14 E Heat Balance

Speed in m.p.h.		28.9	38.1	47.7	56.9	66.9
Heat available from fuel	CHU/gal	77600	77600	77600	77600	77600
	%	100	100	100	100	100
Heat to tractive effort	CHU/gal	16000	21000	21700	23800	23750
	%	20.6	27.1	28.0	30.7	30.6
Heat to exhaust (a) Sensible	CHU/gal	6750	11700	15400	19900	22900
	%	8.7	15.1	19.9	25.6	29.6
(b) Latent	CHU/gal	3080	3540	3630	4200	4460
	%	4.0	4.6	4.7	5.4	5.8
(c) Unburnt gases	CHU/gal	?	?	3310	-	-
	%			4.3		
Heat to Cooling water	CHU/gal	32700	31300	25600	21250	16650
	%	42.2	40.5	31.7	27.4	21.5
Unaccounted for	%	(24.5)	(12.8)	(11.4	(10.9)	(12.5)

FUEL No. 15.

Mixture by volume of:-

> 20 parts ETHYL ALCOHOL
>
> 20 " PETROL
>
> 60 " BENZOL

Fuel Data

Composition by weight

Carbon - 83.1 %

Hydrogen- 10.2 %

Oxygen - 6.7 %

Higher Calorific Value

80,760 C.H.U. per gallon.

9,710 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .832

Latent Heat

113 C.H.U. per lb.

Kinematic Viscosity in abs. cgs. units .00703(1-.0126 $\overline{t-20}$)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	59	105	185

Distillation

Percent distilled	10%	50%	End point
Temperature	55	59	67

Fuel No.15   20% Alcohol-20% Petrol-60% Benzol 7th September P.M.

Table 15A

8.30 A.M. Barometer-24.931 ins Hg Dry bulb-55.9 F Wet bulb-44.5 F
3.00 P.M.   "   24.885 " "   "   "   70.4 F "   "   51.3 F

Approx load 490 lbs.

Initial tyre pressure,lbs/sq ins- front 28,back 29.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 28.7	5-39.5	1.2	320	148	13.5	79	12.35	15.05	27.0
S 28.8	5-46.9	1.4	300	145	13.0		15.62	18.4	27.8
N 28.7	5-52.5	0.7	280	140	14		18.81	21.62	28.1
S 28.7	5-48.4	2.1	310	146	13.0		21.88	24.66	27.8
N 28.7	5-51.4	0.6	270	148	14		24.9	27.7	28.0
S 28.8	5-50.1	1.3	300	145	13.0		30.73	27.93	28.0

Tyre pressures:- Front 30   Back 31

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N -	-	1.9	350	154	12.5	79	31.0	33.65	26.5
S 37.9	4-11.8	2.9	350	154	13.5		34.0	36.65	26.5
N 37.7	4-10.3	1.8	350	153	13.0		36.88	39.5	26.2
S 37.2	4-12.8	3.5	360	151	12.5		39.84	42.45	26.1
N 37.8	4-9.5	2.5	350	159	13.0		42.8	45.42	26.2
S 37.7	4-16	3.2	350	155	13.0		45.7	46.38	26.8

Tyre pressures:- Front 31   Back 31.5

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 47.8	2-43.4	3.2	520	163	11.0	79	48.72	50.89	(21.7)
S 47.1	3-4.6	3.8	500	157	11.2		51.69	54.1	24.1
N 46.8	3-1.2	4.0	560	159	11.0		54.48	56.83	23.5
S 46.7	3-10.2	3.7	570	156	11.0		57.36	59.83	24.7
N 46.7	3-4.8	3.6	550	161	11.0		60.3	62.7	24.0
S 47.2	3-11.5	3.6	530	158	11.5		63.15	65.60	25.1

Tyre pressures:- Front 32   Back 32.5

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N -	-	5.2	640	168	7.0	84	66.06	67.75	16.9
S 55.0	2-5.9	5.5	610	160	8.0		69.1	71.03	19.3
N 57.4	2-21.9	4.0	630	166	10.5		71.81	74.07	22.6
S 56.5	2-14.7	7.2	660	164	6.0		74.85	76.78	21.3
N 57.0	2-21.3	4.0	630	162	9.5		77.43	79.65	22.2
S 57.1	2-15.5	7.0	640	165	9.0		80.25	82.4	21.5

Tyre pressures:- Front 31   Back 32

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 67.0	1-39.5	8.4	690	169	6.0	79	83.3	85.15	18.5
S 67.0	1-43.8	8.3	700	167	5.0		86.12	88.05	19.3
N 66.7	1-40.4	7.0	690	170	7.0		88.85	90.71	18.6
S 67.1	1-39.9	7.7	710	169	5.0		91.7	93.56	18.6
N 66.5	1-40.1	8.0	700	169	5.0		94.6	96.45	18.5
S 67.0	1-36.8	9.5	700	171	5.5		97.28	99.08	18.0

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.9	22.3	20.9	22.9

TABLE **15** B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.26
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.847

Car Speed in m.p.h.		28.7	37.7	47.1	57.0	66.9
Wind Pressure,	N	0.8	2.1	3.9	4.4	7.9
inches of water.	S	1.6	3.2	3.7	6.5	8.5
Absolute Wind Velocity in direction of motion, m.p.h.		4.1	4.0	0.6	5.1	1.3
Mean Tyre Pressure, lbs/sq ins		29.5	30.7	31.7	31.9	32.5
Mean Air Temperature °Cent.		26.1	26.1	27.2	26.1	25.6
Miles per gallon	N	28.0	26.3	23.7	22.4	18.6
	S	27.9	26.4	24.9	21.4	18.6
Simple Mean M.P.G.		27.9	26.4	24.3	21.9	18.6
Inlet Manifold Pressure,	N	9.6	10.6	12.5	13.3	17.6
inches of Hg absolute	S	10.4	10.1	12.3	15.0	18.4
Average.		10.0	10.3	12.4	14.2	18.0
Exhaust Gas Temperature	N	330	395	560	630	675
degrees Centigrade.	S	350	398	552	643	685
(above atmospheric) Average.		340	396	556	636	680
Cooling Water Temperature	N	149	152	160	165	169
at entrance to radiator,	S	145	153	157	164	169
degrees Fahrenheit. Average (converted to Cent.)		63.9	67.0	70.3	73.6	76.1
Temperature Difference, water to air. Degrees Cent.		37.8	40.9	43.1	47.5	50.5
Acceleration Time (seconds)	N	21.4				
	S	22.6			Average:-	22.0

Exhaust Gas Analysis   15.4   %CO₂   0.2   %O₂   0.5   %CO
0.1   %H₂ (estimated)   83.8   %N₂ (by diff)

Remarks:-

TABLE **15** C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.7	37.7	47.1	57.0	66.9
Reciprocal Mean M.P.G. of North & South runs.		27.9	26.4	24.3	21.9	18.6
% Correction for:-	a) Wind	0.3	0.4	-	0.5	-
	b) Weight	1.3	1.3	1.1	0.9	0.7
	c) Barometer	0.3	0.5	0.5	0.7	0.8
	d) Air Temp.	-2.1	-2.3	-3.0	-2.6	-2.6
	e) Tyre Press.	-0.3	-1.0	-1.0	-0.6	-0.4
Total correction- %		-0.5	-1.2	-2.3	-1.1	-1.5
Corrected Miles per Gallon		27.7	26.1	23.8	21.7	18.3

Table 15 D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   12.8

Average Molecular Weight   71.5

Mixture Density relative to Air

                                                  1.046

Speed in m.p.h.	28.7	37.7	47.1	57.0	66.9
Compression Temperature	420	414	381	361	338
" " Pressure	9.75	9.9	11.6	12.85	15.8
Volumetric Efficiency	1.222	.229	.291	.340	.447
Ditto to std. Basis	.223	.232	.298	.343	.454
Theoretical Air/Fuel Ratio	10.4	10.25	12.1	12.7	14.3
Air/Fuel ratio (exh. anal.)	-	-	12.7	-	-
Weight of exhaust gas p. gallon of fuel	95	93.5	109	114.3	127.5

Table 15 E   Heat Balance prahs

Speed in m.p.h.		28.7	37.7	47.1	57.0	66.9
Heat available from fuel	CHU/gal %	80760 100	80760 100	80760 100	80760 100	80760 100
Heat to tractive effort	CHU/gal %	17500 21.7	20150 25.0	22250 27.6	24100 29.9	24000 29.8
Heat to exhaust (a) Sensible	CHU/gal %	8250 10.2	9550 11.8	16100 20.0	19650 24.4	23600 29.2
(b) Latent	CHU/gal %	3500 4.3	3440 4.3	4010 5.0	4210 5.2	4700 5.8
(c) Unburnt gases	CHU/gal %	?	?	1360 1.7	-	-
Heat to Cooling water	CHU/gal %	31000 38.4	27200 33.8	23200 28.7	20900 25.9	16800 20.8
Unaccounted for	%	(25.4)	(25.1)	17.0	14.6	14.4

FUEL No. 16.

Mixture by volume of :-

        10 parts ETHYL ALCOHOL

        20   "   PETROL

        70   "   BENZOL

Fuel Data

Composition by weight   Carbon - 87.0 %

                              Hydrogen- 9.7 %

                              Oxygen - 3.3 %

Higher Calorific Value   83,920 C.H.U. per gallon

                              10,000 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .839

Latent Heat   102 C.H.U. per lb.

Kinematic Viscosity in abs, cgs. units .00663(1-.0115 (T-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	56	100	170

Distillation

Percent distilled	10%	50%	End point
Temperature	60	75	101

Fuel No.16   10% Alcohol-20% Petrol-70% Benzol

Table 16A.

8.30 A.M.   Barometer-24.936 ins Hg Dry bulb-57.1 F Wet bulb-43.2 F
3.00 P.M.   "   24.868 " "   "   "   74.0 F "   "   51.5 F

Approx. load   460 lbs

Initial tyre pressure, lbs/sq ins- front 28, back 29.

Av. speed mph.	Time of run min.sec.	Wind press. insH2O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N							Choke	out	
S 29.1	5-47	1.6	320	138	13.0	60	92.84	95.63	28.1
N 28.9	5-39.5	1.4	320	139	13.2		95.82	98.54	27.2
S 28.8	5-52.6	1.3	325	137	13.1		98.83	01.65	28.2
N 28.7	5-40	1.5	300	139	13.5		01.88	04.59	27.1
S 28.8	5-54	1.6	330	137	13.0		04.85	07.68	28.3
Tyre pressures:- Front 28 back 30									
N 38.0	4-10.3	1.9	390	143	12.9	63	07.85	10.49	26.4
S 37.8	4-17.2	2.1	395	141	12.5		10.85	13.55	27.0
N 37.9	4-8	2.1	390	143	13.2		13.79	16.40	26.1
S 37.7	4-18	2.4	385	142	12.6		16.8	19.5	27.0
N 37.7	4-10.5	2.1	390	143	12.6		19.78	22.4	26.2
S 37.9	4-20.6	2.3	380	141	12.6		22.72	25.47	27.5
Tyre pressures:- Front 29 Back 31									
N 47.6	3-4.5	3.3	530	146	11.0	65	25.79	28.2	24.1
S 48.9	3-13	4.0	550	144	10.8		28.7	31.2	25.0
N 47.2	3-5.2	3.2	490	147	11.4		31.65	34.08	24.3
S 47.2	3-11.6	3.9	530	145	10.5		34.59	37.1	25.1
N 46.8	3-3.2	3.3	555	147	11.2		37.52	39.9	23.8
S 47.5	3-12.5	4.2	540	146	10.7		40.51	43.05	25.4
Tyre pressures:- Front 29 Back 31.5 Sample 1.									
N -	-	5.7	680	151	9.8	66	45.48	45.65	21.7
S 56.5	2-18.5	6.5	670	150	9.0		46.45	48.63	21.7
N 56.9	2-18	5.5	670	151	9.6		49.3	51.48	21.8
S 57.3	2-21.5	6.9	670	150	9.3		52.2	54.45	22.5
N 56.7	2-18.4	5.7	670	151	10.0		55.15	57.33	21.8
S 56.5	2-20.4	6.5	670	150	8.8		58.1	60.3	22.0
Tyre pressures:- Front 30 Back 32									
N 66.9	1-39.1	8.5	740	158	5.0	67	61.25	63.09	18.4
S 66.3	1-42.4	8.6	760	157	4.0		64.13	66.03	19.0
N 66.8	1-42.5	7.8	770	158	5.0		67.05	68.95	19.0
S 66.5	1-44	7.8	750	158	4.5		69.93	71.85	19.2
N 67.9	1-42.2	8.6	750	160	5.0		72.85	74.78	19.3
S -	-	8.6	730	159	5.0	68	75.86	77.8	19.2
Tyre pressures:- Front 31 Back 33									

Acceleration tests

Direction	N	S	N	S	N	S
Accel. time in seconds	22.2	21.2	21.8	22.1	22.1	21.9

TABLE 18 B.   Summarised Results of Table A.

Mean Barometric Pressure corrected for altitude. Ins of Hg   25.24

Vapour Pressure of moisture in atmosphere (Average). Ins of Hg   0.225

Car Speed in m.p.h.		28.9	37.8	47.1	56.8	67.0
Wind Pressure, inches of water.	N	1.4	2.0	3.3	5.6	7.3
	S	1.5	2.3	4.0	6.2	8.3
Absolute Wind Velocity in direction of motion, m.p.h.		0.6	1.1	2.0	1.3	0
Mean Tyre Pressure, lbs/sq ins		28.7	29.5	29.6	30.6	31.5
Mean Air Temperature °Cent.		16.7	17.8	18.3	18.9	19.4
Miles per gallon	N	27.1	26.2	24.1	21.8	18.9
	S	28.2	27.2	25.2	22.1	19.1
Simple Mean M.P.G.		27.6	26.7	24.6	21.9	19.0
Inlet Manifold Pressure, inches of Hg absolute	N	10.3	10.4	12.2	13.6	18.6
	S	9.8	10.7	12.7	14.4	19.1
Average.		10.0	10.5	12.4	14.0	18.8
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	355	430	548	562	717
	S	367	427	558	560	710
Average.		361	428	553	561	713
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	139	143	147	151	158
	S	137	141	145	150	158
Average (converted to Cent.)		58.9	61.1	63.3	65.8	70
Temperature Difference, water to air. Degrees Cent.		42.2	43.3	45.0	46.9	50.6
Acceleration Time (seconds)	N	22.0				
	S	22.0		Average:-	22.0	

Exhaust Gas Analysis   13.9 %CO_2 1.8   %O_2 1.1 %CO

0.2 %H_2 (estimated)   83.0   %N_2 (by diff)

Remarks:- It is possible that some air was left in the exh. gas sampling tube.

TABLE 18 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.9	37.8	47.1	56.8	67.0
Reciprocal Mean M.P.G. of North & South runs.		27.6	26.7	24.6	21.9	19.0
% Correction for:-	a) Wind	-	-	-	-	-
	b) Weight	1.2	0.9	0.8	0.6	0.5
	c) Barometer	0.3	0.4	0.5	0.6	0.7
	d) Air Temp.	1.1	0.9	0.7	0.5	0.2
	e) Tyre Press.	-0.4	-0.4	-0.2	-0.2	-0.1
Total correction- %		2.2	1.8	1.8	1.5	1.3
Corrected Miles per Gallon		28.2	27.2	25.0	22.2	19.3

Table 16 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio 13.2

Average Molecular Weight 76

Mixture Density relative to Air 1.048

Speed in m.p.h.	28.7	37.7	47.1	57.0	66.9
Compression Temperature	415	405	375	360	333
" " Pressure	9.75	10.1	11.6	12.7	16.5
Volumetric Efficiency	.225	.238	.296	.338	.475
Ditto to std. Basis	.221	.234	.291	.333	.469
Theoretical Air/Fuel Ratio	10.4	10.7	12.3	12.5	15.55
Air/Fuel ratio (exh. anal.)	-	-	13.9(?)	-	-
Weight of exhaust gas per gallon of fuel	95.7	98	111.5	113.5	139

Table 16 E Heat Balance probably y = 13.0 is correct.

Speed in m.p.h.		28.7	37.7	47.1	57.0	66.9
Heat available from fuel	CHU/gal %	83920 100	83920 100	83920 100	83920 100	83920 100
Heat to tractive effort	CHU/gal %	17850 21.3	21000 25.0	23350 27.8	24700 29.4	25300 30.2
Heat to exhaust (a) Sensible	CHU/gal %	8850 10.5	10900 13.0	16400 19.5	20300 24.0	27200 32.4
(b) Latent	CHU/gal %	3240 3.9	3320 4.0	3770 4.5	3840 4.6	4700 5.6
(c) Unburnt gases	CHU/gal %	?	?	3040 3.6	?	-
Heat to Cooling water	CHU/gal %	35900 42.8	30400 36.2	25600 30.5	21100 25.1	17800 21.2
Unaccounted for	%	(21.5)	(21.8)	13.1	(16.9)	10.6

FUEL No. 17.

Mixture by volume of:-

        60 parts ETHYL ALCOHOL

        30 "   PETROL

        10 "   BENZOL

Fuel Data

Composition by weight   Carbon - 65.7 %

                           Hydrogen- 13.0 %

                           Oxygen - 21.3 %

Higher Calorific Value   67,560 C.H.U. per gallon

                           8,610 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .785

Latent Heat   156 C.H.U. per lb.

Kinematic Viscosity in abs. cgs. units .0105(1-.0147 T-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	48	90	130

Distillation

Percent distilled	10%	50%	End point
Temperature	61	70	74

Fuel No.17   60% Alcohol-30% Petrol- 10% Benzol

Table 17A.

8.30 A.M. Barometer-24.835 ins Hg Dry bulb-60.0 F wet bulb-56.1 F
3.00 P.M.   "   24.720 "   "   "   "   75.7 F "   "   59.8 ?

Approx. load   380 lbs

Initial tyre pressure, lbs/sq ins:- Front 27, Back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo.	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileage:- Begin	End	Diffxl0
N 28.7	4-59.7	2.5	320	140	12.3	66	25.21	27.68	24.7
S 29.2	5-40.1	0.4	290	144	13.7		38.14	40.9	27.6
N 30.37	4-59.6	2.2	325	141	12.2		41.12	43.84	25.27
S 29.0	5-55	0.3	290	146	14.0		44.14	47.0	28.6
N 29.1	5-1.3	3.0	310	142	12.1		47.24	49.68	24.4
S 28.9	5-59	0.4	280	149	14.1		50.17	53.05	28.8

Tyre pressures:- Front 27.5
Back 28

N 38.1	3-21.8	5.0	470	143	11.0	68	53.27	55.4	21.3
S 37.7	4-19.2	0.9	460	147	12.8		56.29	59.0	27.1
N 37.8	3-29.4	3.7	450	142	11.4		59.24	61.44	22.0
S 37.2	4-18.7	1.4	470	148	13.0		62.16	64.9	27.4
N 37.8	3-32.5	4.8	460	142	11.3		65.15	67.38	22.3
S 37.1	4-19.5	1.0	465	149	13.1		68.1	70.84	27.4

Tyre pressures:-   Front 28.5
Back 28.5

N 47.4	2-22.4	8.7	560	145	9.0	69	71.11	72.98	18.7
S 47.3	2-2.1	1.8	545	148	11.0		74.06	76.45	23.9 @
N 47.4	2-28.6	5.4	570	147	9.2		76.9	78.85	19.5 @
S 46.9	2-7.5	2.3	550	149	11.5		79.52	81.96	24.4
N 47.1	2-29.1	5.0	570	146	9.0		82.21	84.16	19.5
S 47.2	3-7.1	1.7	550	152	11.6		84 89	87.34	24.5

Tyre pressures:-   Front 29   @ Sample 1.
Back 29.5

N 56.2	1-46.4	8.5	630	151	6.8	71	87.75	89.81	18.6
S 58.0	2-13	3.0	600	153	8.5		90.4	92.54	21.4
N 57.0	1-4817	7.2	635	152	7.0		93.16	94.88	17.2
S 56.8	2-17.7	4.0	580	153	9.8		95.62	97.79	21.7
N 57.1	1-46	9.0	620	151	6.5		98.22	99.9	16.8
S 57.7	2-13.6	3.0	590	156	9.1		00.8	02.94	21.4

Tyre pressures:-   Front 30
Back 30.5

N 67.5	1-14.7	12.4	705	157	2.3	73	03.86	05.26	14.0
S 67.1	1-32.9	5.7	680	161	4.9		06.25	08.98	17.3
N 66.6	1-17.5	11.0	700	160	2.4		09.08	10.51	14.3
S 67.6	1-34.3	6.3	670	161	5.2		11.4	13.17	17.7
N 67.0	1-14.7	11.6	710	161	1.8		14.1	15.49	13.9
S 67.9	1-26	5.1	670	162	5.3		16.5	18.12	16.2

Tyre pressures:-   Front 30
Back 31

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.6	20.2	21.6	20.2

<u>TABLE **17** B.</u>   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   **25.11**
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.390

Car Speed in m.p.h.		29.2	37.6	47.2	57.1	67.3
Wind Pressure, inches of water.	N	2.6	4.5	5.7	8.1	11.7
	S	0.4	1.1	1.9	3.3	5.7
Absolute Wind Velocity in direction of motion, m.p.h.		10.8	12.7	12.6	12.6	12.0
Mean Tyre Pressure, lbs/sq ins		27.6	28.1	28.9	29.7	30.4
Mean Air Temperature °Cent.		18.4	20.0	21.1	22.2	22.8
Miles per gallon	N	24.6	21.9	19.2	16.9	14.1
	S	28.3	27.3	24.3	21.5	17.1
Simple Mean M.P.G.		26.4	24.6	21.7	19.2	15.6
Inlet Manifold Pressure, inches of Hg absolute	N	11.1	12.1	14.2	16.6	21.3
	S	9.3	10.2	11.9	14.2	18.4
Average.		10.2	11.2	13.0	15.4	19.8
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	360	420	580	627	684
	S	332	493	562	602	662
Average.		346	491	571	614	673
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	141	142	146	151	159
	S	146	148	150	154	161
Average (converted to Cent.)		62.0	62.8	64.4	67.0	71.1
Temperature Difference, water to air. Degrees Cent.		42.6	42.8	43.3	44.6	48.3
Acceleration Time (seconds)	N	21.6				
	S	30.2		Average:-		20.9

Exhaust Gas Analysis   12.5% CO_2 3.1 %O_2 0.2 %CO
- %H_2 (estimated)   84.2 %N_2 (by diff)

Remarks:-

<u>TABLE **17** C</u>   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.2	37.6	47.2	57.1	67.3
Reciprocal Mean M.P.G. of North & South runs.		26.3	24.3	21.4	18.9	15.5
% Correction for:-	a) Wind	3.5	4.0	3.2	2.7	1.9
	b) Weight	-	-	-	-	-
	c) Barometer	0.1	0.2	0.2	0.2	0.3
	d) Air Temp.	0.2	-	-0.4	-0.7	-1.3
	e) Tyre Press.	0.2	0.2	-	0.1	0.1
Total correction- %		4.0	4.4	3.0	2.1	1.0
Corrected Miles per Gallon		27.3	25.4	22.1	19.1	15.7

Table __17__ D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   11.1
Average Molecular Weight   57.5
Mixture Density relative to Air   1.038

Speed in m.p.h.	29.2	37.6	47.2	57.1	67.3
Compression Temperature	383	368	346	328	310
" " Pressure	9.95	10.65	12.15	13.95	17.3
Volumetric Efficiency	.247	.275	.354	.4.4	.530
Ditto to std. Basis	.238	.263	.324	.405	.525
Theoretical Air/Fuel Ratio	11.75	12.1	13.0	14.2	15.2
Air/Fuel ratio (exh. anal.)	-	-	12.8	-	-
Weight of exhaust gas per gallon of fuel	100	103	110	119	127

Table __17__ E   Heat Balance

Speed in m.p.h.		29.2	37.9	47.4	57.4	67.5
Heat available from fuel	CHU/gal %	67560 100	67560 100	67560 100	67560 100	67560 100
Heat to tractive effort	CHU/gal %	17300 25.6	19600 29.0	20650 30.6	21250 31.4	20600 30.5
Heat to exhaust (a) Sensible	CHU/gal %	8840 13.1	13300 19.7	16750 24.8	19650 29.1	23200 34.4
(b) Latent	CHU/gal %	4610 6.8	4750 7.0	5060 7.5	5500 8.1	5860 8.7
(c) Unburnt gases	CHU/gal %	?	?	400 0.6	-	-
Heat to Cooling water	CHU/gal %	35100 51.9	26000 41.4	21600 32.0	17100 25.3	13600 20.1
Unaccounted for	%	(2.6)	(2.9)	4.5	6.1	6.3

FUEL No. 18.

Mixture by volume of:-

50 parts ETHYL ALCOHOL

30 "   PETROL

20 "   BENZOL

Fuel Data

Composition by weight   Carbon - 70.1 %

                               Hydrogen- 12.4 %

                               Oxygen - 17.5 %

Higher Calorific Value   70,720 C.H.U. per gallon

                               8,920 C.H.U. per lb.

Specific Gravity at 20 degrees centigrade - .793

Latent Heat   144 C.H.U. Per lb

Kinematic Viscosity in abs. ags. units .00913(1-.0120 T-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	48	90	150

Distillation

Percent distilled	10%	50%	End point
Temperature	60	68	95

Table 18A.

8.30 A.M.   Barometer-24.745 ins Hg   Dry bulb-56.8 F   Wet bulb-52.6 F
3.00 P.M.   "   24.670 " "   "   "   77.2 F   "   "   57.0 F

Approx. load   340 lbs

Initial tyre pressures, lbs/sq ins-front 28, back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages: Begin	End	Diff&Ib
N 29.0	5-24.4	1.3	310	149	13.9	74.5	17.14	19.76	26.2
S 28.9	5-40	1.1	320	146	13.8		20.15	22.88	27.3
N 28.8	5-28.5	1.0	310	147	14.0		23.08	25.71	26.3
S 28.6	5-36	1.3	320	146	13.9		26.03	28.7	26.7
N 28.8	5-32.3	1.2	310	148	13.8		29.97	31.51	26.6
S 28.8	5-35.8	1.6	300	147	14.0		31.75	34.44	26.9

Tyre pressures:-   Front 27.5
                   Back 29.5

N 37.8	4-5.5	1.8	395	152	13.6	76	34.6	37.18	25.8
S 38.1	4-10.2	2.5	415	148	12.5		37.49	40.14	26.5
N 37.8	4-7.9	1.9	415	153	13.4		40.3	42.9	26.0
S 37.8	4-16.4	2.5	410	151	12.2		43.15	45.84	26.9
N 37.8	4-6.1	1.8	400	152	12.9		46.01	48.6	25.9
S 37.9	4-18.3	2.3	370	151	13.0		48.98	51.7	27.2

Tyre pressures:-   Front 28.
                   Back 29.5

N 47.6	2-46.6	3.3	540	154	11.5	78	51.95	54.15	22.0
S 47.9	2-52.4	3.7	555	253	10.5		54.85	57.14	22.9 @
N 47.6	2-53.2	3.2	550	154	11.3		57.66	59.95	22.9 @
S 47.2	2-55.4	4.0	555	154	10.3		60.55	62.85	23.0
N 47.0	2-53.9	3.1	550	157	11.8		63.34	65.61	22.7
S 46.9	2-48.9	3.4	540	156	11.3		66.25	68.45	22.0

Tyre pressures:-   Front 28.5   @ Sample 2.
                   Back 29.5

N 57.0	2-9	5.3	610	159	9.5	78	69.34	71.38	20.4
S 57.3	2-6.4	6.3	610	160	8.0		71.95	73.96	20.1
N 57.4	2-5.4	6.0	600	159	8.9		74.78	76.78	20.0
S 57.5	2-10.6	4.9	595	159	8.5		77.61	79.7	20.9
N 57.8	2-9.1	5.3	610	161	8.8		80.4	82.47	20.7
S 57.6	2-7.6	6.5	610	160	8.7		83.26	85.3	20.4

Tyre pressures:-   Front 29.5
                   Back 32

N 68.0	1-30.6	8.0	690	187	4.3	81	86.27	87.98	17.1
S 67.3	1-27.2	9.1	700	164	4.0		89.09	90.72	16.3
N 67.6	1-31.6	7.2	680	166	5.0		91.95	93.67	17.2
S 66.8	1-29.3	9.7	700	166	4.9		94.84	96.5	16.6
N 67.8	1-34.5	7.0	680	167	5.4	83	97.5	99.28	17.8
S -	-	8.4	690	167	4.2		00.3	01.99	16.9

Tyre pressures:-   Front 30.5
                   Back 32.5

Acceleration tests

Direction	N	S	N	S	N	S
Accel. time in seconds	19.2	20.1	18.8	21.0	19.1	20.5

TABLE 18 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg 28.05
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg 0.319

Car Speed in m.p.h.		28.8	37.9	47.4	57.4	67.5
Wind Pressure, inches of water.	N	1.2	1.8	3.2	5.5	7.4
	S	1.5	2.4	3.7	5.9	9.1
Absolute Wind Velocity in direction of motion, m.p.h.		0.6	2.3	1.7	1.0	3.2
Mean Tyre Pressure, lbs/sq ins		28.8	28.6	28.8	29.9	31.1
Mean Air Temperature °Cent.		23.9	25.0	25.6	26.1	27.6
Miles per gallon	N	26.4	25.9	22.5	20.4	17.4
	S	27.0	26.9	22.6	20.5	16.6
Simple Mean M.P.G.		26.7	26.4	22.5	20.4	17.0
Inlet Manifold Pressure, inches of Hg absolute	N	9.2	9.8	11.5	14.1	18.5
	S	9.2	10.5	12.6	14.8	19.0
Average.		9.2	10.1	12.0	14.4	18.7
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	353	437	563	610	668
	S	357	442	566	607	678
Average.		355	439	564	608	673
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	148	172	155	160	167
	S	146	150	154	160	166
Average (converted to Cent.)		63.9	66.1	68.0	71.1	74.7
Temperature Difference, water to air. Degrees Cent.		40.0	41.1	42.8	45.0	46.9
Acceleration Time (seconds)	N	19.0				
	S	20.5		Average:-	19.7	

Exhaust Gas Analysis 13.6 %CO₂   2.0   %O₂ 0.2 %CO

-   %H₂ (estimated)   84.2 %N₂ (by diff)

Remarks:-

TABLE 18 C   M.P.G. converted to Standard Basis.

		28.8	37.9	47.4	57.4	67.5
Car Speed in m.p.h.		28.8	37.9	47.4	57.4	67.5
Reciprocal Mean M.P.G. of North & South runs.		26.7	26.4	22.5	20.4	17.0
% Correction for:-	a) Wind	-	-	-	-	-
	b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
	c) Barometer	0.1	0.1	0.1	0.1	0.1
	d) Air Temp.	-1.3	-1.9	-2.3	-2.6	-3.6
	e) Tyre Press.	-0.1	-	0.1	-	-
Total correction- %		-1.7	-2.1	-2.4	-2.7	-3.7
Corrected Miles per Gallon		26.3	25.9	22.0	19.9	16.4

Table 16 D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio			11.6		
Average Molecular Weight			60.5		
Mixture Density relative to Air			1.04		

Speed in m.p.h.	28.8	37.9	47.4	57.4	67.5
Compression Temperature	420	398	357	344	323
" " Pressure	9.0	9.7	11.2	13.05	16.35
Volumetric Efficiency	.203	.232	.290	.360	.481
Ditto to std. Basis	.205	.237	.297	.370.	.497
Theoretical Air/Fuel Ratio	9.5	10.9	11.8	13.25	14.75
Air/Fuel ratio (exh. anal.)	-	-	12.7	-	-
Weight of exhaust gas per gallon of fuel	83	94.5	101.5	113	125

Table 16 E   Heat Balance

Speed in m.p.h.		28.8	37.9	47.4	57.4	67.5
Heat available from fuel	CHU/gal %	70720 100	70720 100	70720 100	70720 100	70720 100
Heat to tractive effort	CHU/gal %	16650 23.6	20000 28.3	20580 29.1	22100 31.3	21500 30.4
Heat to exhaust (a) Sensible	CHU/gal %	7550 10.7	10500 16.1	15250 21.6	18450 26.1	22900 32.4
(b) Latent	CHU/gal %	3700 5.2	4200 5.9	4520 6.4	5030 7.1	5560 7.9
(c) Unburnt gases	CHU/gal %	-	-	400 0.6	-	-
Heat to Cooling water	CHU/gal %	31400 44.4	27200 38.4	21200 30.0	17950 25.4	13700 19.4
Unaccounted for	%	(16.1)	(16.3)	12.3	10.1	9.9

FUEL No.19

Mixture by volume of:-

40 parts ETHYL ALCOHOL

30 " PETROL

30 " BENZOL

Fuel Data

Composition by weight	Carbon - 74.2 %	
	Hydrogen- 11.9 %	
	Oxygen - 13.9 %	

Higher Calorific Value   73,880 C.H.U. per gallon

9,220 C.H.U. per lb.

Specific Gravity at 20 degrees centigrade .801

Latent Heat   132 C.H.U. per lb.

Kinematic Viscosity in abs. cgs. units   .00829(1-.0123 $\overline{t\ 20}$)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	56	98	156

Distillation

Percent distilled	10%	50%	End point
Temperature	59	66	111

Fuel No.19   40% Alcohol-30% Petrol-30% Benzol   27th September A.M.

Table 19A.

8.30. A.M.   Berometer-24.852 ins Hg Dry bulb-58.2 F Wet bulb-53.3 F
3.00 P.M.   "   24.787 " "   "   " 74.5 F "   " 60.3 F

Approx. load 380 lbs

Initial tyre pressures; lbs/sq ins- front 26, back 27.

	Av. speed mph.	time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10	
N	29.4	5-5.5	2.4	300	141	13.9	61	44.2	46.69	24.9	
S	28.8	5-20.9	1.1	270	144	14.0		47.21	49.78	25.7	
N	29.0	5-6.1	2.3	300	142	13.7		50.1	52.57	24.7	
S	29.1	5-22.5	0.8	270	144	14.1		52.96	55.57	26.1	
N	29.3	5-3.7	2.5	295	143	13.7		55.81	52.28	24.7	
S	28.9	5-24.8	0.7	280	146	14.0		58.69	61.3	26.1	

Tyre pressures:- Front 26
                  Back 27

N	38.0	3-47.5	3.7	420?	145	12.3	66	61.63	64.03	24.0	
S	38.3	4-18.3	2.0	465	151	13.2		64.48	87.23	27.5	
N	38.2	3-47.8	3.5	470	147	12.3		67.54	69.95	24.1	
S	38.3	4-23.2	1.9	470	152	13.2		70.45	73.35	28.0	
N	38.3	3-47.5	3.7	485	151	12.2		73.58	76.0	24.2	
S	38.3	4-24.5	1.6	450	152	13.4		76.49	79.3	28.1	

Tyre pressures:- Front 27
                  Back 28

N	–	–	6.5	590	152	10.0	70	79.74	81.88	21.4	
S	47.6	3-10.7	3.1	560	156	11.9		82.63	85.15	25.2	@
N	47.4	2-44.7	5.8	590	154	10.5		85.38	87.55	21.7	@
S	47.0	3-15	2.8	560	155	12.2		88.22	90.77	25.5	
N	47.2	2-45.6	5.6	590	155	10.8		91.05	93.22	21.7	
S	48.1	3-11.1	3.2	580	156	11.8		93.92	96.47	25.5	

Tyre pressures:- Front 28   @ Sample 4.
                  Back 29

N	56.1	1-57.3	8.0	660	158	7.5	72	98.84	98.67	18.3	
S	57.6	2-16.7	5.1	630	160	9.2		99.66	01.85	21.9	
N	57.2	1-57.6	8.8	640	158	8.0		02.48	04.35	18.7	
S	57.6	2-22.4	4.2	620	160	9.8		05.3	07.57	22.7	
N	57.1	2-1.0	8.2	630	160	7.9		08.15	10.07	19.2	
S	57.3	2-20.1	3.9	610	160	9.6		10.97	13.2	22.3	

Tyre pressure.:- Front 28
                  Back 29

N	66.5	1-21.1	1.3	750	162	3.0	74	14.4	15.9	15.0	
S	68.2	1-35.1	6.0	690	163	6.2		17.12	18.92	18.0	
N	66.8	1-21.4	11.6	740	161	3.7		20.06	21.57	15.1	
S	67.6	1-35.3	4.8	690	164	5.8		22.76	24.55	17.9	
N	67.0	1-26.1	12.0	740	161	4.1		25.7	27.3	16.0	
S	–	–	5.2	680	164	6.2	75	28.44	30.4	19.6	

Tyre pressures:- Front 29
                  Back 30

Acceleration tests

Direction	N	S	N	S	N	S
Accel. time in seconds	20.6	18.9	21.6	18.4	21.2	18.8

TABLE 19 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.16
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.377

Car Speed in m.p.h.		29.1	38.2	47.5	57.2	57.2
Wind Pressure, inches of water.	N	2.4	3.6	6.0	8.3	11.6
	S	0.9	1.8	3.0	4.3	5.3
Absolute Wind Velocity in direction of motion, m.p.h.		7.0	6.5	8.2	9.4	13.0
Mean Tyre Pressure, lbs/sq ins		26.5	27	28	28.5	29
Mean Air Temperature °Cent.		17.8	20.0	21.7	22.8	23.3
Miles per gallon	N	24.8	24.1	21.6	18.7	15.4
	S	26.0	27.9	25.4	22.3	18.5
Simple Mean M.P.G.		25.4	26.0	23.5	20.5	16.9
Inlet Manifold Pressure, inches of Hg absolute	N	9.6	10.9	13.0	15.7	21.0
	S	9.3	10.0	11.4	13.9	17.4
Average.		9.4	10.4	12.2	14.8	19.2
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	340	498	598	638	710
	S	318	490	580	622	670
Average.		329	494	589	630	690
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	142	148	154	159	161
	S	145	152	156	160	164
Average (converted to Cent.)		62.0	65.6	68.3	70.8	72.5
Temperature Difference, water to air. Degrees Cent.		44.2	45.6	46.6	48.0	49.2
Acceleration Time (seconds)	N	21.2				
	S	18.7		Average:-	19.9	

Exhaust Gas Analysis   14.6 %CO_2 0.7 %O_2 0.4 %CO
                  0.1 %H_2 (estimated)   84.2 %N_2 (by diff)

Remarks:-

TABLE 19 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	29.1	38.2	47.5	57.2	67.2
Reciprocal Mean M.P.G. of North & South runs.	25.4	25.9	23.4	20.4	16.8
% Correction for:- a) Wind	1.4	1.0	1.4	1.5	1.5
b) Weight	-	-	-	-	-
c) Barometer	0.2	0.3	0.4	0.4	0.5
d) Air Temp.	0.8	-	-0.6	-1.2	-1.5
e) Tyre Press.	0.8	0.7	0.4	0.4	0.4
Total correction- %	3.2	2.0	1.6	1.1	0.9
Corrected Miles per Gallon	26.2	26.4	23.8	20.6	17.0

Table 19 D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   12.05

Average Molecular Weight   64.5

Mixture Density relative to Air   1.042

Speed i. p.h.	29.1	38.2	47.5	57.2	67.2
Compression Temperature	414	393	367	344	322
" " Pressure	9.2	10.0	11.4	13.4	16.8
Volumetric Efficiency	.211	.242	.296	.371	.497
Ditto to std. Basis	.205	.237	.291	.367	.493
Theoretical Air/Fuel Ratio	9.3	11.0	12.3	13.5	15.0
Air/Fuel ratio (exh. anal.)	-	-	12.3	-	-
Weight of exhaust gas per gallon of fuel	82.5	96	106.5	116	128.5

Table 19 E   Heat Balance

Speed in m.p.h.		29.1	38.2	47.5	57.2	67.2
Heat available from fuel	CHU/gal %	73880 100	73880 100	73880 100	73880 100	73880 100
Heat to tractive effort	CHU/gal %	16500 22.4	20400 27.6	22250 30.2	22900 31.0	22250 30.1
Heat to exhaust (a) Sensible	CHU/gal %	6910 9.4	12500 16.9	16800 22.7	19700 26.6	24200 32.7
(b) Latent	CHU/gal %	3630 4.9	4070 5.5	4690 6.3	5100 6.9	5660 7.7
(c) Unburnt gases	CHU/gal %	?	?	1100 1.5	-	-
Heat to Cooling water	CHU/gal %	35200 47.6	31400 42.5	25450 34.4	20200 27.3	15100 20.4
Unaccounted for	%	(15.7)	(7.5)	(5.0)	8.2	9.1

FUEL No. 20.

Mixture by volume of:-

>30 parts ETHYL ALCOHOL
>
>30 " PETROL
>
>40 " BENZOL

Fuel Data

Composition by weight	Carbon - 78.4 %
	Hydrogen -11.3 %
	Oxygen - 10.3 %
Higher Calorific Value	77,040 C.H.U. per gallon
	9,540 C.H.U. per lb.

Specific Gravity at 20 degrees centigrade .808

Latent Heat   182 C.H.U. per lb.

Kinematic Viscosity in abs. cgs. units .00746(1-.0121 T-20)

Vapour pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	50	90	150

Distillation

Percent distilled	10%	50%	End point
Temperature	58.5	64	126

Table 20A.

6.30 A.M. Barometer-24.761 ins Hg Dry bulb-60.1 F wet bulb-56.3 F
3.00 P.M.   "   24.666 "   "   "   "   74.0 F "   "   60.? F

Approx. load 380 lbs

Initial tyre pressures, lbs/sq ins-front 27, back 28.

Av. speed mph.	time of run min.sec.	Wind press. insH2O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. ?	Mileages: Begin	End	Diff x10
N 29.2	5-7.1	1.6	290	142	13.7	64	85.28	87.77	24.9
S 29.3	5-14.7	1.0	285	142	13.8		88.2	90.76	25.6
N 29.2	5-7.4	1.4	290	143	13.7		91.06	93.55	24.9
S 29.2	5-16.7	1.0	280	142	13.8		93.9	96.47	25.7
N 29.2	5-12.3	1.3	290	144	13.8		96.76	99.3	25.4
S 29.1	5-15.7	1.0	270	143	13.9		99.6	02.15	25.5

Tyre pressures:- Front 27
                 Back 28.5

N 38.0	3-58.7	2.6	370	144	13.1	66	02.48	04.95	25.0
S 38.1	4-20	1.9	370	146	13.4		05.37	06.12	27.5
N 37.8	4-2.4	2.3	390	146	13.0		08.35	10.9	25.5
S 38.1	4-22.5	1.9	370	146	13.3		11.35	14.13	27.8
N 38.2	3-58.1	2.7	390	148	12.3		14.32	16.85	25.3
S 38.2	4-22.3	1.8	370	148	13.5		17.29	20.08	27.9

Tyre pressures:- Front 28
                 Back 30

N 47.2	2-55.4	3.7	560	150	11.8	68	20.3	22.6	23.0
S 46.7	3-15.6	2.7	550	150	12.2		23.25	25.81	25.4
N 47.0	3-1.3	3.4	570	152	11.8		26.15	28.52	23.7
S 46.9	3-16.6	3.7	565	153	12.0		28.95	31.51	25.6
N 47.5	2-56.8	4.0	570	154	11.8		31.78	34.09	23.3
S 47.0	2-46.7	3.4	560	155	11.8		34.35	36.84	21.9?

Tyre pressures:- Front 28.5   Sample 2
                 Back 32 reduced to 30

N 57.4	2-12.2	6.5	640	157	9.5	73	37.52	39.63	21.1
S 57.0	2-22.6	4.3	630	157	10.0		40.34	42.6	22.6
N 56.6	2-13.7	5.6	640	159	9.6		43.2	45.3	21.0
S 57.1	2-21.9	5.8	630	158	9.9		46.02	48.27	22.5
N 56.5	2-15.7	6.1	640	160	9.4		48.87	51.0	21.3
S 57.5	2-21.6	5.8	635	159	9.7		51.69	53.95	22.6

Tyre pressures:- Front 30.5
                 Back 31.5

N 66.5	1-36.9	7.8	690	163	5.8	73	54.74	56.53	17.9
S 66.4	1-45.2	7.9	700	164	6.0		57.66	59.6	19.4
N 67.2	1-38.2	9.2	690	165	6.5		60.41	62.24	18.3
S 67.5	1-40.2	7.8	700	165	6.5		63.16	65.04	18.8
N 67.3	1-36.9	8.8	710	167	5.7		66.08	67.69	18.1
S 66.5	1-43	8.0	690	165	3.3	73	68.81	70.71	19.0

Tyre pressures:- Front 32
                 Back 32

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	19.5	19.8	19.6	20.0

TABLE 20 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg 25.05
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg 0.418

Car Speed in m.p.h.		29.2	38.1	47.1	57.0	66.2
Wind Pressure, inches of water.	N	1.4	2.5	3.7	6.1	8.6
	S	1.0	1.9	3.3	5.5	7.9
Absolute Wind Velocity in direction of motion, m.p.h.		2.0	2.4	1.5	1.5	1.2
Mean Tyre Pressure, lbs/sq ins		27.7	28.4	29.6	30.1	31.5
Mean Air Temperature °Cent.		18.3	19.4	21.1	22.8	21.8
Miles per gallon	N	25.1	25.3	23.3	21.1	18.1
	S	25.6	27.8	25.4	22.6	19.1
Simple Mean M.P.G.		25.3	26.5	24.3	21.8	18.5
Inlet Manifold Pressure, inches of Hg absolute	N	9.5	10.1	11.4	13.7	17.4
	S	9.3	9.7	11.3	13.3	17.1
Average.		9.4	9.9	11.3	13.5	17.3
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	334	420	580	636	690
	S	320	410	572	630	680
Average.		327	415	576	633	680
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	143	146	152	159	165
	S	142	146	153	156	165
Average (converted to Cent.)		61.4	63.3	67.0	70.3	73.9
Temperature Difference, water to air. Degrees Cent.		43.1	43.9	45.9	49.5	51.1
Acceleration Time (seconds)	N	19.7				
	S	19.9		Average:-	19.8	

Exhaust Gas Analysis 14.5 %CO₂ 0.2 %O₂ 0.3 %CO
- %H₂ (estimated) 85.0 %N₂ (by diff)

Remarks:-

TABLE 20 C M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.2	38.1	47.1	57.0	66.2
Reciprocal Mean M.P.G. of North & South runs.		25.3	26.5	24.3	21.8	18.6
% Correction for:-	a) Wind	-	-	-	-	-
	b) Weight	-	-	-	-	-
	c) Barometer	0.1	0.1	0.1	0.1	0.1
	d) Air Temp.	0.6	0.2	-0.4	-1.2	-1.3
	e) Tyre Press.	0.2	-	-0.2	-	-0.1
Total correction- %		0.9	0.3	-0.5	-1.1	-1.3
Corrected Miles per Gallon		25.6	26.6	24.2	21.6	18.4

Table 20 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio 12.5

Average Molecular Weight 68

Mixture Density relative to Air 1.044

Speed in m.p.h.	29.2	38.1	47.1	57.0	66.9
Compression Temperature	419	408	384	359	335
" " Pressure	9.2	9.5	10.55	12.2	15.05
Volumetric Efficiency	.210	.22	.262	.324	.429
Ditto to std. Basis	.208	.221	.263	.327	.434
Theoretical Air/Fuel Ratio	9.1	10.2	11.1	12.5	14.2
Air/Fuel ratio (exh. anal.)	-	-	12.5	-	-
Weight of exhaust gas per gallon of fuel	81.7	90.4	97.7	109	122.5

Table 20 E Heat Balance

Speed in m.p.h.		29.2	38.1	47.1	57.0	66.9
Heat available from fuel	CHU/gal %	77040 100	77040 100	77040 100	77040 100	77040 100
Heat to tractive effort	CHU/gal %	16200 21.0	20500 26.6	22600 29.3	24000 31.2	24100 31.3
Heat to exhaust (a) Sensible	CHU/gal %	6800 8.8	9720 13.9	15020 19.5	18600 24.1	22650 29.4
(b) Latent	CHU/gal %	3420 4.4	3780 4.9	4090 5.3	4560 5.9	5130 6.7
(c) Unburnt gases	CHU/gal %	?	?	600 0.8	-	-
Heat to Cooling water	CHU/gal %	33300 43.3	29400 38.1	25400 32.9	21950 28.5	17200 22.3
Unaccounted for	%	(22.5)	(16.5)	12.2	10.3	10.3

FUEL No. 21.

Mixture by volume of:-

	20 parts	ETHYL ALCOHOL
30	30 "	PETROL
	50 "	BENZOL

Fuel Data

Composition by weight

Carbon - 84.4 %

Hydrogen - 10.8 %

Oxygen - 6.8 %

Higher Calorific Value

80,200 C.H.U. per gallon

9,810 C.H.U. per lb

Specific Gravity at 20 degrees Centigrade - .918

Latent Heat   111 C.H.U. per lb

Kinematic Viscosity in abs. cgs. units .00681(1=.0107 ₸ 20)

Vapour pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	55	100	175

Distillation

Percent Distilled	10%	50%	End point
Temperature	56	62.5	125

Fuel No. 21 20% Alcohol-30% Petrol-50% Benzol   23rd September A.M.

Table 21A

8.30 A.M.	Barometer-24.703 ins Hg	Dry bulb-61.0 F	Wet bulb-55.9 F
3.00 P.M.	" 24.559 " "	" " 77.9 F	" " 59.8 F

Approximate load 380 lbs

Initial tyre pressures,lbs/sq ins- front 27,back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 29.1	5-15.8	2.2	320	112	12.5	87.5	55.58	58.11	25.5
S 28.8	5-46.9	0.3	275	146	13.8		56.77	61.54	27.7
N 29.2	5-8.5	2.3	300	142	12.4		61.76	64.26	25.0
S 28.6	5-51.1	0.5	270	147	14.0		64.76	67.55	27.9
N 29.0	5-12	2.8	300	142	12.8		67.74	70.25	25.1
S 29.2	5-46.9	0.5	270	148	14.0		70.72	73.55	28.3

Tyre pressures:- front 23.5
              back 28

Av. speed mph.	Time of run min.sec.	Wind press.	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Begin	End	Diffx10
N 38.2	3-45.3	4.3	420	148	11.9.	70	73.71	76.1	23.9
S 38.2	4-31.4	1.4	380	150	13.2		76.82	79.7	28.8
N -	-	3.0	400	147	12.0		80.04	82.46	24.2
S 38.3	4-26.6	1.7	370	150	13.7		83.16	86.0	28.4
N 38.1	3-52.5	3.6	420	150	12.3		86.23	88.69	24.6
S 38.5?	4-10 ?	2.1	370	152	13.9		89.36	92.1	(27.4) $

Tyre pressures:- front 28 $ Brakes used.
              back 29

Av. speed mph.	Time of run min.sec.	Wind press.	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Begin	End	Diffx10
N 47.5	2-40.3	5.6	570	156	11.0	72.5	92.27	94.49	21.2
S 47.2	3-10	3.1	560	155	11.3		95.36	97.85	24.9 @
N 48.9	2-50.6	4.7	580	155	10.6		98.18	00.4	22.2 @
S 46.9	3-12	3.5	570	156	11.9		01.06	03.55	25.0
N 47.3	2-48.3	5.1	575	157	10.9		03.85	06.06	22.1
S 47.4	3-11	3.3	550	159	12.0		06.7	09.21	25.1

Tyre pressures:- front 29   @ Sample4.
              back 30

Av. speed mph.	Time of run min.sec.	Wind press.	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Begin	End	Diffx10
N 57.6	2-7.6	7.4	640	162	8.8	74	09.63	11.7	20.4
S 57.5	2-21.3	5.3	640	164	9.5		12.51	14.77	22.6
N 57.2	2-2.9	6.4	650	163	9.0		15.39	17.34	19.5
S 57.2	2-21.7	5.5	630	163	9.9		18.24	20.49	22.5
N 57.0	2-7.7	8.7	660	163	8.2		21.1	23.12	20.2
S 58.0	2-16.6	5.8	640	163	9.9		23.88	26.08	22.0

Tyre pressures:- front 30
              back 31.

Av. speed mph.	Time of run min.sec.	Wind press.	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Begin	End	Diffx10
N 68.0	1-29.1	11.2	710	169	5.2	76	27.03	28.76	16.8
S 67.0	1-40.7	8.4	750	171	4.6		29.83	31.7	18.7
N 67.5	1-29.6	10.5	750	171	4.5		32.85	34.53	16.8
S 67.3	1-42.1	7.0	720	172	5.7		35.59	37.5	19.1
N 65.7	1-28.6	10.0	740	170	4.4	78	39.79	41.46	16.7
S 67.3	1-40.1	7.6	720	172	5.9		42.48	44.35	18.7

Tyre pressures:- front 30
              back 31

Acceleration tests

Direction	n	s	n	s
Accel. time in seconds	21.2	20.8	21.0	20.5

<u>TABLE 21 B.</u>   Summarised Results of Table A.

Mean Barometric Pressure corrected for altitude. Ins of Hg	24.87				
Vapour Pressure of moisture in atmosphere (Average). Ins of Hg	0.376				

Car Speed in m.p.h.		29.0	38.2	47.2	57.4	67.5
Wind Pressure, inches of water.	N	2.4	3.6	5.1	7.5	10.6
	S	0.4	1.7	3.3	5.5	7.7
Absolute Wind Velocity in direction of motion, m.p.h.		12.2	7.2	5.3	4.4	5.5
Mean Tyre Pressure, lbs/sq ins		27.4	27.9	29	30	30.5
Mean Air Temperature °Cent.		20	21.7	22.8	23.9	24.4
Miles per gallon	N	25.3	24.2	21.8	20.0	16.8
	S	28.0	28.6	25.0	22.4	18.8
Simple Mean M.P.G.		26.6	26.4	23.4	21.2	17.8
Inlet Manifold Pressure, inches of Hg absolute	N	10.5	11.0	12.4	14.5	18.7
	S	9.2	9.5	11.5	13.4	1.
Average.		9.8	10.2	11.9	13.9	18.4
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	350	450	586	642	702
	S	318	412	574	632	700
Average.		334	431	580	637	701
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	142	148	156	163	170
	S	147	151	157	164	172
Average (converted to Cent.)		62.5	65.3	69.2	73.0	77.2
Temperature Difference, water to air. Degrees Cent.		42.5	43.6	46.4	49.1	52.8
Acceleration Time (seconds)	N	21.1				
	S	20.7			Average:-	20.9

Exhaust Gas Analysis   15.0 %CO$_2$ 0.2   %O$_2$ 0.9 %CO

0.2 %H$_2$ (estimated)   83.7   %N$_2$ (by diff)

Remarks:-

<u>TABLE 21 C</u>   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.0	38.2	47.2	57.4	67.5
Reciprocal Mean M.P.G. of North & South runs.		26.5	26.2	23.3	21.1	17.7
% Correction for:-	a) Wind	4.5	1.3	0.6	0.3	0.4
	b) Weight	-	-	-	-	-
	c) Barometer	-	-	-	-	-
	d) Air Temp.	-	-0.6	-1.0	-1.6	-2.0
	e) Tyre Press.	0.3	0.3	-	-	0.1
Total correction- %		4.8	1.0	-0.4	-1.3	-1.5
Corrected Miles per Gallon		27.8	26.5	23.2	20.8	17.4

Table __21__ D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio 12.5
Average Molecular Weight 73
Mixture Density relative to Air 1.046

Speed in m.p.h.	29.0	38.2	47.2	57.4	67.5
Compression Temperature	417	410	382	362	336
" " Pressure	9.6	9.8	11.15	12.6	16.1
Volumetric Efficiency	.220	.225	.279	.332	.458
Ditto to std. Basis	.210	.226	.280	.335	.465
Theoretical Air/Fuel Ratio	10.0	10.25	11.2	12.1	14.2
Air/Fuel ratio (exh. anal.)	-	-	12.7	-	-
Weight of exhaust gas per gallon of fuel	89.7	92	100	107	124.5

Table 21   E   Heat Balance

Speed in m.p.h.		29.0	38.2	47.2	57.4	67.5
Heat available from fuel	CHU/gal %	80200 100	80200 100	80200 100	80200 100	80200 100
Heat to tractive effort	CHU/gal %	17600 21.9	20500 25.5	21700 27.1	23100 28.8	22800 28.5
Heat to exhaust (a) Sensible	CHU/gal %	7650 9.5	10360 12.9	15500 19.3	18400 23.0	23850 29.7
(b) Latent	CHU/gal %	3450 4.3	3510 4.8	3840 4.8	4100 5.1	4780 6.0
(c) Unburnt gases	CHU/gal %	?	?	2280 2.8	?	-
Heat to Cooling water	CHU/gal %	35600 44.3	29000 36.2	24700 30.8	20900 26.0	16900 21.1
Unaccounted for	%	(20.0)	(21.0)	15.2	(17.1)	14.7

FUEL No. 22.

Mixture by volume of:-

10 parts ETHYL ALCOHOL

30 "   PETROL

60 "   BENZOL

Fuel Data

Composition by weight   Carbon - 86.3 %

                            Hydrogen- 10.3 %

                            Oxygen - 3.4 %

Higher Calorific Value   83,560 C.H.U. per gallon.

                            10,090 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade   .828

Latent Heat   100 C.H.U. per lb.

Kinematic Viscosity in abs. Cgs. units   .00645(1-.0107 T-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	56	100	170

Distillation

Percent distilled	10%	50%	End point
Temperature	59	73.2	127

Table 22A.

8.30 A.M.   Barometer 24.335 ins   Dry bulb-60.0 F wet bulb-56.1 F
3.00 P.M.   "   24.720 " "   "   "   75.7 F "   "   59.8 F

Approx load 340 lbs
Initial tyre pressures, lbs/sq ins-Front 27.5, back 27.5.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 28.9	5-28.7	2.3	280	148	13.1	77	23.34	25.9	25.6
S 29.1	5-58.5	0.4	280	151	14.0		26.25	29.15	29.0
N 28.9	5-21.4	2.1	280	146	13.0		29.32	31.9	25.8
S 29.1	6-4 5	0.7	260	152	14.2		32.35	35.3	29.5
N 28.7	5-23.5	2.9	275	148	13.0		35.49	38.07	25.8
S 29.3	5-51.7	0.8	260	150	14.1		38.54	41.4	28.6

Tyre pressures:- Front 28
                  Back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 37.9	3-57.8	3.5	380	152	12.8	78	41.6	44.1	25.0
S 38.0	4-35.5	0.9	360	156	13.5		44.64	47.55	29.1
N 38.0	4-1.8	4.0	405	150	12.4		47.8	50.35	25.5
S 38.0	4-34.2	2.0	360	152	13.1		51.0	53.9	29.0
N 37.9	3-56.5	4.7	450	151	11.9		54.15	56.64	24.9
S 38.1	4-38.5	1.2	360	156	13.3		57.27	60.22	29.5

Tyre pressures:- Front 28.5
                  Back   29.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 47.5	2-52.8	5.5	550	158	11.3	79	60.58	62.86	22.8
S 47.6	3-27.1	2.0	510	161	12.7		63.61	66.35	27.4 @
N 47.3	2-56	4.6	580	160	11.1		66.67	68.98	23.1 ●
S 47.6	3-25	3.0	550	160	12.2		69.79	72.5	27.1
N 47.5	2-52.9	5.3	585	161	10.9		72.79	75.07	22.8
S 47.4	3-31.8	2.1	560	161	11.8		73.74	76.52	27.8

Tyre pressures:- Front 29   @ Sample 2.
                  Back 30.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 57.5	2-3.5	8.5	660	164	8.0	81	78.93	80.9	19.7
S -	-	5.5	645	164	9.8		81.87	84.3	24.3
N 57.4	2-8.7	7.2	645	166	9.2		84.75	86.8	20.5
S 57.6	2-36.2	4.3	630	167	9.9		87.55	90.05	25.0
N 57.0	2-10.2	7.8	645	164	8.7		90.51	92.57	20.6
S 57.6	6-34.4	4.2	615	166	10.6		93.38	95.85	24.7

Tyre pressures:- Front 30
                  Back 30.5

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 68.1	1-31	11.5	715	171	5.6	82	96.56	98.28	17.2
S 67.5	1-49.4	7.0	690	171	7.0		99.4	01.45	20.5
N 67.3	1-34.2	10.0	720	172	5.0		02.2	03.96	17.6
S 67.4	1-51.2	7.7	670	173	7.1		03.47	05.55	20.8
N 67.0	1-37.5	11.0	710	173	5.5		09.44	11.25	18.1
S 67.5	1-44.5	6.8	685	174	7.0	83	12.19	14.15	19.6

Tyre pressures:- Front 30.5
                  Back 31.

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.2	20.6	21.9	20.2

TABLE 22 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg **25.11**
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg 0.590

Car Speed in m.p.h.		29.0	38.0	47.5	57.4	67.5
Wind Pressure,	N	2.4	4.1	5.1	7.8	10.8
inches of water.	S	0.6	1.4	2.4	4.7	7.2
Absolute Wind Velocity in direction of motion, m.p.h.		9.7	10.0	8.9	7.3	6.8
Mean Tyre Pressure, lbs/sq ins		27.7	28.4	29.1	29.9	30.5
Mean Air Temperature °Cent.		25.0	25.6	26.7	27.2	27.8
Miles per gallon	N	25.7	25.1	22.9	20.3	17.6
	S	29.1	29.2	27.4	24.7	20.3
Simple Mean M.P.G.		27.4	27.1	25.1	22.5	18.9
Inlet Manifold Pressure,	N	10.2	10.8	12.2	14.8	18.1
inches of Hg absolute	S	9.1	9.9	11.2	13.2	16.4
Average.		9.6	10.3	11.7	14.0	17.2
Exhaust Gas Temperature	N	323	435	585	640	690
degrees Centigrade.	S	318	400	557	622	668
(above atmospheric) Average.		320	417	571	631	679
Cooling Water Temperature	N	147	151	159	165	172
at entrance to radiator,	S	151	155	161	166	173
degrees Fahrenheit. Average (converted to Cent.)		65	67.2	71.1	74.2	78.0
Temperature Difference, water to air. Degrees Cent.		40.0	41.6	44.4	47.0	50.2
Acceleration Time (seconds)	N	21.5				
	S	20.4			Average:-	20.9

Exhaust Gas Analysis   14.6 %CO_2 -   %O_2 2.3 %CO
0.4 %H_2 (estimated) 82.7 %N_2 (by diff)

Remarks:-

TABLE 22 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.0	38.0	47.5	57.4	67.5
Reciprocal Mean M.P.G. of North & South runs.		27.3	26.9	25.0	22.3	18.9
	a) Wind	2.3	2.5	1.6	0.9	0.6
% Correction for:-	b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
	c) Barometer	0.1	0.2	0.2	0.2	0.3
	d) Air Temp.	-1.7	-2.1	-2.7	-3.1	-3.6
	e) Tyre Press.	0.2	-	-	-	0.1
Total correction- %		1.0	0.3	-1.2	-2.2	-2.8
Corrected Miles per Gallon		27.6	27.0	24.7	21.8	18.4

<u>TABLE 22 B.</u>   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg **25.11**
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg **0.390**

Car Speed in m.p.h.		29.0	38.0	**47.5**	**57.4**	67.5
Wind Pressure, N		2.4	4.1	5.1	7.8	10.8
inches of water. S		0.6	1.4	2.4	4.7	7.2
Absolute Wind Velocity in direction of motion, m.p.h.		9.7	10.0	8.9	7.3	5.8
Mean Tyre Pressure, lbs/sq ins		27.7	28.4	29.1	29.9	30.5
Mean Air Temperature °Cent.		25.0	25.6	26.7	27.2	27.8
Miles per gallon N		25.7	25.1	22.9	20.3	17.6
S		29.1	29.2	27.4	24.7	20.3
Simple Mean M.P.G.		27.4	27.1	25.1	22.5	18.9
Inlet Manifold Pressure, N		10.2	10.8	12.3	14.8	18.1
inches of Hg absolute S		9.1	9.9	11.2	13.2	16.4
Average.		9.6	10.3	11.7	14.0	17.2
Exhaust Gas Temperature N		322	435	585	640	690
degrees Centigrade. S		318	400	557	622	668
(above atmospheric) Average.		320	417	571	631	679
Cooling Water Temperature N		147	151	159	165	172
at entrance to radiator, S		151	155	161	166	173
degrees Fahrenheit. Average (converted to Cent.)		65	67.2	71.1	74.2	78.0
Temperature Difference, water to air. Degrees Cent.		40.0	41.6	44.4	47.0	50.2
Acceleration Time (seconds) N		21.5				
S		20.4		Average:-		20.9

Exhaust Gas Analysis   14.6 %CO₂   -   %O₂ **2.3** %CO

      0.4 %H₂ (estimated) **82.7**   %N₂ (by diff)

Remarks:-

<u>TABLE 22 C</u>   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.0	38.0	47.5	57.4	67.5
Reciprocal Mean M.P.G. of North & South runs.		27.3	26.9	25.0	22.3	18.9
% Correction for:-	a) Wind	2.8	2.5	1.6	0.9	0.6
	b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
	c) Barometer	0.1	0.2	0.2	0.2	0.3
	d) Air Temp.	-1.7	-2.1	-2.7	-3.1	-3.6
	e) Tyre Press.	0.2	-	-	-	0.1
Total correction-%		1.0	0.3	-1.2	-2.2	-2.8
Corrected Miles per Gallon		27.6	27.0	24.7	21.5	18.4

Table __22__ D   Volumetric Efficiency & Air/Fuel Ratio

     Ideal Air/Fuel Ratio   13.3

     Average Molecular Weight   78

     Mixture Density relative to Air   1.048

Speed in m.p.h.	29.0	35.0	47.5	57.4	67.5
Compression Temperature	433	417	394	368	348
" " Pressure	9.4	9.9	10.9	12.7	15.05
Volumetric Efficiency	.208	.227	.264	.330	.413
Ditto to std. Basis	.206	.226	.267	.337	.421
Theoretical Air/Fuel Ratio	9.6	10.4	11.2	12.7	13.4
Air/Fuel ratio (exh. anal.)	–	–	12.5	–	–
Weight of exhaust gas per gallon of fuel	87.5	94	101	113	119

Table __22__ E   Heat Balance

		29.0	35.0	47.5	57.4	67.5
Speed in m.p.h.		29.0	35.0	47.5	57.4	67.5
Heat available from fuel	CHU/gal %	83360 100	83360 100	83360 100	83360 100	83360 100
Heat to tractive effort	CHU/gal %	17450 21.0	20850 25.0	23100 27.7	24250 29.1	24100 29.0
Heat to exhaust (a) Sensible	CHU/gal %	7110 8.5	10150 12.2	15400 18.5	19200 23.1	22000 26.4
(b) Latent	CHU/gal %	3280 3.9	3520 4.2	3790 4.5	4230 5.1	4450 5.3
(c) Unburnt gases	CHU/gal %	?	?	5860 7.0	?	?
Heat to Cooling water	CHU/gal %	33000 39.6	28800 34.5	24900 29.9	20750 24.9	16750 20.1
Unaccounted for	%	(27.0)	(24.1)	12.4	(17.8)	(20.2)

FUEL No. 23.

Mixture by volume of :-

> 50 parts ETHYL ALCOHOL
>
> 40 " PETROL
>
> 10 " BENZOL

Fuel Data

Composition by weight

Carbon - 69.0 %

Hydrogen - 13.2 %

Oxygen - 17.8 %

Higher Calorific Value

70,160 C.H.U. per gallon

9,040 C.H.U. per lb.

Specific Gravity at 20 degrees Centigrade - .777

Latent Heat 143 C.H.U. per lb.

Kinematic Viscosity in abs. Cgs. units .00930(1-.0130 $\overline{t-20}$)

Vapour pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	45	87	160

Distillation

Percent distilled	10%	50%	End point
Temperature	60	69.5	118

Fuel No.23. 50% Alcohol-40% Petrol-10% Benzol   20th September P.M.

Table 23A.

8.30 A.M. Barometer-24.760 ins Hg Dry bulb-61.4 F Wet bulb-48.6 F
3.00 P.M;   "   24.702 " "   "   "   81.1 F "   "   54.8 F

Approximate load 340 lbs

Initial tyre pressures, lbs/sq ins- front 23, back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Begin	End	Diff×10	
N 29.3	5-51.6	0.8	300	165	13.6	83	05.49	08.35	28.6	
S 28.7	5-50.8	2.4	390	157	13.5		08.56	11.36	28.0	
N 28.7	5-46.1	1.2	310	154	13.3		11.54	14.3	27.6	
S 28.5	5-57.6	1.8	300	152	13.2		14.5	17.33	28.3	
N 28.7	5-53.6	4.7	300	158	13.4		17.5	20.32	28.2	
S 28.6	5-53.5	2.5	300	151	13.3		20.5	23.11	28.1	
Tyre pressures:- Front 28 Back 28.5										
N 37.9	4-6.7	1.5	440	130	12.6	85	23.55	26.15	26.0	
S 37.9	3-50.9	2.9	450	158	12.5		26.57	29.0	24.3	
N 37.9	4-10.5	1.5	460	160	12.6		29.36	32.0	26.4	
S 37.2	4-7.7	3.7	460	155	12.4		32.25	34.81	25.6	
N 38.0	4-11.4	2.3	470	163	13.0		35.04	37.68	26.5	
S 38.0	4-6.6	3.4	480	156	11.9		37.9	40.5	26.0	
Tyre pressures:- Front 29 Back 29										
N 48.3	2-47.8	3.0	560	184	10.9	87	40.8	43.05	22.5	
S 47.2	2-44.2	5.2	570	161	10.0		43.54	45.69	21.5	@
N 47.3	2-55	3.0	560	159	11.2		46.34	48.64	23.0	@
S 47.5	2-43.2	4.0	560	161	9.8		49.15	51.3	21.5	
N 47.7	2-52.3	3.6	550	162	11.5		51.96	54.24	22.8	
S 47.8	2-40.5	5.5	560	158	10.0		54.87	57.0	21.3	
Tyre pressures:- Front 29.5 Back 31.5 @ Sample 2.										
N 57.1	2-4.7	4.9	620	154	7.9	74	62.35	64.33	19.8	
S 57.1	2-5.5	5.6	610	150	8.2		65.25	67.24	19.9	
N 57.5	2-5.2	5.3	630	151	7.9		68.06	70.06	20.0	
S 57.8	2-7.8	5.8	620	152	7.6		70.6	72.85	20.5	
N 57.8	2-5.2	4.8	620	152	8.0		73.13	75.14	20.1	
S 57.0	2-9.9	5.2	620	153	7.7		75.65	77.7	20.5	
Tyre pressures:- Front 31 Back 32										
N 62.7	1-30.1	7.2	710	160	4.5	76	78.31	79.98	16.7	
S 67.2	1-29.5	8.0	700	161	3.3		80.92	82.59	16.7	
N 67.0	1-30.8	7.5	690	161	5.0		83.55	85.24	16.9	
S 65.8	1-30.4	8.8	700	160	3.5		86.28	87.93	16.5	
N 67.4	1-30.8	7.3	680	161	5.0		86.9	90.6	17.0	
S 68.3	1-29.7	8.4	700	160	3.9	77	91.57	93.27	17.0	
Tyre pressures:- Front 31 Back 32										

Acceleration tests.

		N	S	N	S
Direction		N	S	N	S
Accel. time in seconds		19.7	20.0	20.0	19.9

Remarks:-
30 to 50 mph tests carried out last.

TABLE 23 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.07
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.205

Car Speed in m.p.h.		28.8	37.8	47.6	57.4	67.1
Wind Pressure,	N	0.9	1.8	2.9	5.0	7.3
inches of water.	S	2.2	3.3	4.9	5.5	8.4
Absolute Wind Velocity in direction of motion, m.p.h.		6.3	5.5	6.0	1.3	2.0
Mean Tyre Pressure, lbs/sq ins		28.1	28.9	29.5		31.5
Mean Air Temperature °Cent.		28.9	30.0	30.5		34.4
Miles per gallon	N	28.1	26.3	22.8	20.5	16.9
	S	28.1	25.4	21.4	20.3	16.7
Simple Mean M.P.G.		28.1	25.8	22.1	20.1	16.8
Inlet Manifold Pressure,	N	9.8	10.5	12.1	15.4	18.7
inches of Hg absolute	S	9.9	10.9	13.3	15.5	19.9
Average.		9.8	10.7	12.7	15.4	19.3
Exhaust Gas Temperature	N	348	486	672	527	677
degrees Centigrade.	S	340	492	670	518	683
(above atmospheric) Average.		344	489	673	522	680
Cooling Water Temperature	N	158	161	162	153	161
at entrance to radiator,	S	153	156	160	152	160
degrees Fahrenheit. Average (converted to Cent.)		68.6	70.3	71.7	67.0	71.4
Temperature Difference, water to air. Degrees Cent.		39.7	40.3	41.1	43.1	47.0
Acceleration Time (seconds)	N	19.8				
	S	20.0		Average:- 19.9		

Exhaust Gas Analysis   13.5 %   1.9   %O$_2$ 0.5   %CO

    -        % (estimated) 84.3   %N$_2$ (by diff)

Remarks:-   Test rung at 60 and 70 m.p.h. and accel. tests were
            carried out first.

TABLE 23 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.8	37.8	47.6	57.4	67.1
Reciprocal Mean M.P.G. of North & South runs.		28.1	25.8	22.1	20.1	16.8
% Correction for:-	a) Wind	1.2	0.8	0.7	-	-
	b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
	c) Barometer	0.1	0.1	0.1	0.2	0.2
	d) Air Temp.	-3.0	-3.8	-4.4	-1.6	-2.0
	e) Tyre Press.	-	-0.1	-0.2	-0.3	-0.1
Total correction- %		-2.1	-3.3	-4.1	-1.9	-2.1
Corrected Miles per Gallon		27.5	25.0	21.1	19.7	16.5

Table **23** D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio	11.7
Average Molecular Weight	61
Mixture Density relative to Air	1.041

Speed in m.p.h.	28.8	37.8	47.6	57.4	67.1
Compression Temperature	417	398	370	340	321
" " Pressure	9.6	10.3	11.9	13.95	16.9
Volumetric Efficiency	.219	.246	.306	.391	.502
Ditto to std. Basis	.223	.254	.318	.398	.512
Theoretical Air/Fuel Ratio	11.15	11.55	12.25	14.5	15.75
Air/Fuel ratio (exh. anal.)	-	-	12.7	-	-
Weight of exhaust gas per gallon of fuel	94.3	97.5	103	120.5	130

Table **23** E Heat Balance

Speed in m.p.h.		28.8	37.8	47.6	57.4	67.1
Heat available from fuel	CHU/gal %	70160 100	70160 100	70160 100	70160 100	70160 100
Heat to tractive effort	CHU/gal %	17400 24.8	19300 27.5	19700 28.1	21900 31.2	21550 30.8
Heat to exhaust (a) Sensible	CHU/gal %	8250 11.7	12500 17.8	15800 22.6	20200 28.7	24000 34.3
(b) Latent	CHU/gal %	4460 6.4	4620 6.6	4880 6.9	5710 8.1	6160 8.8
(c) Unburnt gases	CHU/gal %	?	?	640 0.9	-	-
Heat to Cooling water	CHU/gal %	32500 46.4	25600 36.5	19350 27.6	16800 24.0	13800 19.7
Unaccounted for	%	(10.7)	(11.6)	13.9	8.0	6.4

FUEL No. 24.

Mixture by volume of:-

> 40 parts ETHYL ALCOHOL
>
> 40 " PETROL
>
> 20 " BENZOL

Fuel Data

Composition by weight	Carbon - 73.3 %
	Hydrogen- 12.6 %
	Oxygen - 14.1 %
Higher Calorific Value	73,320 C.H.U. per gallon
	9,340 C.H.U. per lb.
Specific Gravity	.785
Latent Heat	133 C.H.U. per lb.
Kinematic Viscosity	$.00349(1-.0140 \overline{t-20})$

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	52	97	175

Distillation

Percent distilled	10%	50%	End point
Temperature	58	67	142

Table 24A

8.30 A.M.   Barometer-24.808 ins Hg   Dry bulb-62.0 F Wet bulb-55.7 F
3.00 P.M.   "   24.736 " "   "   78.0 F "   "   58.1 F

Approximate load 380 lbs

Initial tyre pressures, lbs/sq ins:- front 27, back 27.5

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 29.0	5-40.1	1.3	295	138	13.9	58	98.8	01.34	27.4
S 29.1	5-58.9	1.1	300	138	13.7		01.6	04.5	29.
N 28.9	5-39.3	1.4	300	138	13.6		04.7	07.42	27.2
S 28.6	5-58.9	1.2	300	138	13.8		07.74	10.59	28.5
N 28.6	5-39.6	1.1	290	139	13.9		10.78	13.48	27.0
S -	-	1.2	290	139	13.8		13.77	16.64	28.7

Tyre pressures:- front 28   Car stopped for 5 minutes.
                back 27

N 37.9	3-32.3	2.2	370	140	13.0	66	16.9	19.14	(22.4)
S 37.6	4-23.7	1.8	390	141	12.9		19.82	22.57	27.5
N 38.2	5-53.6	2.1	400	142	12.6		22.88	25.36	24.8
S 37.8	4-19.2	1.9	390	142	12.5		25.84	28.56	27.2
N 38.2	4-1.8	2.2	405	143	12.8		28.88	31.45	25.7
S 37.9	4-19.4	2.2	380	143	13.0		31.77	34.5	27.3

Tyre pressures:- front 27.5
                back 27.5

N 47.1	2-50.4	3.3	550	146	11.3	68	34.77	37.0	22.3
S 47.3	2-58.9	3.5	570	145	11.0		37.7	40.05	23.5
N 47.2	2-54	3.2	560	148	11.6		40.5	42.78	22.8 o
S 47.8	3-1	3.9	560	147	10.9		43.35	45.75	24.0 ●
N 47.3	2-55.3	3.2	555	149	11.6		46.18	48.48	23.0
S 47.2	3-1.9	4.0	570	147	10.8		49.06	51.44	23.8

Tyre pressures:- front 28.0   ⊘ Sample 3
                back 27.5

N 57.2	2-6.5	4.9	610	152	9.0	71	51.94	53.95	20.1
S 56.7	2-5.2	5.7	610	150	8.9		54.78	56.75	19.7
N 57.4	2-1.1	5.0	610	151	9.5		57.58	56.75	19.3
S 57.0	2-7.7	5.8	620	.151	9.1		60.37	62.39	20.2
N 57.4	2-10.5	5.2	620	152	8.6		63.21	65.29	20.8
S 58.1	2-12	6.2	620	152	8.9		65.9	68.03	21.3

Tyre pressures:- front 28.5
                back 29

N 68.3	1-36.6	8.4	680	162	5.2	74	68.89	70.61	17.2
S →	-	8.5	680	161	4.3		71.75	73.55	16.0
N -	-	7.5	710	163	5.0		74.64	76.4	17.6
S 68.4	1-35	9.0	680	165	5.3		77.4	79.15	17.5
N 67.5	1-34.6	7.8	680	164	5.1		80.08	81.85	17.7
S 67.1	1-35.1	8.0	680	163	4.0	77	83.01	84.78	17.7

Tyre pressures:- front 28.5
                back 29

Acceleration tests.

Direction	N	S	N	S
Accel. time in seconds	19.8	20.4	19.6	20.1

TABLE 24 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   **25.11**
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   **0.345**

Car Speed in m.p.h.		28.8	37.9	47.3	57.6	67.3
Wind Pressure, inches of water.	N	1.3	2.2	3.8	5.0	7.9
	S	1.1	2.0	3.8	5.9	8.5
Absolute Wind Velocity in direction of motion, m.p.h.		1.0	0.7	2.0	2.2	1.1
Mean Tyre Pressure, lbs/sq ins		27	27	27.6	28.6	28.6
Mean Air Temperature °Cent.		17.2	19.4	20.6	22.2	23.9
Miles per gallon	N	27.2	25.1	22.8	20.1	17.8
	S	28.7	27.3	23.8	20.4	17.7
Simple Mean M.P.G.		27.9	26.2	23.1	20.2	17.6
Inlet Manifold Pressure, inches of Hg absolute	N	9.4	10.5	11.8	14.2	18.4
	S	9.4	10.5	12.4	14.3	19.0
Average.		9.4	10.5	12.1	14.2	18.7
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	340	430	570	615	673
	S	340	425	580	618	668
Average.		340	427	575	616	670
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	138	143	148	152	163
	S	138	142	146	151	163
Average (converted to Cent.)		58.9	61.1	63.9	66.4	72.8
Temperature Difference, water to air. Degrees Cent.		41.7	41.7	43.3	44.2	48.9
Acceleration Time (seconds)	N	19.7				
	S	20.2		Average:-		19.9

Exhaust Gas Analysis   14.1 %CO_2 1.0 %O_2 0.0 %CO
    -    %H_2 (estimated)   84.3 %N_2 (by diff)

Remarks:-

TABLE 24 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	28.8	37.9	47.3	57.6	67.3
Reciprocal Mean M.P.G. of North & South runs.	27.9	26.2	23.2	20.2	17.6
a) Wind	-	-	-	-	-
% Correction for:- b) Weight	-	-	-	-	-
c) Barometer	0.1	0.2	0.2	0.2	0.3
d) Air Temp.	1.0	0.2	-0.2	-0.9	-1.8
e) Tyre Press.	0.5	0.7	0.5	0.4	0.5
Total correction- %	1.6	1.1	0.5	-0.3	-1.0
Corrected Miles per Gallon	28.3	26.6	23.3	20.1	17.4

Table 24 D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   12.15

Average Molecular Weight   65

Mixture Density relative to Air   1.043

Speed in m.p.h.	28.8	37.9	47.3	57.6	67.3
Compression Temperature	413	392	368	349	327
" " Pressure	9.2	10.1	11.3	12.85	16.4
Volumetric Efficiency	.212	.245	.292	.350	.478
Ditto to std. Basis	.209	.243	.290	.351	.482
Theoretical Air/Fuel Ratio	10.6	11.6	12.25	12.8	15.4
Air/Fuel ratio (exh. anal.)	-	-	12.8	-	-
Weight of exhaust gas per gallon of fuel	91	99	104	104.5	129

Table 24 E   Heat Balance

Speed in m.p.h.		28.8	37.9	47.3	57.6	67.3
Heat available from fuel	CHU/gal %	73320 100	73320 100	73320 100	73320 100	73320 100
Heat to tractive effort	CHU/gal %	17900 24.4	20500 27.9	21800 29.7	22350 30.5	22800 31.1
Heat to exhaust (a) Sensible	CHU/gal %	7900 10.8	11000 15.0	15950 21.8	18100 24.7	23500 32.1
(b) Latent	CHU/gal %	4100 5.6	4450 6.1	4680 6.4	4890 6.7	5800 7.9
(c) Unburnt gases	CHU/gal %	?	?	640 0.9	-	-
Heat to Cooling water	CHU/gal %	35500 48.5	26300 35.6	22800 31.1	17700 24.2	15350 20.9
Unaccounted for	%	(10.7)	(12.4)	10.1	13.9	8.0

FUEL No. 25.

Mixture by volume of :-

                       30 parts ETHYL ALCOHOL

                       40   "   PETROL

                       30   "   BENZOL

Fuel Data

Composition by weight	Carbon - 75.5 %
	Hydrogen- 12.0 %
	Oxygen -10.5 %
Higher Calorific Value	76,480 C.H.U. per gallon
	9,630 C.H.U. per lb.
Specific Gravity	.798
Latent Heat	127 C.H.U. per lb.
Kinematic Viscosity	.0o741(1-.0116 $\bar{t}$-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	55	102	184

Distillation

Percent distilled	10%	50%	End point
Temperature	57	65	137

Fuel No. 25 30% Alcohol-40% Petrol-30% Benzol

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Table 25A

8.30 A.M.   Barometer-24.760 ins Hg   Dry bulb-61.4 F Wet bulb-48.6 F
3.00 P.M.   "   24.702 "   "   "   " 81.1 F "   "   54.8 F

Approximate load 380 lbs

Initial tyre pressures, lbs/sq ins- front 28, back 29.

	Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N	29.3	5-35.2	1.4	300	138	13.8	62	69.29	72.02	27.3
S	29.0	6-0.2	1.0	285	138	13.7		72.4	75.3	29.0
N	28.9	5-40.2	1.8	300	138	13.8		75.55	78.28	27.3
S	28.8	6-4.1	1.1	300	139	13.8		78.58	81.5	29.2
N	29.0	5-39.8	1.3	295	139	13.9		81.68	84.42	27.4
S	29.0	6-2.5	1.3	290	139	13.6		84.7	87.92	29.2

Tyre pressures:- front 27.5
back 29

N	37.8	4-8.6	2.2	390	142	13.0	66	87.83	90.44	26.1
S	37.7	4-24.4	2.2	395	141	12.9		90.78	93.55	27.7
N	37.9	4-10.4	2.0	390	143	13.2		93.81	96.45	26.4
S	37.8	4-26.5	2.3	400	142	13.3		96.77	99.57	28.0
N	38.2	4-12	2.1	400	143	13.0		99.8	02.47	26.7
S	38.1	4-25	2.1	390	143	13.1		02.87	05.67	28.0

Tyre pressures:- front 28
back 29

N	47.5	3-0.4	3.4	575	146	11.4	68	05.9	08.28	23.8
S	46.6	3-14.8	3.0	560	145	11.3		08.85	11.37	25.2
N	47.7	3-0.4	3.7	580	147	11.4		11.7	14.09	23.9
S	47.0	3-16.1	3.2	570	146	11.5		14.54	17.1	25.6
N	47.3	3-0.3	3.7	570	148	11.5		17.41	19.78	23.7
S	46.4	3-18.1	3.1	560	147	11.9		20.25	22.8	25.5

Tyre pressures:- front 29
back 30

N	56.8	2-13.3	5.4	625	151	9.6	70	23.15	25.25	21.0
S	57.1	2-18	5.3	640	149	9.3		25.96	28.15	21.9
N	57.4	2-15	4.9	620	150	9.4		28.8	30.95	21.5
S	57.1	2-19.6	5.4	630	151	9.0		31.63	33.84	22.1
N	57.2	2-14.1	5.6	635	152	9.3		34.45	36.58	21.3
S	57.2	2-19.8	5.5	630	151	9.1		37.31	39.53	22.2

Tyre pressures:- front 30
back 32

N	67.4	1-38.3	7.5	710	159	5.2	72	40.34	42.18	18.4
S	67.7	1-39.6	8.0	705	157	5.2		43.1	44.97	18.7
N	67.8	1-39.1	7.3	710	158	5.4		45.91	47.78	18.7
S	67.4	1-40	8.5	700	158	5.8		48.7	50.57	18.7
N	68.1	1-39.1	7.8	710	159	5.8		51.58	53.46	18.8
S	66.9	1-39.1	7.3	705	159	6.0		54.35	56.19	18.4

Tyre pressures:- front 31.5
back 32.5

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	19.5	20.3	19.5	20.7

<u>TABLE</u> 25 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg **28.07**
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.205

Car Speed in m.p.h.		29.0	37.9	47.1	57.2	67.5
Wind Pressure,	N	1.4	2.1	3.6	5.3	7.5
inches of water.	S	1.1	2.2	3.1	5.4	7.9
Absolute Wind Velocity in direction of motion, m.p.h.		1.6	0.3	1.5	0.8	1.0
Mean Tyre Pressure, lbs/sq ins		28.4	28.4	29	30.2	31.5
Mean Air Temperature °Cent.		17.8	19.4	20.6	21.7	23.3
Miles per gallon	N	27.3	26.4	23.8	21.3	18.5
	S	29.1	27.9	25.4	22.1	18.6
Simple Mean M.P.G.		28.2	27.1	24.6	21.7	18.6
Inlet Manifold Pressure,	N	9.4	10.1	11.9	13.9	17.9
inches of Hg absolute	S	9.5	10.1	11.5	14.2	17.7
Average.		9.4	10.1	11.7	14.0	17.8
Exhaust Gas Temperature	N	340	430	587	626	690
degrees Centigrade.	S	337	433	577	630	685
(above atmospheric) Average.		338	431	582	628	687
Cooling Water Temperature	N	138	143	147	151	159
at entrance to radiator,	S	139	142	146	150	158
degrees Fahrenheit. Average (converted to Cent.)		59.2	61.4	63.6	65.8	70.3
Temperature Difference, water to air. Degrees Cent.		41.4	42.0	43.0	44.	48.1
Acceleration Time (seconds)	N	19.5				
	S	20.5		Average:-		20.0

Exhaust Gas Analysis   **14.0** %CO₂   **1.3** %O₂   **0.2** %CO
                 - %H₂ (estimated) **84.5** %N₂ (by diff)

Remarks:-

<u>TABLE</u> 25 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.0	37.9	47.1	57.2	67.5
Reciprocal Mean M.P.G. of North & South runs.		28.2	27.1	24.1	21.7	18.6
% Correction for:-	a) Wind	-	-	-	-	-
	b) Weight	-	-	-	-	-
	c) Barometer	0.1	0.1	0.1	0.2	0.2
	d) Air Temp.	0.8	0.2	-0.2	-0.7	-1.0
	e) Tyre Press.	-0.2	-	-	-	-0.1
Total correction- %		0.7	0.3	-0.1	-0.5	-0.9
Corrected Miles per Gallon		28.4	27.2	24.1	21.6	18.4

Table __25__ D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   12.6

Average Molecular Weight   69

Mixture Density relative to Air   1.045

Speed in m.p.h.	29.0	37.9	47.1	57.2	67.5
Compression Temperature	420	405	378	354	332
" " Pressure	9.2	9.7	10.95	12.7	15.6
Volumetric Efficiency	.209	.229	.276	.342	.449
Ditto to std. Basis	.208	.228	.276	.343	.453
Theoretical Air/Fuel Ratio	10.4	11.0	11.9	13.3	15.1
Air/Fuel ratio (exh. anal.)	-	-	13.3	-	2
Weight of exhaust gas per gallon of fuel	90.7	95.2	102.5	113.5	128

Table   25   E   Heat Balance

Speed in m.p.h.		29.0	37.9	47.1	57.2	67.5
Heat available from fuel	CHU/gal %	76480 100	76480 100	76480 100	76480 100	76480 100
Heat to tractive effort	CHU/gal %	17950 23.5	21000 27.4	22500 29.5	24000 31.4	24100 31.6
Heat to exhaust (a) Sensible	CHU/gal %	7840 10.3	10650 13.9	15900 20.8	19200 25.1	24000 31.4
(b) Latent	CHU/gal %	3770 4.9	3960 5.2	4260 5.6	4720 6.2	5310 6.9
(c) Unburnt gases	CHU/gal %	?	?	400 0.6	-	-
Heat to Cooling water	CHU/gal %	35300 46.2	29300 38.4	23400 30.6	19000 24.9	15900 20.8
Unaccounted for	%	(15.1)	(15.1)	12.9	12.4	9.3

FUEL NO. 28.

Mixture by volume of:-

20 parts ETHYL ALCOHOL

40　"　　PETROL

40　"　　BENZOL

Fuel Data

Composition by weight

Carbon　- 81.6 %

Hydrogen- 11.5 %

Oxygen　-　6.9 %

Higher Calorific Value

79,640 C.H.U. per gallon

9,930 C.H.U. per lb.

Specific Gravity

.802

Latent Heat

110 C.H.U. per lb.

Kinematic Viscosity

.00682(1-.0115 $\overline{T-20}$)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	48	92	165

Distillation

Percent distilled	10%	50%	End point
Temperature	57	33	142

Fuel No. 26 20% Alcohol-40% Petrol-40% Benzol 21st September P.M.

Table 26A

8.30 A.M.   Barometer-24.808 ins Hg Dry bulb-62.0 F Wet bulb-55.7 F
3.00 P.M.   "   24.736 " "   "   "   "   73.0 F "   "   58.1 F

Approximate load 340 lbs

Initial tyre pressures, lbs/sq ins:- front 27, back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂0	Exh. temp. galvo.	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	end	Diffx10
N	-	0.8	280	153	13.9	82	89.78	92.5	27.4
S 29.0	5-58.8	1.9	300	150	13.3		92.75	95.63	28.8
N 28.8	5-52.9	0.8	280	155	13.7		95.82	98.64	28.2
S 28.4	5-58.1	1.9	300	151	12.9		98.8	01.63	28.3
N 28.8	5-59.5	1.3	270	156	14.1		01.8	04.68	28.8
S 29.0	5-51.3	1.8	310	147	13.0		04.89	07.72	28.3

Tyre pressures:- Front 27.5
                 Back 28.5

Av. speed mph.	Time of run min.sec.	Wind press. insH₂0	Exh. temp. galvo.	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	end	Diffx10
N 38.1	4-14.2	2.0	360	156	13.8	82	07.94	10.83	28.9
S 37.6	4-25.2	2.7	395	157	13.0		10.91	13.68	27.7
N 38.0	4-19.4	1.8	410	160	13.4		13.92	16.66	27.4
S 37.9	4-22	2.8	380	155	13.0		16.86	19.62	27.6
N 38.0	4-13.8	2.1	400	161	13.3		20.0	22.68	26.8
S 38.8	4-26.1	2.5	390	157	13.0		22.89	25.7	28.1

Tyre pressures:- Front 28
                 Back 29

Av. speed mph.	Time of run min.sec.	Wind press. insH₂0	Exh. temp. galvo.	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	end	Diffx10
N 47.3	4-1.9	4.3	560	163	11.8	83	25.94	28.33	23.9
S 47.3	3-14.5	4.8	570	159	11.3		28.95	31.5	25.5 @
N 47.4	3-6.2	3.7	560	164	12.0		31.77	34.22	24.5 @
S 47.4	3-7.7	4.2	565	183	11.3		34.63	37.1	24.7
N 47.5	3-10.3	2.8	550	166	12.3		37.46	39.97	25.1
S 47.5	3-8.8	5.3	575	164	11.8		40.34	42.83	24.9

Tyre pressures:- Front 28.5   @ Sample 4.
                 Back 30

Av. speed mph.	Time of run min.sec.	Wind press. insH₂0	Exh. temp. galvo.	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	end	Diffx10
N 57.7	2-11.7	5.5	640	171	9.3	85	43.28	45.37	21.1
S 57.4	2-17.7	6.5	655	168	9.0		46.04	48.23	21.9
N 57.6	2-15.5	5.0	660	171	9.4		48.84	51.01	21.7
S 57.6	5-17.0	7.0	680	167	8.4		51.66	53.85	21.9
N 57.7	2-18.4	5.4	640	169	10.0		54.48	56.7	22.2
S 57.7	2-18.6	6.5	660	167	8.7		57.3	59.52	22.2

Tyre pressures:- Front 29.5
                 Back 31.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂0	Exh. temp. galvo.	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	end	Diffx10
N 66.6	1-38.4	9.3	720	177	6.5	85	60.39	62.23	18.4
S 67.1	1-3812	9.0	750	175	4.8		63.25	65.1	18.5
N 68.4	1-41.1	7.2	720	178	5.8		65.95	67.87	19.2
S 67.8	1-40.5	9.6	730	174	4.8		68.9	70.79	18.9
N 68.3	1-43.2	9.5	\-	176	-		71.61	73.57	19.6
S 67.1	1-42	9.5	730	174	5..	86	74.49	76.39	19.0

Tyre pressures:- Front 31
                 Back 32.

Acceleration tests

Direction	N	S	N	S	N	S
Accel. time in seconds	19.7	21.8	19.1	21.4	19.4	21.2

TABLE 26 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.11
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.345

Car Speed in m.p.h.		28.8	38.1	47.4	57.6	67.5
Wind Pressure, inches of water.	N	1.0	2.0	3.6	5.3	8.7
	S	1.9	2.7	4.8	6.7	9.4
Absolute Wind Velocity in direction of motion, m.p.h.		4.5	2.6	3.5	3.3	1.3
Mean Tyre Pressure, lbs/sq ins		27.7	28.2	28.9	29.8	30.9
Mean Air Temperature °Cent.		27.8	28.3	28.9	29.4	29.4
Miles per gallon	N	28.3	27.0	24.5	21.7	19.0
	S	28.5	27.8	25.0	22.0	18.8
Simple Mean M.P.G.		28.4	27.4	24.7	21.8	18.9
Inlet Manifold Pressure, inches of Hg absolute	N	9.3	9.7	11.2	13.7	17.4
	S	10.0	10.2	12.1	14.6	18.5
Average.		9.6	9.9	11.6	14.1	17.9
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	320	425	572	640	696
	S	348	425	582	665	705
Average.		334	425	577	653	700
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	155	159	16.	170	177
	S	149	156	162	167	174
Average (converted to Cent.)		66.7	69.7	72.8	75.8	79.7
Temperature Difference, water to air. Degrees Cent.		38.9	41.4	43.9	46.4	50.3
Acceleration Time (seconds)	N	19.4				
	S	21.5			Average:-	20.4

Exhaust Gas Analysis   14.6   %CO$_2$ 0.2   %O$_2$ 0.5   %CO

         0.1   %H$_2$ (estimated)   84.6   %N$_2$ (by diff)

Remarks:-   **Wind very gusty**

TABLE 26 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.8	38.1	47.4	57.6	67.5
Reciprocal Mean M.P.G. of North & South runs.		28.4	27.4	24.7	21.8	18.9
% Correction for:-	a) Wind	0.5	0.1	0.2	0.1	-
	b) Weight	-0.4	-0.3	-0.3	-0.3	-0.3
	c) Barometer	0.1	0.2	0.2	0.2	0.3
	d) Air Temp.	-2.5	-3.2	-3.6	-4.1	-4.3
	e) Tyre Press.	0.1	0.1	-	-	-
Total correction- %		-2.2	-3.1	-3.5	-4.0	-4.3
Corrected Miles per Gallon		27.8	26.6	23.9	21.0	18.1

Table __26__ D   Volumetric Efficiency & Air/Fuel Ratio

      Ideal Air/Fuel Ratio   13.05
      Average Molecular Weight   74
      Mixture Density relative to Air **1.047**

Speed in m.p.h.	28.8	38.1	47.4	57.5	67.5
Compression Temperature	435	428	396	380	356
" " Pressure	9.4	9.5	10.85	12.8	15.7
Volumetric Efficiency	.206	.215	.262	.322	.420
Ditto to std. Basis	.210	.221	.271	.335	.438
Theoretical Air/Fuel Ratio	10.2	10.3	11.4	12.5	14.2
Air/Fuel ratio (exh. anal.)	-	-	13.0	-	-
Weight of exhaust gas per gallon of fuel	89.7	90.5	99.5	108	122

Table   26   E   Heat Balance

Speed in m.p.h.		28.8	38.1	47.4	57.6	67.5
Heat available from fuel	CHU/gal %	79640 100	79640 100	79640 100	79640 100	79640 100
Heat to tractive effort	CHU/gal %	17600 22.1	20500 25.8	22350 28.1	23300 29.3	23750 29.8
Heat to exhaust (a) Sensible	CHU/gal %	7640 9.6	10000 12.5	15300 19.2	19050 23.9	23300 29.3
(b) Latent	CHU/gal %	3630 4.6	3660 4.6	4030 5.1	4370 5.5	4950 6.2
(c) Unburnt gases	CHU/gal %	?	?	1230 1.5	?	-
Heat to Cooling water	CHU/gal %	32100 40.3	28200 35.3	23800 29.8	19700 24.7	16550 20.8
Unaccounted for	%	(23.4)	(21.8)	16.3	(16.6)	13.9

FUEL No. 27.

Mixture by volume of:-

10	parts	ETHYL ALCOHOL
40	"	PATROL
50	"	BENZOL

Fuel Data

Composition by weight	Carbon - 85.6 %
	Hydrogen- 11.0 %
	Oxygen - 3.4 %

Higher Calorific Value   82,800 C.H.U. per gallon.

10,220 C.H.U. per lb.

Specific Gravity   .810

Latent Heat   59 C.H.U. per lb.

Kinematic Viscosity   .00631(1-.0102 $\overline{T\ 20}$)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	50	94	170

Distillation

Percent distilled	10%	50%	End point
Temperature	57	72	151

FUEL No. 27.

Mixture by volume of:-

10 parts ETHYL ALCOHOL

40 " PATROL

50 " BENZOL

Fuel Data

Composition by weight	Carbon - 85.6 %
	Hydrogen- 11.0 %
	Oxygen - 3.4 %
Higher Calorific Value	82,800 C.H.U. per gallon.
	10,220 C.H.U. per lb.
Specific Gravity	.810
Latent Heat	99 C.H.U. per lb.
Kinematic Viscosity	.00631(1-.0102 T 20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	50	94	170

Distillation

Percent distilled	10%	50%	End point
Temperature	57	72	121

Fuel No.27   10% Alcohol-40% Petrol-50% Benzol   16th September P.M.

Table 27A.

8.30 A.M.   Barometer-24.642 ins Hg   Dry bulb-64.5 F Wet bulb-51.0 F
3.00 P.M.   "   24.575 "   "   "   "   75.5 F "   "   55.3 F

Approx. load   420 lbs.

Initial tyre pressure, lbs/sq ins- front 27, back 27.

Av. speed mph.	time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In,man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
W 29.0	5-15.7	2.5	280	154	13.1	79	10.46	13.0	25.4
S 28.7	6-8.4	0.4	300	155	12.9		13.59	16.51	29.4
N 28.5	5-21	3.0	290	151	12.0		16.68	19.22	25.4
S 29.4	6-5.6	1.0	280	154	13.3		19.8	22.78	29.8
N 28.7	6-21	3.0	280	149	12.8		23.1	25.66	25.6
S 29.0	6-9.8	0.8	270	157	13.5		26.12	29.1	29.8
Tyre pressures:- Front 27 Back 27									
N 37.8	3-49.4	3.8	490	158	11.2	81	29.31	31.72	24.1
S 38.1	4-28.5	1.1	380	157	13.0		32.41	35.23	28.4
N 37.8	3-48.4	3.5	490	156	11.5		35.5	37.9	24.0
S -	-	1.8	390	158	13.2		38.55	41.5	29.5
N 38.1	3-49.6	5.3	500	155	11.0		41.86	44.29	24.3
S 38.2	4-33.8	1.4	390	161	13.0		44.8	47.7	29.0
Tyre pressures:- Front 28 Back 29									
N 47.0	2-47.5	7.2	590	161	9.7	82	48.03	50.22	21.9
S 47.0	3-19	2.0	550	163	11.8		51.05	53.65	26.0
N 47.8	2-51	4.5	580	164	10.7		53.93	56.2	22.7
S 47.7	3-23.1	2.7	560	165	11.2		56.91	59.6	26.9
N 47.9	2.39.3	6.3	600	166	9.7		59.95	62.07	21.2
S 47.6	3-23.8	2.8	550	166	11.3		62.96	65.55	26.9
Tyre pressures:- Front 29 Sample 2 Back 29.5									
N 56.8	1-57.1	9.0	670	166	7.0	83	65.0	67.85	18.5
S 57.5	2-24.7	3.4	640	168	9.2		68.85	71.16	23.1
N 57.3	2-3.8	7.7	670	168	8.0		71.7	73.67	19.7
S 57.3	2-2?.4	5.0	630	171	9.5		74.47	76.75	22.8
N -	-	8.0	660	171	8.2		77.34	79.35	20.1
S 57.6	2-20.5	5.0	620	170	9.8		80.1	82.35	22.5
Tyre pressures:- Front 29 Back 29.5									
N 67.3	1-20.8	13.0	750	172	5.0	81	83.35	84.86	15.1
S 67.4	1-39.5	8.0	730	170	4.8		86.0	87.87	18.7
N 66.9	1-27.7	9.0	740	173	4.5		89.06	90.69	16.3
S 67.7	1-42.1	6.5	730	174	5.0		91.67	93.59	19.2
N 67.7	1-28.7	11.5	730	175	4.2		94.68	96.35	16.7
S 67.5	1-31.9	7.0	720	171	4.5		00.05	01.77	17.2
Tyre pressures:- Front 29.5 Back 30.									

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.5	22.0	21.4	21.9

TABLE 27 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   24.95
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.245

Car Speed in m.p.h.		28.8	38.0	47.5	57.3	67.4
Wind Pressure,	N	2.8	4.2	6.0	8.2	11.3
inches of water.	S	0.7	1.4	2.5	4.5	7.2
Absolute Wind Velocity in direction of motion, m.p.h.		9.8	10.7	10.2	8.3	7.4
Mean Tyre Pressure, lbs/sq ins		27	27.8	28.7	29.2	29.3
Mean Air Temperature °Cent.		24.7	27.2	27.8	28.3	27.8
Miles per gallon	N	25.5	24.1	21.9	19.4	13.0
	S	29.7	29.0	26.6	22.3	18.5
Simple Mean M.P.G.		27.6	26.5	24.2	21.1	17.2
Inlet Manifold Pressure,	N	10.5	12.0	13.2	15.6	18.
inches of Hg absolute	S	9.9	10.0	11.8	13.7	18.3
Average.		10.2	11.0	12.5	14.6	18.8
Exhaust Gas Temperature	N	330	518	600	657	702
degrees Centigrade.	S	330	426	570	630	648
(above atmospheric) Average.		330	472	585	643	673
Cooling Water Temperature	N	151	156	164	166	173
at entrance to radiator,	S	155	159	165	170	172
degrees Fahrenheit. Average (converted to Cent.)		67.2	69.7	73.6	76.1	78.0
Temperature Difference, water to air. Degrees Cent.		40.5	42.5	45.8	47.8	50.2
Acceleration Time (seconds)	N	21.4				
	S	22.0		Average:-	21.7	

Exhaust Gas Analysis   14.9 %CO₂   -   %O₂ 1.4 %CO

0.3 %H₂ (estimated)   83.4 %N₂ (by diff)

Remarks:-

TABLE 27 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.3	38.0	47.5	57.3	67.4
Reciprocal Mean M.P.G. of North & South runs.		27.4	26.4	24.0	20.9	17.1
% Correction for:-	a) Wind	2.9	2.9	2.1	1.3	0.7
	b) Weight	0.5	0.4	0.3	0.3	0.2
	c) Barometer	-0.1	-0.1	-0.1	-0.2	-0.2
	d) Air Temp.	-2.3	-2.7	-3.2	-3.6	-3.3
	e) Tyre Press.	0.5	0.3	0.1	0.2	0.3
Total correction- %		1.8	0.8	-0.8	-2.1	-2.3
Corrected Miles per Gallon		27.9	26.6	23.8	20.5	16.7

Table __27__ D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   13.5
Average Molecular Weight   79
Mixture Density relative to Air   1.049

Speed in m.p.h.	28.8	38.0	47.5	57.3	67.4
Compression Temperature	423	408	387	366-	348
" " Pressure	10.0	10.5	11.7	13.8	15.5
Volumetric Efficiency	.226	.249	.290	.345	.468
Ditto to std. Basis	.222	.248	.292	.351	.472
Theoretical Air/Fuel Ratio	10.7	11.6	12.8	12.65	13.95
Air/Fuel ratio (exh. anal.)	-	-	13.0	-	-
Weight of exhaust gas per gallon of fuel	95	101	107	110.5	121

Table __27__ E   Heat Balance

Speed in m.p.h.		28.8	38.0	47.5	57.3	67.4
Heat available from fuel	CHU/gal	82800	82800	82800	82800	82800
	%	100	100	100	100	100
Heat to tractive effort	CHU/gal	17650	20500	22250	22800	21900
	%	21.3	24.8	26.9	27.5	26.5
Heat to exhaust (a) Sensible	CHU/gal	8000	12500	16750	19200	22200
	%	9.7	15.1	20.2	23.2	26.8
(b) Latent	CHU/gal	3600	3840	4050	4200	4600
	%	4.4	4.6	4.9	5.1	5.6
(c) Unburnt gases	CHU/gal	?	?	3800	?	?
	%			4.6		
Heat to Cooling water	CHU/gal	33800	29000	24950	19900	15450
	%	40.8	35.1	30.2	24.1	18.7
Unaccounted for	%	(24.8)	(20.4)	13.2	(0.1)	(22.4)

FUEL No, 28.

Mixture by volume of:-

40 parts	ETHYL ALCOHOL
50 "	PETROL
10 "	BENZOL

Fuel Data

Composition by weight	Carbon - 72.2 %
	Hydrogen - 13.4 %
	Oxygen - 14.4 %
Higher Calorific Value	72,760 C.H.U. per gallon
	9,440 C.H.U. per lb.
Specific Gravity	.771
Latent Heat	131 C.H.U. per lb.
Kinematic Viscosity	.00855(1-.0153 T-20)

Vapour Pressure

Temperature	10 C	2 C	30 C
V.P.,mm, of Hg	51	98	175

Distillation

Percent distilled	10%	50%	End point
Temperature	59.5	68.7	141.5

Fuel No. 28   40% Alcohol-50% Petrol-10% Benzol   14th September A.M.

Table 28A

8.30 A.M.   Barometer-24.761 ins Hg   Dry bulb-61.3 F Wet bulb-52.8 F
5.00 P.M.   "   24.681 "   "   "   "   78.6 F "   "   57.7 F

Approx. load   530 lbs

Initial tyre pressures, lbs/sq ins- front 28, back 29.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Miltx10
N -	7	2.2	310	139	12.5	68	46.52	48.95	24.3
S 29.3	6-2.9	0.3	290	146	14.0		49.43	52.39	29.6
N 29.3	5-4.8	2.5	300	140	13.0		52.7	55.18	24.8
S 29.4	6-2.5	0.6	290	149	13.8		55.95	58.92	29.7
N 28.9	5-2.1	2.8	300	143	13.5		59.27	61.7	24.3
S 29.2	5-59.5	0.5	290	148	13.7		62.74	65.66	29.2

Tyre pressures:- front 26   back 27

N 38.3	3-29.8	4.8	470	147	11.0	72	65.87	68.1	22.3
S 38.2	4-23.9	0.7	440	150	12.3		68.9	71.7	28.0
N 37.9	3-40.2	3.8	510	148	10.5		71.93	74.25	23.2
S 38.0	4-19.5	1.7	400	151	13.5		75.1	77.84	27.4
N 37.9	3-37.1	5.1	490	147	11.70		78.12	80.41	22.9
S 38.0	4-30	1.1	440	152	12.5		81.25	84.1	28.5

Tyre pressures:- front 27   back 29

N 47.1	2-33.6	6.0	560	151	10.6	75	84.37	86.38	20.1
S 47.4	2-8.6	2.4	550	152	10.7		87.3	89.78	24.9
N 47.0	2-35.4	5.3	560	153	10.0		90.25	92.28	20.3
N 47.3	2-34.5	6.8	580	151	9.5		98.27	98.3	20.3
S 47.0	3-12	3.0	550	154	10.8		93.27	95.78	25.1
S -	-	2.3	560	154	10.9		99.13	01.6	24.7

Tyre pressures:- front 28.5   back 30

N 56.0	1-49.5	8.5	600	53	7.8	78	02.25	03.95	17.0
S 57.5	2-17.7	4.8	590	155	9.0		05.6	07.2	22.0
N 57.2	1-54.1	7.2	630	157	6.9		07.92	09.73	18.1
S 56.6	2-20.3	4.8	590	157	8.8		10.65	12.86	22.1
N -	-	9.0	620	157	7.1		-	-	-
S 57.5	2-18.6	5.0	590	158	9.6		16.31	18.49	21.8

Tyre pressures:- front 29   back 31

N 67.0	1-20.6	11.7	720	160	3.0	78	19.46	20.96	15.0
S 66.5	1-38.5	6.2	690	162	4.3		22.1	23.92	18.2
bN 67.2	1-23.8	10.0	700	162	3.2		25.13	26.69	15.6
S 67.4	1-40.6	6.5	670	161	5.0		27.8	29.68	18.8
N 65.9	1-19.3	12.0	730	166	3.2		38.2	39.65	14.5
S 67.4	1-40.6	5.2	780	164	4.0		35.39	37.27	18.8

Tyre pressures:- front 29.5   back 31

Acceleration tests.

Direction		N	S	N	S
Accel. time in seconds		22.6	21.3	22.7	20.9

TABLE 28 B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.06
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.304

Car Speed in m.p.h.	29.2	38.1	47.8	57.0	66.9
Wind Pressure, N inches of water. S	2.5 0.5	4.6 1.1	6.0 2.6	8.2 4.9	11.2 6.0
Absolute Wind Velocity in direction of motion, m.p.h.	11.1	13.2	9.8	7.3	10.5
Mean Tyre Pressure, lbs/sq ins	27.5	27.7	28.0	29.6	30.2
Mean Air Temperature °Cent.	21.1	23.3	24.4	25.0	25.6
Miles per gallon N S	24.5 29.5	22.7 28.0	20.8 24.9	17.6 22.0	15.1 18.6
Simple Mean M.P.G.	27.0	25.3	22.5	19.8	16.8
Inlet Manifold Pressure, N inches of Hg absolute S	10.2 9.4	12.5 10.4	13.5 12.6	16.1 14.2	20.1 19.3
Average.	9.8	11.4	13.0	15.1	19.7
Exhaust Gas Temperature N degrees Centigrade. S (above atmospheric)	348 337	516 457	577 562	618 602	685 680
Average.	342	486	569	610	682
Cooling Water Temperature N at entrance to radiator, S degrees Fahrenheit.	141 148	147 151	152 153	156 157	162 164
Average (converted to Cent.)	62.5	65.0	67.0	69.2	72.8
Temperature Difference, water to air. Degrees Cent.	41.4	41.7	42.6	44.2	47.2
Acceleration Time (seconds) N S	22.5 21.1			Average:-	21.8

Exhaust Gas Analysis   12.8 %CO₂   2.6 %O₂   - %CO
                - %H₂ (estimated)   84.4 %N₂ (by diff)

Remarks:-

TABLE 28 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	29.2	38.1	47.8	57.0	66.9
Reciprocal Mean M.P.G. of North & South runs.	26.8	25.1	22.3	19.6	16.6
% Correction for:- a) Wind	3.7	4.3	1.9	0.9	1.4
b) Weight	2.0	1.7	1.4	1.2	0.9
c) Barometer	-	-	-	-	-
d) Air Temp.	-0.4	-1.2	-1.8	-2.1	-2.6
e) Tyre Press.	0.3	0.3	-	0.1	0.2
Total correction- %	5.4	5.1	1.5	0.1	-0.1
Corrected Miles per Gallon	28.3	26.4	22.7	19.6	16.6

Table **28** **D** Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   **12.3**

Average Molecular Weight   66

Mixture Density relative to Air **1.043**

Speed in m.p.h.	29.2	38.1	47.2	57.0	66.9
Compression Temperature	413	385	367	350	328
" " Pressure	9.6	10.95	12.05	13.7	17.2
Volumetric Efficiency	.221	.271	.313	.373	.500
Ditto to std. Basis	.210	.258	.308	.373	.500
Theoretical Air/Fuel Ratio	10.9	12.55	12.9	13.6	15.5
Air/Fuel ratio (exh. anal.)	-	-	14.05	-	-
Weight of exhaust gas per gallon of fuel	91.5	104.5	107.5	112.5	127.5

Table **28** **E**   Heat Balance

Speed in m.p.h.		29.2	38.1	47.2	57.0	66.9
Heat available from fuel	CHU/gal %	72760 100	72760 100	72760 100	72760 100	72760 100
Heat to tractive effort	CHU/gal %	17900 24.5	20400 28.0	21200 29.1	21800 29.8	21600 29.9
Heat to exhaust (a) Sensible	CHU/gal %	7990 11.0	13340 18.4	16300 22.4	18400 25.4	23650 32.5
(b) Latent	CHU/gal %	4000 5.5	4570 6.3	4700 6.5	4920 6.8	5580 7.7
(c) Unburnt gases	CHU/gal %	-	-	-	-	-
Heat to Cooling water	CHU/gal %	33850 46.5	28100 38.6	21760 29.9	17330 23.8	14100 19.4
Unaccounted for	%	12.4	8.7	12.1	14.1	11.4

FUEL No. 29

Mixture by volume of:-

        30 parts ETHYL ALCOHOL

        50   "   PETROL

        20   "   BENZOL

Fuel Data

Composition by weight	Carbon - 76.5 %
	Hydrogen- 12.8 %
	Oxygen - 10.7 %
Higher Calorific Value	75,920 C.H.U. per gallon
	9,750 C.H.U. per lb.
Specific Gravity	.778
Latent heat	119 C.H.U. per lb.
Kinematic Viscosity	.02760(1-.0133 t-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	55	99	175

Distillation

Percent distilled	10%	50%	End point
Temperature	56	66	144

Fuel No.29   30% Alcohol-50% Petrol-20% Benzol   16th September A.M.

Table 29A

8.30 A.M.   Barometer-24.842 ins Hg Dry bulb-64.5 F Wet bulb-51.0 F
3.00 P.M.   "   "   24.575 "   "   "   "   76.5 F "   "   55.3 F

Approx load 460 lbs.

Initial tyre pressure. lbs/sq ins- front 28, back 29.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages: Begin	End	Diff x10
N 29.5	5-17	1.7	320	139	13.2	70	12.72	15.32	28.0
S 28.6	5-58.4	0.4	300	144	13.9		15.74	18.61	28.7
N 29.2	5-36.8	0.9	300	144	13.3		18.85	21.58	27.3
S 28.9	5-50.6	1.6	300	144	13.2		21.90	24.78	28.8
N 29.0	5-41	1.5	290	146	13.6		25.07	27.82	27.5
S 29.0	5-46.9	2.0	310	140	13.0		28.16	30.95	27.9
Tyre pressures:- Front 28 Back 29									
N 37.8	3-57.9	2.6	400	148	13.0	73	31.1	33.8	25.0
S 37.8	4-19.6	2.0	390	148	12.8		34.07	36.79	27.2
N 38.0	3-54	3.1	450	149	13.0		37.04	39.51	24.7
S 38.1	4-15.8	2.5	430	150	13.9		39.97	42.68	27.1
N 38.2	3-52.4	3.3	470	152	12.5		42.88	45.35	24.7
S 38.0	4-21.2	1.8	420	154	13.0		45.91	48.67	27.6
Tyre pressures:- Front 28.5 Back 29.									
N 47.5	2-42.5	5.7	580	155	10.0	74	49.0	51.18	21.8
S 47.2	3-8.4	3.0	570	155	11.2		51.88	54.35	24.7
N 47.1	2-47.2	4.4	570	153	10.2		54.68	56.87	21.9
S 47.2	3-12.5	3.4	570	156	11.0		57.45	59.98	25.3 ●
N 47.0	2-45.4	5.4	580	156	10.0		60.24	62.4	21.6
S 47.1	3-14.5	3.0	580	157	11.0		62.95	65.5	25.5 ●
Tyre pressures:- Front 29 Back 29 @ Sample I.									
N 57.2	1-57.1	8.2	670	160	7.0	76	65.85	67.71	18.6
S 57.0	2-19.5	5.0	630	159	8.5		68.45	70.66	22.1
N 57.2	1-59.7	7.5	670	161	7.5		71.07	72.97	19.0
S 57.4	2-16.2	4.6	670	160	7.5		73.86	76.03	21.7 ?
N 55.0	2-0.4	8.0	650	160	7.8		76.6	78.54	18.4
S 57.7	2-21	5.5	630	161	9.2		79.29	81.54	22.6
Tyre pressures:- Front 29 Back 30									
N 67.1	1-25.2	12.0	730	165	4.5	76	82.29	83.88	15.9
S 67.2	1-39.7	7.7	700	164	5.2		84.82	86.68	18.6
N 68.8	1-29	9.5	720	165	4.7		87.59	89.29	17.0
S 67.0	1-41	8.2	680	168	5.5		91.17	92.05	18.8
N 67.2	1-29	11.0	740	166	4.2		92.94	94.6	16.6
S 66.7	1-43.1	6.5	700	167	6.0		95.96	97.87	19.1
Tyre pressures:- Front 30 Back 32									

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	21.3	20.0	21.1	20.6

TABLE 29   B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   24.95
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.245

Car Speed in m.p.h.		29.1	38.0	47.2	56.9	67.3
Wind Pressure,	N	1.4	3.0	5.2	7.9	10.8
inches of water.	S	1.3	2.1	3.1	5.0	7.5
Absolute Wind Velocity in direction of motion, m.p.h.		0.5	3.2	6.0	6.4	6.3
Mean Tyre Pressure, lbs/sq ins		28.5	28.6	28.9	29.2	30.2
Mean Air Temperature °Cent.		23.2	22.8	23.9	24.4	24.4
Miles per gallon	N	27.4	24.8	21.8	18.7	16.5
	S	28.5	27.3	25.2	22.2	18.8
Simple Mean M.P.G.		27.9	26.0	23.5	20.4	17.6
Inlet Manifold Pressure,	N	9.7	10.3	13.1	15.9	18.9
inches of Hg absolute	S	9.7	10.2	12.1	14.8	17.4
Average.		9.7	10.2	12.6	15.3	18.1
Exhaust Gas Temperature	N	350	47 0	590	654	700
degrees Centigrade.	S	350	448	583	640	678
(above atmospheric) Average.		350	459	586	647	689
Cooling Water Temperature	N	143	150	155	160	165
at entrance to radiator,	S	142	151	156	160	166
degrees Fahrenheit. Average (converted to Cent.)		61.4	65.9	68.6	71.1	74.2
Temperature Difference, water to air. Degrees Cent.		39.2	43.0	44.7	46.7	49.8

| Acceleration Time (seconds) | N | 21.2 | | | | |
| | S | 20.3 | | Average:- | | 20.7 |

Exhaust Gas Analysis   14.6 %CO₂   0.4 %O₂   0.4 %CO

0.1 %H₂ (estimated)   84.5 %N₂ (by diff)

Remarks:-

TABLE   29C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	29.1	38.0	47.2	56.9	67.3
Reciprocal Mean M.P.G. of North & South runs.	27.9	26.0	23.4	20.3	17.5
% Correction for:- a) Wind	-	0.2	0.8	0.8	0.6
b) Weight	1.1	0.9	0.8	0.6	0.5
c) Barometer	-0.1	-0.1	-0.1	-0.2	-0.2
d) Air Temp.	-0.7	-1.0	-1.6	-1.9	-2.0
e) Tyre Press	-0.3	-	-	0.2	0.2
Total correction- %	-	-	-0.1	-0.5	-0.9
Corrected Miles per Gallon	27.9	26.0	23.4	20.2	17.4

Table __29__ D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio	12.75
Average Molecular Weight	70
Mixture Density relative to Air	1.04

Speed in m.p.h.	29.1	38.0	47.2	56.9	67.3
Compression Temperature	419	410	372	349	334
" " Pressure	9.5	9.8	11.8	13.85	15.8
Volumetric Efficiency	.216	.226	.303	.379	.452
Ditto to std. Basis	.216	.228	.303	.381	.456
Theoretical Air/Fuel Ratio	10.9	10.7	13.0	14.2	14.7
Air/Fuel ratio (exh. anal.)	-	-	12.85	-	-
Weight of exhaust gas per gallon of fuel	92.7	91	109	116	122

Table __29__ E   Heat Balance

Speed in m.p.h.		29.1	38.0	47.2	56.9	67.3
Heat available from fuel	CHU/gal %	75920 100	75920 100	75920 100	75920 100	75920 100
Heat to tractive effort	CHU/gal %	17650 23.3	20100 26.5	21900 28.8	22500 29.6	22800 30.0
Heat to exhaust (a) Sensible	CHU/gal %	8300 11.0	10900 14.4	17100 22.5	20650 27.2	22900 30.2
(b) Latent	CHU/gal %	4200 5.5	4120 5.4	4940 6.5	5350 7.0	5530 7.3
(c) Unburnt gases	CHU/gal %	?	?	1120 1.5	?	-
Heat to Cooling water	CHU/gal %	32500 42.8	28800 37.9	23800 31.4	19100 25.2	15700 20.7
Unaccounted for	%	(17.4)	(15.8)	9.3	11.0	11.8

FUEL No. 30.

Mixture by volume of:-

20 parts ETHYL ALCOHOL

50 "   PETROL

30 "   BENZOL

Fuel Data

Composition by weight | Carbon - 80.9 %
| Hydrogen- 12.1 %
| Oxygen - 7.0 %

Higher Calorific Value | 79,060 C.H.U. per gallon.
| 10,060 C.H.U. per lb.

Specific Gravity | .788

Latent Heat | 108 C.H.U. per lb.

Kinematic Viscosity | .00682(1-.0124 $\overline{T-20}$)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	52	100	180

Distillation

Percent distilled	10%	50%	End point
Temperature	56	69	135

Fuel No.30 20% Alcohol-50% Petrol-30% Benzol

Table 30A.

8.30 A.M. Barometer-24.742 ins Hg Dry bulb-47.0 F Wet bulb-38.7 F
3.00 P.M.   "   24.642 " " "   " 71.7 F " " 50.9 F

Approx. load 380 lbs

Initial tyre pressure, lbs/sq ins- front 28, back 29.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man.Air vacuum ins Hg	temp. F	Mileages:- Begin	2nd	Diff x10
N 29.0	5-48.9	0.6	290	138	13.7	56	48.19	51.0	28.1
S 29.0	5-35.2	2.5	300	135	13.1		51.25	53.95	27.0
N 28.9	5-56.4	0.6	290	136	13.5		54.23	57.06	28.3
S 28.8	5-34.7	2.8	310	135	12.8		57.3	59.98	28.8
N 29.2	5-47.6	0.4	300	149	13.8		60.2	63.01	28.1
S 28.9	5-37.5	2.4	310	135	13.1		63.28	65.99	27.1

Tyre pressures:- Front 28
                  Back 29

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man.Air vacuum ins Hg	temp. F	Mileages:- Begin	2nd	Diff x10
N 37.6	4-15.7	1.5	370	138	12.8	55	66.14	68.81	26.7
S 37.6	4-11.6	3.6	100	137	12.1		69.1	71.73	26.3
N 37.9	4-20.2	1.5	360	140	13.0		71.95	74.69	27.4
S 37.8	4-11.2	3.4	410	137	12.2		74.98	77.62	26.4
N 38.2	4-16.4	1.8	770	139	13.4		77.82	80.54	27.2
S 37.9	4-13.6	3.1	400	136	12.2		80.77	83.44	26.7

Tyre pressures:- Front 29
                  Back 29.5

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man.Air vacuum ins Hg	temp. F	Mileages:- Begin	2nd	Diff x10
N 47.5	3-8.9	2.6	510	142	12.1	53	83.7	86.19	24.9
S 48.0	2-59.7	4.9	670	139	10.8		86.57	88.9	23.3
N 46.9	3-6.4	2.7	540	142	12.0		89.38	91.81	24.3
S 47.2	3-0.2	5.2	590	139	10.7		92.28	94.64	23.6
N 47.0	3-11.5	2.9	560	141	11.9		95.17	97.67	25.0
S 46.9	3-7.3	4.5	580	139	11.0		98.16	00.6	24.4

Tyre pressures:- Front 29   Sample 3.
                  Back 29.5

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man.Air vacuum ins Hg	temp. F	Mileages:- Begin	2nd	Diff x10
N 56.2	2-21.7	4.9	580	144	10.5	58	01.15	03.36	21.1
S 56.0	2-13	7.3	670	1433	7.5		04.05	06.12	20.7
N 57.0	2-22	4.5	640	143	10.0		06.94	09.19	22.4
S 56.6	2-15.6	7.0	650	143	9.0		09.77	11.9	21.3
N 57.0	2-24.1	4.0	650	145	9.5		12.57	14.85	22.8
S 57.1	2-14.5	6.8	660	143	8.8		15.4	17.53	21.3

Tyre pressures:- Front 30
                  Back 30

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man.Air vacuum ins Hg	temp. F	Mileages:- Begin	2nd	Diff x10
N 65.8	1-45.1	6.4	700	149	7.0	61	18.58	20.31	19.5
S 65.9	1-35.2	9.8	730	149	4.5		21.21	22.95	17.4
N 66.8	1-45.2	6.8	690	150	7.5		24.03	25.98	19.5
S 66.1	1-36	10.0	720	150	5.5		26.84	28.6	17.6
N	Insufficient Fuel								
S									

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	13.6	20.1	18.5	19.8

TABLE 30 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.05
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.162

Car Speed in m.p.h.		29.0	37.8	47.1	56.6	66.4
Wind Pressure, inches of water.	N	0.5	1.6	2.7	4.5	6.6
	S	2.6	3.3	4.9	7.0	9.9
Absolute Wind Velocity in direction of motion, m.p.h.		10.6	6.5	6.8	5.8	6.5
Mean Tyre Pressure, lbs/sq ins		28 5	28.9	29.2	29.6	30 3
Mean Air Temperature °Cent.		12.2	13.3	13.9	15.0	16.1
Miles per gallon	N	28.2	27.1	24.7	22.5	19.5
	S	27.0	26.5	23.8	21.1	17.5
Simple Mean M.P.G.		27.6	26.8	24.2	31.8	18.5
Inlet Manifold Pressure, inches of Hg absolute	N	9.4	10.0	11.2	13.2	16.1
	S	10.1	10.9	12.4	14.8	18.4
Average.		9.7	10.4	11.8	14.0	17.2
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	340	415	552	636	678
	S	350	440	587	653	698
Average.		345	427	569	644	688
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	138	139	142	144	150
	S	135	137	139	143	149
Average (converted to Cent.)		58.0	58.9	60.3	62.0	65.3
Temperature Difference, water to air. Degrees Cent.		45.8	45.6	46.4	47.0	49.2
Acceleration Time (seconds)	N	18.5				
	S	20.0			Average:-	19.2

Exhaust Gas Analysis 14.5 %CO_2 0.6 %O_2 0.9 %CO

0.2 %H_2 (estimated)   83.8 %N_2 (by diff)

Remarks:-

TABLE 30 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.0	37.8	47.1	56.6	66.4
Reciprocal Mean M.P.G. of North & South runs.		27.6	26.5	23.2	21.8	18.4
% Correction for:-	a) Wind	3.4	1.0	1.0	0.6	0.6
	b) Weight	-	-	-	-	-
	c) Barometer	-	-	-	-	-
	d) Air Temp.	2.7	2.6	2.6	2.2	1.8
	e) Tyre Press.	-0.3	-0.2	-0.1	0.1	0.1
Total correction- %		5.8	3.4	3.5	2.9	2.5
Corrected Miles per Gallon		29.2	27.8	24.0	22.4	18.9

Table 30 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio 13.15
Average Molecular Weight 75
Mixture Density relative to Air .. 1.047

Speed in m.p.h.	29.0	37.8	47.1	56.6	66.4
Compression Temperature	410	396	374	352	333
" " Pressure	9.5	10.0	11.05	12.7	15.0
Volumetric Efficiency	.222	.242	.283	.346	.432
Ditto to std. Basis	.210	.234	.273	.337	.422
Theoretical Air/Fuel Ratio	10.95	11.7	11.9	13.6	14.6
Air/Fuel ratio (exh. anal.)			13.15		
Weight of exhaust gas per gallon of fuel	94	100	101	116	122.5

Table 30 E Heat Balance

Speed in m.p.h.		29.0	37.6	47.1	56.6	66.4
Heat available from fuel	CHU/gal %	79080 100	79080 100	79080 100	79080 100	79080 100
Heat to tractive effort	CHU/gal %	18500 23.3	21450 27.1	22450 28.4	24900 31.4	24800 31.3
Heat to exhaust (a) Sensible	CHU/gal %	8280 10.5	11070 14.0	15350 19.4	20200 25.5	23000 29.0
(b) Latent	CHU/gal %	3930 5.0	4180 5.3	4220 5.3	4850 6.1	5120 6.5
(c) Unburnt gases	CHU/gal %	?	?	2310 2.9	?	-
Heat to Cooling water	CHU/gal %	40850 51.6	33000 41.7	25550 32.3	21350 27.0	16800 21.2
Unaccounted for	%	(9.6)	(11.9)	11.7	10.0	12.0

FUEL No. 31.

Mixture by volume of:-

10 parts ETHYL ALCOHOL

50 " PETROL

40 " BENZOL

Fuel Data

Composition by weight	Carbon - 84.8 %
	Hydrogen- 11.7 %
	Oxygen - 3.5 %
Higher Calorific Value	82,240 C.H.U. per gallon
	10,330 C.H.U. per lb.
Specific Gravity	.796
Latent Heat	97 C.H.U. per lb.
Kinematic Viscosity	.00618(1-.0089 T-20)

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	56	102	185

Distillation

Percent distilled	10%	50%	End point
Temperature	56	74	142

Table 31A.

8.30.A.M. Barometer-24.7131ns Hg Dry buld-66.0 F Wet bulb-57.9 F
3.00 P.M.   "   24.849 " "   "   "   79.7 F "   "   59.9 F

Approx. load 380 lbs

Initial tyre pressures, lbs/sq ins-front 27, back 28.

Av. speed mph.	Time of run min.sec.	Wind press. insH$_2$O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff×10
N 29.0	4-55.2	2.8	280	145	13.2	72	02.97	05.35	23.8
S 29.3	5-15.5	0.6	270	152	14.0		05.94	08.51	25.7
N 29.2	4-55.6	2.3	300	148	12.9		08.77	11.18	24.1
S 29.0	5-20.7	0.6	270	150	14.1		11.87	14.26	23.9
N 29.6	4-57.1	2.8	290	148	13.0		14.53	16.94	24.1
S 29.3	5-23.4	0.4	280	152	13.8		17.4	20.03	26.3

Tyre pressures:- Front 27
                 Back 27

N 38.4	3-38.7	4.1	380	149	11.8	75	20.22	22.53	23.1
S 38.4	4-16.9	0.8	370	156	12.9		23.1	25.84	27.4
N 38.2	3-38.6	3.6	430	151	12.0		26.15	28.47	23.2
S 38.2	4-22.5	1.5	380	157	13.6		29.03	31.84	27.8
N 38.3	3-39	5.0	440	154	12.2		32.17	34.5	23.3
S 38.2	4-24.7	1.1	380	158	13.8		35.08	37.89	28.1

Tyre pressures:- Front 27
                 Back 28

N -	-	6.7	520	156	10.2	75.5	38.36	40.46	21.0
S 47.6	3-21.4	1.5	570	161	13.0		41.16	43.82	26.6
N 47.5	2-41.3	5.4	580	158	10.3		44.12	46.25	21.3
S 47.6	3-17.5	2.5	520	160	12.4		47.08	49.69	26.1
N 47.3	2-32.3	6.9	570	160	10.4		50.03	52.03	20.0 @
S 47.6	3-16.8	2.7	520	161	12.0		52.9	55.5	26.0 @

Tyre pressures:- Front 27.5   @ Sample 3
                 Back 28

N 57.0	2-6.4	7.8	840	163	7.8	77.5	55.96	57.96	20.0
S 57.0	2-29	4.4	590	167	10.0		58.76	61.12	23.6
N 57.0	2-6.6	7.1	845	165	8.4		61.64	63.64	20.0
S 57.1	2-26.3	4.8	610	168	10.3		64.39	66.71	23.2
N 56.8	2-7.7	8.2	840	167	8.9		67.25	69.26	20.1
S 57.5	2-23	4.8	620	166	9.9		70.08	72.36	22.8

Tyre pressures:- Front 28   Idling poor.
                 Back 29

N 67.0	1-32.4	11.2	720	170	5.8	79	73.18	74.9	17.2
S 67.5	1-44.3	7.0	690	172	6.9		75.85	77.81	19.6
N 67.1	1-35.6	9.5	730	171	5.5		78.81	80.59	17.8
S 67.2	1-47.7	7.0	700	174	6.9		81.47	83.48	20.1
N -	-	9.6	710	173	6.1		84.45	86.25	18.0
S 66.7	1-48.4	7.6	690	173	7.0	79	87.15	89.16	20.1

Tyre pressures:- Front 30
                 Back 31

Acceleration tests

Direction	N	S	N	S
Accel. time in seconds	20.7	20.1	20.6	19.9

TABLE 31 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.02
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.373

Car Speed in m.p.h.		29.2	38.3	47.5	57.1	67.1
Wind Pressure, inches of water.	N S	2.8 0.6	4.2 1.1	6.3 2.2	7.7 4.6	10.1 7.2
Absolute Wind Velocity in direction of motion, m.p.h.		10.3	12.3	12.3	7.0	5.5
Mean Tyre Pressure, lbs/sq ins		27.2	27.2	27.6	28.1	29.5
Mean Air Temperature °Cent.		22.8	23.9	24.4	25.6	26.1
Miles per gallon	N S	24.0 26.0	23.2 27.8	20.8 26.2	20.0 23.2	17.7 19.9
Simple Mean M.P.G.		25.0	25.5	23.5	21.6	18.8
Inlet Manifold Pressure, inches of Hg absolute	N S	10.1 9.1	11.2 9.3	12.5 10.7	14.9 13.1	18.7 16.4
Average.		9.6	10.2	11.6	14.0	17.5
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N S	333 318	455 416	585 532	638 610	694 672
Average.		325	435	558	624	683
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N S	146 151	151 157	158 161	165 166	171 173
Average (converted to Cent.)		64.7	67.8	70.8	74.2	77.8
Temperature Difference, water to air. Degrees Cent.		41.9	43.9	46.4	48.6	51.7
Acceleration Time (seconds)	N S	20.7 20.0			Average:-	20.3

Exhaust Gas Analysis   13.1 %CO$_2$ - %O$_2$ 3.3 %CO

0.7 %H$_2$ (estimated) 82.9 %N$_2$ (by diff)

Remarks:-

TABLE 31 C   M.P.G. converted to Standard Basis.

	29.2	38.3	47.5	57.1	67.1
Car Speed in m.p.h.	29.2	38.3	47.5	57.1	67.1
Reciprocal Mean M.P.G. of North & South runs.	25.0	25.3	23.2	21.5	18.7
% Correction for:- a) Wind	3.2	3.7	3.0	0.8	0.4
b) Weight	-	-	-	-	-
c) Barometer	-	-	-	-	-
d) Air Temp.	-0.9	-1.5	-1.8	-2.4	-2.8
e) Tyre Press.	0.4	0.6	0.5	0.6	0.3
Total correction- %	2.7	2.8	1.7	- 1.0	-2.1
Corrected Miles per Gallon	25.7	26.0	23.6	21.3	18.3

Table **31** D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   13.65

Average Molecular Weight   81

Mixture Density relative to Air   1.049

Speed in m.p.h.	29.2	38.3	47.5	57.1	67.1
Compression Temperature	431	418	3?	368	346
" " Pressure	9.4	9.8	10.85	12.7	15.3
Volumetric Efficiency	.210	.225	.265	.331	.424
Ditto to std. Basis	.205	.220	.260	.334	.433
Theoretical Air/Fuel Ratio	9.2	10.1	10.85	12.75	14.3
Air/Fuel ratio (exh. anal.)	-	-	12.5	-	-
Weight of exhaust gas per gallon of fuel	81	88	94.5	109.5	122

Table **31** E   Heat Balance

Speed in m.p.h.		29.2	38.3	47.5	57.1	67.1
Heat available from fuel	CHU/gal %	82240 100	82240 100	82240 100	82240 100	82240 100
Heat to tractive effort	CHU/gal %	16250 19.6	20100 24.4	22100 26.8	23650 28.8	24000 29.2
Heat to exhaust (a) Sensible	CHU/gal %	6700 8.1	9550 11.8	14030 17.1	18400 22.3	22700 27.6
(b) Latent	CHU/gal %	3280 4.0	3560 4.3	3820 4.6	4430 5.4	4930 6.0
(c) Unburnt gases	CHU/gal %	?	?	7900 9.6	?	?
Heat to Cooling water	CHU/gal %	32400 39.3	29500 35.8	25100 30.5	21150 25.7	17300 21.0
Unaccounted for	%	(29.0)	(23.7)	11.4	(17.8)	(16.2)

FUEL No. 32

Mixture by volume of:-

30 parts ETHYL ALCOHOL

60 " PETROL

10 " BENZOL

Fuel Data

Composition by weight	Carbon - 75.7 %		
	Hydrogen- 13.6 %		
	Oxygen - 10.9 %		
Higher Calorific Value	75,360 C.H.U. per gallon		
	9,900 C.H.U. per lb.		
Specific Gravity	.760		
Latent Heat	118 C.H.U. per lb.		
Kinematic Viscosity	.00778(1-.0133 $\overline{t-20}$)		

Vapour pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	60	114	210

Distillation

Percent distilled	10%	50%	End point
Temperature	55	67.5	140

Fuel No. 32 30% Alcohol-60% Petrol-10% Benzol <u>14th September P.M.</u>

<u>Table 32A</u>

8.30 A.M. Barometer-24.751 ins Hg Dry bulb-61.3 F Wet bulb-52.8 F
3.00 P.M.   "   24.681 " "   "   78.8 F   "   "   57.7 F

Approx. load   490 lbs

Initial tyre pressures, lbs/sq ins- front 26.5, back 28.

Av. speed MPH.	Time of run min.sec.	Wind press. insH2O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 28.7	5-17.5	1.8	290	150	13.2	86	70.45	72.98	25.3
S 28.7	6-0.8	0.4	310	150	13.0		73.49	76.37	28.8
N 28.8	5-26.3	1.4b	300	150	13.5		76.74	79.35	26.1
S 29.5	6-3.7	1.2	290	153	13.8		79.68	82.55	28.7
N 29.1	5-27.7	1.6	300	152	13.0		82.85	85.46	26.1
S 28.8	6-5.8	1.0	300	150	13.5		85.95	88.88	29.3

Tyre pressures:- front 28
                back 29.5

N 37.9	3-50.9	2.4	400	152	13.0	86	89.35	91.78	24.3
S 38.1	4-20.5	1.6	390	151	13.0		82.41	85.17	27.6
N 37.6	3-53.8	3.0	480	154	11.8		95.54	98.0	24.4
S 38.2	4-25.5	1.7	420	157	13.5		98.41	01.23	28.2
N 37.8	4-0.8	4.5	460	159	11.0		01.57	04.1	25.3
S 37.7	4-27.2	2.4	430	158	13.0		04.55	07.35	28.0

Tyre pressures:- front 28
                back 30

N 47.4	2-51.2	4.7	520	160	9.8	86	07.63	09.88	22.5
S 47.3	3-7.2	3.5	520	157	10.8		10.74	13.2	24.6
N 47.0	2-56.2	3.8	530	161	11.8		13.7	16.0	23.0
S 47.5	3-11	3.1	520	162	11.0		16.65	19.17	25.2
N -	-	4.0	540	161	9.5		19.54	21.8	22.6
S 47.4	3.0	3.2	520	159	11.5		22.46	24.95	24.9

Tyre pressures:- front 29   @ Sample 2.
                back 30

N -	-	6.8	580	160	6.8	86	25.48	27.39	19.1
S 56.9	2-17.4	4.8	580	161	9.5		28.33	30.5	21.7
N 57.2	2-6	6.7	610	160	8.8		31.15	33.15	20.0
S 57.2	2-11.5	4.5	590	163	8.7		33.96	36.05	20.9
N -	-	6.8	560	161	8.0		36.85	38.86	20.1
S -	-	4.7	590	163	9.5		39.61	41.9	22.9

Tyre pressures:- front 29
                back 31

N 68.0	1-39	9.0	680	167	4.0	85	42.67	44.35	16.8
S 66.7	1-23.7	9.0	670	171	7.0		64.2	65.75	15.5
S 67.1	1-37.1	7.2	650	164	6.0		52.9	54.71	18.1
N -	-	7.4	670	167	5.8		55.75	57.5	17.5
S 68.0	1-32.8	9.5	690	166	5.0		58.7	60.45	17.5
N 67.5	1-28.4	8.0	670	169	6.0		61.67	63.33	16.6

Tyre pressures:- front 31.5
                back 32

<u>Acceleration tests.</u>

Direction   N   S   N   S
Accel. time in seconds   22.2 21.3 22.0 21.8

TABLE 32   B.   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.06
 Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.504

Car Speed in m.p.h.		28.8	37.9	47.3	57.1	67.6
Wind Pressure, inches of water.	N	1.6	3.3	4.2	6.8	8.2
	S	0.9	1.9	3.3	4.7	8.1
Absolute Wind Velocity in direction of motion, m.p.h.		3.7	5.1	3.0	5.0	0.8
Mean Tyre Pressure, lbs/sq ins		28	28.7	29.2	29.7	30.0
Mean Air Temperature °Cent.		30.0	30.0	30.0	29.4	29.4
Miles per gallon	N	26.1	24.7	22.7	19.7	17.5
	S	28.9	27.9	24.9	21.9	16.6
Simple Mean M.P.G.		27.5	26.3	23.8	20.7	17.0
Inlet Manifold Pressure, inches of Hg absolute	N	10.0	11.3	12.9	15.4	18.5
	S	9.7	10.0	12.2	14.1	17.1
Average.		9.8	10.6	12.4	14.7	17.8
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	346	438	557	600	662
	S	348	417	547	596	657
Average.		347	427	552	598	659
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	151	155	160	160	166
	S	152	155	159	162	169
Average (converted to Cent.)		66.4	68.3	70.8	71.7	75.3
Temperature Difference, water to air. Degrees Cent.		36.4	38.3	40.8	42.3	45.9
Acceleration Time (seconds)	N	22.0				
	S	21.5		Average:- 21.7		

Exhaust Gas Analysis   %CO₂   %O₂   %CO

SAMPLE   LOST.   %H₂ (estimated)   %N₂ (by diff)

Remarks:-

TABLE 32 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.8	37.9	47.3	57.1	67.6
Reciprocal Mean M.P.G. of North & South runs.		27.4	26.2	23.8	20.7	17.0
% Correction for:-	a) Wind	0.4	0.6	0.2	0.4	-
	b) Weight	1.5	1.3	1.1	0.9	0.7
	c) Barometer	0.1	0.1	0.1	0.1	0.1
	d) Air Temp.	-3.4	-3.8	-4.1	-4.1	-4.4
	e) Tyre Press.	-	-0.1	-0.1	-0.1	0.2
Total correction- %		-1.4	-1.9	-2.8	-2.6	-3.4
Corrected Miles per Gallon		27.0	25.7	23.0	20.2	16.4

Table 32   D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   12.9

Average Molecular Weight   71

Mixture Density relative to Air 1.046

Speed in m.p.h.	28.8	37.9	47.3	57.1	67.6
Compression Temperature	432	415	387	362	345
" " Pressure	9.5	10.2	11.6	13.3	15.5
Volumetric Efficiency	.212	.235	.287	.351	.432
Ditto to std. Basis	.215	.239	.295	.361	.447
Theoretical Air/Fuel Ratio	10.7	11.4	12.7	13.7	13.85
Air/Fuel ratio (exh. anal.)	-	-	-	-	-
Weight of exhaust gas per gallon of fuel	89	94.5	104	112	113

Table   32   E   Heat Balance

Speed in m.p.h.		28.8	37.9	47.3	57.1	67.6
Heat available from fuel	CHU/gal %	75360 100	75360 100	75360 100	75360 100	75360 100
Heat to tractive effort	CHU/gal %	17100 22.7	19850 26.4	21500 28.5	22450 29.8	21500 28.6
Heat to exhaust (a) Sensible	CHU/gal %	7900 10.5	10480 13.9	15250 20.3	17950 23.8	20200 26.8
(b) Latent	CHU/gal %	4170 5.5	4420 5.9	4870 6.5	5250 7.0	5300 7.0
(c) Unburnt gases	CHU/gal %	?	?	??	?	?
Heat to Cooling water	CHU/gal %	28800 38.3	24750 32.8	20900 27.7	16520 22.4	13300 17.7
Unaccounted for	%	(23.0)	(21.0)	17.0	17.0	(19.9)

FUEL No. 33.

Mixture by volume of:-

                20 parts ETHYL ALCOHOL

                60 "   PETROL

                20 "   BENZOL

Fuel Data

Composition by weight

                          Carbon - 79.8 %

                          Hydrogen- 13.0 %

                          Oxygen - 7.2 %

Higher Calorific Value   78,520 C.H.U. per gallon.

                          10,190 C.H.U. per lb.

Specific Gravity   .771

Latent Heat   107 C.H.U. per lb.

Kinematic Viscosity   .00668(1-.0108 T-20)

Vapour Pressure

          Temperature   10 C   20 C   30 C
          V.P. in mm. of Hg   61   115   215

Distillation

          Percent distilled   10%   50% End point
          Temperature   53   64.5   152

Fuel No.33   20% Alcohol-60% Petrol-20% Benzol   9th September P.M.

Table 33A

8.30 A.M.   Barometer-24.840 ins Hg Dry bulb-59.7 F Wet bulb-49.0 F
3.00 P.M.   "   24.719 "   "   "   "   75.1 F "   "   53.2 F

Approx. load 420 lbs.
Initial Tyre pressure Front 29, back 29, lbs per sq ins.

Av. speed mph.	Time of run min.sec.	Wind press. ins H₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
N 31.4	5-7.2	1.2	310	146	13.7	79	48.12	50.8	26.8
S 28.1	5-51	2.0	300	144	13.1		51.16	53.9	2?.4
N 28.5	5-49	0.8	290	146	13.7		54.11	56.87	27.6
S 28.4	6-0.3	1.7	320	143	13.0		57.15	59.99	28.4
N 28.3	6-0	0.9	280	147	13.9		60.31	63.14	28.3
S 28.5	5-57.4	1.8	300	142	13.9		63.4	66.23	28.3

Tyre pressures:-   Front 30
                    Back 30.5

Av. speed mph.	Time of run min.sec.	Wind press. ins H₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
N 38.7	4-20.2	1.2	350	152	14.8	82	66.49	69.18	26.9
S 39.0	4-17	2.5	390	149	13.0		69.47	72.15	26.8
N 38.9	4-20.5	1.2	360	153	13.2		72.35	75.05	27.0
S 39.2	4-21.6	3.4	360	148	13.5		75.3	78.04	27.4
N 38.9	4-20.7	1.5	350	152	13.8		78.28	80.99	27.1
S 38.9	4-21.6	3.0	365	147	12.9		81.28	84.0	27.2

Tyre pressures:-   Front 30
                    Back 31

Av. speed mph.	Time of run min.sec.	Wind press. ins H₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
N 46.7	3-6.6	3.3	480	154	12.1	81	84.45	86.68	24.3
S 46.7	3-6.6	4.0	530	152	11.0		87.25	89.67	24.2
N -	-	3.0	520	156	12.0		90.04	92.54	25.0
S 47.1	3-8	3.8	560	152	11.0		92.9	95.56	24.6 @
N 46.8	3-12.5	4.2	520	156	12.0		95.7	98.2	25.0
S 46.0	3-7.7	5.0	550	152	11.5		98.54	00.98	24.0

Tyre pressures:-   Front 30.5   @ Sample 2.
                    Back 31.5

Av. speed mph.	Time of run min.sec.	Wind press. ins H₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
N 57.8	2-22.2	3.8	645	161	9.8	82	01.5	03.78	22.8
S 57.5	2-10.4	7.5	660	160	8.0		04.25	06.33	20.8
N 56.6	2-20.5	4.5	630	159	10.0		07.09	09.3	22.1
S 57.2	2-14.1	6.5	680	160	7.8		09.88	12.01	21.3
N 57.0	2-19.7	4.0	650	159	9.8		12.6?	14.9	22.1
S 56.8	2-16.3	7.4	660	160	8.8		15.??	17.8	21.5

Tyre pressures:-   Front 31.5
                    Back 30

Av. speed mph.	Time of run min.sec.	Wind press. ins H₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diff x10
N 67.1	1-44.1	6.0	690	165	7.0	81	18.81	20.55	19.4
S 68.0	1-36	10.0	730	165	4.5		21.64	23.45	18.1
N 66.9	1-43.3	7.0	700	167	6.5		24.23	26.15	19.2
S 68.0	1-35.5	8.5	710	166	5.2		27.05	28.85	18.0
N 68.5	1-41.5	7.7	720	166	5.0		29.9	31.83	19.3
S 67.3	1-30.5	9.5	700	165	6.0		33.09	34.78	16.9

Tyre pressures:-   Front 32
                    Back 33

Acceleration tests

Direction	N	S	N	S	N	S
Accel. time in seconds	20.89	22.0	19.8	21.6	20.0	21.0

TABLE 33 B. Summarised Results of Table A.

Mean Barometric Pressure corrected for altitude. Ins of Hg	25.12	
Vapour Pressure of moisture in atmosphere (Average). Ins of Hg	0.300	

Car Speed in m.p.h.		28.4	38.8	46.7	57.1	67.6
Wind Pressure, inches of water.	N	1.0	1.3	3.5	4.1	7.0
	S	1.8	3.0	4.3	7.1	9.3
Absolute Wind Velocity in direction of motion, m.p.h.		3.8	2.8	2.3	7.0	4.8
Mean Tyre Pressure, lbs/sq ins		29.6	30.4	30.8	30.9	31.6
Mean Air Temperature °Cent.		26.7	27.5	27.5	27.5	27.2
Miles per gallon	N	27.9	27.0	24.8	22.3	19.3
	S	28.3	27.1	24.3	21.2	17.7
Simple Mean M.P.G.		28.1	27.0	24.5	21.7	18.5
Inlet Manifold Pressure, inches of Hg absolute	N	10.4	10.6	11.3	13.5	17.5
	S	10.8	11.1	12.1	15.2	18.3
Average.		10.6	10.8	11.7	14.3	17.8
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	332	398	526	640	684
	S	365	410	565	655	690
Average.		348	404	545	647	687
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N	146	152	155	160	166
	S	143	148	152	160	165
Average (converted to Cent.)		62.5	65.6	67.5	71.1	74.3
Temperature Difference, water to air. Degrees Cent.		35.8	38.1	40.0	43.6	47.0
Acceleration Time (seconds)	N	20.2				
	S	21.5		Average:- 20.8		

Exhaust Gas Analysis   13.1 %CO_2 1.9 %O_2 0.2 %CO

       %H_2 (estimated)   84.9 %N_2 (by diff)

Remarks.-

TABLE 33 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		28.4	38.8	46.7	57.1	67.6
Reciprocal Mean M.P.G. of North & South runs.		28.1	27.0	24.5	21.7	18.4
% Correction for:-	a) Wind	0.4	1.2	0.1	0.8	0.3
	b) Weight	0.6	0.5	0.4	0.4	0.3
	c) Barometer	0.1	0.2	0.3	0.3	0.3
	d) Air Temp.	-2.3	-2.8	-3.0	-3.2	-3.3
	e) Tyre Press.	-0.8	-0.8	-0.6	-0.3	-0.2
Total correction- %		-2.0	-1.7	-2.8	-2.0	-2.6
Corrected Miles per Gallon		27.6	26.6	23.8	21.3	17.9

Table 33 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   13.3

Average Molecular Weight   75

Mixture Density relative to Air   1.048

Speed in m.p.h.	28.4	38.8	46.7	57.1	67.6
Compression Temperature	414	410	397	368	346
" " Pressure	10.4	10.45	10.9	12.»	15.6
Volumetric Efficiency	.240	.244	.263	.336	.432
Ditto to std. Basis	.245	.248	.270	.343	.442
Theoretical Air/Fuel Ratio	12.5	12.2	11.85	13.55	14.8
Air/Fuel ratio (exh. anal.)	-	-	14.4	-	-
Weight of exhaust gas per gallon of fuel	104	101.5	99	112	121.5

Table 33 E   Heat Balance

Speed in m.p.h.		28.4	38.8	46.7	57.1	67.6
Heat available from fuel	CHU/gal %	78520 100	78520 100	78520 100	78520 100	78520 100
Heat to tractive effort	CHU/gal %	17450 22.2	20500 26.1	22250 28.2	23700 30.1	23450 29.8
Heat to exhaust (a) Sensible	CHU/gal %	9250 11.7	10600 13.4	14300 18.2	19600 24.9	22800 28.9
(b) Latent	CHU/gal %	4350 5.5	4250 5.4	4150 5.3	4680 5.9	5080 6.5
(c) Unburnt gases	CHU/gal %	?	?	410 0.5	-	-
Heat to Cooling water	CHU/gal %	28900 36.7	25450 32.3	21100 26.8	18450 23.4	15000 19.0
Unaccounted for	%	(23.9)	(22.8)	21.0	15.7	15.8

FUEL No. 34.

Mixture by volume of:-

 10 parts ETHYL ALCOHOL
 60 " PETROL
 30 " BENZOL

Fuel Data

Composition by weight	Carbon - 84.0 %
	Hydrogen -12.4 %
	Oxygen - 3.6 %
Higher Calorific Value	81,680 C.H.U. per gallon.
	10,450 C.H.U. per lb.
Specific Gravity	.783
Latent Heat	98 C.H.U. per lb.
Kinematic Viscosity	$.00593(1-.0076 \frac{t}{t-25})$

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	62	115	220

Distillation

Percent distilled	10%	50%	End point
Temperature °C	54	78	141

Fuel No. 34   10% Alcohol-60% Petrol-30% Benzol   24th September P.M.

Table 34A

| 8.30 A.M. | Barometer-24.706 ins Hg | Dry bulb-49.7 F | Wet bulb-41.6 F |
| 3.00 P.M. | "   24.699 " " | "   71.3 F | "   "   51.0 F |

Approximate load 340 lbs.

Initial tyre pressures,lbs/sq ins- front 27, back 27.5.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Miffx10	
N 29.5	5-14.7	1.2	325	143	13.1	66	74.9	77.48	25.8	
S 28.8	5-35.5	1.4	300	143	13.6		77.75	80.44	26.9	
N 29.1	5-25.5	1.0	310	144	13.7		80.57	83.2	26.3	
S 29.1	5-37.9	1.3	310	144	13.8		83.45	86.18	27.3	
N 29.0	5-24.1	1.0	300	145	14.0		86.34	88.15	26.1	
S 29.0	5-38	1.7	320	143	13.3		89.22	91.93	27.1	

Tyre pressures:- front 27.5 back 28.5

N 38.1	4-5	2.0	360	147	13.8	70	92.11	94.7	25.9	
S 38.1	4-19.8	2.4	400	146	13.0		94.94	97.6	26.6	
N 38.1	4-6.6	1.7	380	148	13.3		97.82	00.43	26.1	
S 38.2	4-14.2	2.7	410	147	13.0		00.67	03.37	27.0	
N 38.0	4-5.7	1.5	370	149	13.6		03.61	06.2	25.9	
S 37.9	4-18.6	2.6	395	146	13.0		06.5	09.22	27.2	

Tyre pressures:- front 28 back 29

N 47.4	3-56.4	3.4	550	150	11.9	70	09.42	11.8	23.5	
S 47.4	3-5.8	3.8	560	150	11.5		12.36	14.82	24.4	@
N 47.6	3-3.7	3.6	570	152	12.0		15.22	17.65	24.3	@
S 47.5	3-8.8	4.6	580	150	11.4		18.07	20.55	24.8	
N 47.5	3-5.9	2.8	550	152	12.1		20.89	23.34	24.5	
S 47.5	3-5.9	4.2	580	151	11.5		23.75	26.20	24.5	

Tyre pressures:- front 29 back 30   @ Sample 2.

N 57.3	2-15.9	5.0	650	157	9.8	73	26.64	28.8	21.5	
S 57.3	2-18.9	6.2	660	155	9.5		29.47	31.68	22.1	
N 57.5	2-18.3	4.8	640	157	10.3		32.3	34.51	22.1	
S -	-	6.2	650	156	9.6		35.16	37.38	22.2	
N 57.4	2-20	4.6	655	157	9.8		37.96	40.19	22.3	
S 57.8	2-15.8	6.0	660	158	9.6		40.78	42.96	21.8	

Tyre pressures:- front 30 back 30

N 68.1	1-38.3	8.0	710	162	6.3	73	43.82	45.68	18.6	
S 67.5	1-40.4	8.0	720	163	7.0		46.56	48.44	18.8	
N 67.7	1-41.7	7.4	700	161	7.5		51.4	53.31	19.1	
S 67.0	1-36.8	9.0	740	162	6.0		54.08	55.88	18.0	
" 67.8	1-42.6	6.8	720	164	7.0		56.96	58.89	19.3	
S 67.4	1-38.4	8.3	725	164	6.8		59.72	61.56	18.4	

Tyre pressures:- front 30 back 32.5

Acceleration tests.

Direction	N	S	N	S
Accel. time in seconds	19.1	20.6	19.1	19.9

TABLE 34 B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.040
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.184

Car Speed in m.p.h.		29.1	38.1	47.5	57.5	67.6
Wind Pressure, inches of water.	N S	1.1 1.5	1.7 2.6	3.3 4.2	4.8 6.1	7.4 8.4
Absolute Wind Velocity in direction of motion, m.p.h.		2.3	3.5	2.5	3.2	2.0
Mean Tyre Pressure, lbs/sq ins		27.6	28.2	29	29.8	30.6
Mean Air Temperature °Cent.		20.6	21.1	21.7	22.8	23.3
Miles per gallon	N S	26.1 27.1	26.0 26.9	24.1 24.6	22.0 22.0	19.0 18.4
Simple Mean M.P.G.		26.6	26.4	24.3	22.0	18.7
Inlet Manifold Pressure, inches of Hg absolute	N S	9.5 9.5	9.5 10.1	11.1 11.7	13.2 13.6	16.4 16.7
Average.		9.5	9.8	11.4	13.4	16.5
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N S	355 352	410 440	570 585	640 648	685 705
Average.		353	425	577	644	696
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N S	144 143	148 146	151 150	157 156	162 163
Average (converted to Cent.)		62.0	63.9	65.8	69.1	72.5
Temperature Difference, water to air. Degrees Cent.		41.4	42.8	44.1	46.3	49.2
Acceleration Time (seconds)	N S	19.1 20.3			Average:-	19.7

Exhaust Gas Analysis   13.8 %CO$_2$ - %O$_2$ 2.4 %CO

0.5 %H$_2$ (estimated)   83.3 %N$_2$ (by diff)

Remarks:-

TABLE 34 C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.		29.1	38.1	47.5	57.5	67.6
Reciprocal Mean M.P.G. of North & South runs.		26.6	26.4	24.3	22.0	18.7
% Correction for:-	a) Wind	0.2	0.2	0.2	0.2	0.1
	b) Weight	-0.3	-0.3	-0.3	-0.2	-0.2
	c) Barometer	-	-	0.1	0.1	0.1
	d) Air Temp.	-0.2	-0.4	-0.6	-1.2	-1.5
	e) Tyre Press.	-0.2	0.1	-	-	0.1
Total correction- %		-0.1	-0.4	-0.6	-1.1	-1.4
Corrected Miles per Gallon		26.6	26.3	24.2	21.8	18.4

Table 34 D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   13.8
Average Molecular Weight   83
Mixture Density relative to Air   1.05

Speed in m.p.h.	29.1	38.1	47.5	57.5	67.6
Compression Temperature	431	425	394	371	349
" " Pressure	9.3	9.4	10.7	12.15	14.45
Volumetric Efficiency	.207	.212	.261	.314	.398
Ditto to std. Basis	.207	.213	.262	.317	.403
Theoretical Air/Fuel Ratio	9.3	10.0	11.1	12.5	13.55
Air/Fuel ratio (exh. anal.)	-	-	12.95	-	-
Weight of exhaust gas per gallon of fuel	84.5	86	94.7	106	114

Table 34 E Heat Balance

Speed in m.p.h.		29.1	38.1	47.5	57.5	67.6
Heat available from fuel	CHU/gal %	81680 100	81680 100	81680 100	81680 100	81680 100
Heat to tractive effort	CHU/gal %	16800 20.6	20300 24.8	22600 27.6	24200 29.6	24100 29.5
Heat to exhaust (a) Sensible	CHU/gal %	7630 9.3	9470 11.6	14600 17.8	18450 22.5	21700 26.5
(b) Latent	CHU/gal %	3550 4.3	3610 4.4	3980 4.9	4450 5.4	4800 5.9
(c) Unburnt gases	CHU/gal	?	?	5700	?	?
Heat to Cooling water	CHU/gal %	33100 40.5	29000 35.4	24200 29.6	20350 24.9	16350 20.0
Unaccounted for	%	(28.5)	(23.8)	13.1	(17.6)	(18.1)

Fuel No. 34(1) 10% Alcohol-60% Petrol-30% Benzol   25th October A.M.

Table 34(1) A.

8.30 A.M.   Barometer-24.926 ins Hg   Dry bulb-57.0 F Wet bulb-54.7 F
3.00 P.M.   "   24.857 " "   "   "   " 67.8 F "   "   59.6 F

Approximate load 380 lbs.

Initial tyre pressures:- front 27, back 28 lbs/sq ins.

Av. speed mph.	Time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 29.2	4-38.5	2.7	320	174	12.6	61	17.94	20.2	22.6
S 29.3	4-57.3	0.5	300	180	13.1		20.94	23.36	24.2
N 28.8	4-40.7	2.6	310	176	12.8	61.5	23.8	26.05	22.5
S 28.7	5-2.1	0.7	280	180	13.3		26.71	29.12	24.1
N 28.8	4-41.3	2.7	300	177	12.7	62	29.54	31.79	22.5
S 29.0	4-58.5	0.8	285	179	13.2		32.39	34.79	24.0
Tyre pressures:- front 27 back 28									
N 37.8	3-24.6	4.0	390	177	11.9	63	35.28	37.43	21.5
S 37.7	4-1.6	1.7	380	181	13.0		38.15	40.68	25.3
N 38.1	3-30	4.3	430	178	11.7	62	41.0	43.22	22.2
S 38.0	4-1.8	1.5	400	181	13.1		43.85	46.43	25.8
N 37.7	3-29.4	4.1	410	181	11.7	62	46.69	48.88	21.9
S 38.0	4-3.8	1.5	410	181	13.0		49.57	52.14	25.7
Tyre pressures:- front 28 back 29									
N 47.2	2-36.4	5.8	500	180	10.8	62.5	52.5	54.55	20.5
S 46.9	3-2.9	2.5	460	183	11.7		55.32	57.7	23.8
N 46.9	2-39.6	5.5	520	181	10.8	62.5	58.15	60.23	20.8
S 47.3	3-1.9	3.0	510	183	11.6		61.04	63.43	24.3
N 47.4	2-39.6	5.6	510	183	10.5	64	63.87	65.97	21.0
S 46.8	3-3.2	2.8	500	184	11.0		66.7	69.12	24.2
Tyre pressures:- front 28 back 30 Sample 3.									
N 56.7	2-28.9	8.0	570	185	8.8	65.5	69.67	71.54	18.7
S 56.4	2-49.1	4.0	530	186	9.5		72.48	74.66	21.8
N 56.4	2-30.9	8.4	570	185	8.2	66	75.35	77.24	18.9
S 57.3	2-45.8	4.5	520	188	9.3		78.16	80.32	21.6
N 57.0	2-25.9	9.2	580	187	7.9	66	81.06	82.94	18.8
S 57.0	2-45.1	4.2	580	189	9.6		85.39	87.53	21.4
Tyre pressures:- front 29 back 30									
N 65.1	1-26.9	12.5	630	190	4.5	67	88.54	90.11	15.7
S 66.6	1-46	5.8	600	192	6.0		91.36	93.32	19.6
N 68.0	1-25.3	11.9	670	191	4.8	67	94.16	95.77	16.1
S 66.8	1-46.2	6.0	580	194	7.1		96.78	98.75	19.7
N 67.2	1-26.3	12.2	630	192	4.2	67	98.57	01.18	16.1
S 66.5	1-35.9	6.1	670	193	6.8		02.45	04.22	(17.7)
Tyre pressures:- front 30 back 31									

Acceleration tests

Direction	N	S
Accel. time in seconds	23.0	21.0

<u>TABLE 34(1)B.</u>   Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   25.23
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.420

Car Speed in m.p.h.		29.0	37.9	47.1	56.8	66.7
Wind Pressure, inches of water.	N	2.7	4.1	5.6	8.5	12.8
	S	0.7	1.6	2.8	4.2	6.0
Absolute Wind Velocity in direction of motion, m.p.h.		9.5	9.0	8.0	9.6	11.7
Mean Tyre Pressure, lbs/sq ins		27.5	28	29	29.5	30
Mean Air Temperature °Cent.		16.4	16.9	17.2	18.9	19.4
Miles per gallon	N	22.5	21.9	20.8	18.8	16.0
	S	24.1	25.6	24.1	21.6	19.6
Simple Mean M.P.G.		23.3	23.7	22.4	20.2	17.8
Inlet Manifold Pressure, inches of Hg absolute	N	10.6	11.6	12.8	15.2	19.1
	S	10.1	10.3	11.8	13.9	16.9
Average.		10.3	10.9	12.3	14.5	18.0
Exhaust Gas Temperature degrees Centigrade. (above atmospheric)	N	352	448	532	585	638
	S	332	435	520	560	620
Average.		342	440	526	572	629
Cooling Water Temperature at entrance to radiator, degrees Fahrenheit.	N *	136	139	140	146	151
	S *	139	140	142	147	152
Average (converted to Cent.)		58.6	59.7	60.7	63.6	66.4
Temperature Difference, water to air. Degrees Cent.		42.2	42.8	43.5	44.7	47.0
Acceleration Time (seconds)	N	23.0				
	S	21.0		Average:-		22.0

Exhaust Gas Analysis 13.13   %CO₂   -   %O₂   2.7 %CO

0.6   %H₂ (estimated)   83.4   %N₂ (by diff)

Remarks:-   * corrected.

<u>TABLE 34(1)C</u>   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	29.0	37.9	47.1	56.8	66.7
Reciprocal Mean M.P.G. of North & South runs.	23.2	23.6	22.3	20.1	17.6
% Correction for:- a) Wind	2.7	2.0	1.3	1.6	1.5
b) Weight	0.1	0.1	0.1	0.1	-
c) Barometer	0.3	0.4	0.5	0.6	0.7
d) Air Temp.	1.2	1.2	1.2	0.5	0.3
e) Tyre Press.	0.3	0.2	-	0.2	0.2
Total correction- %	4.6	3.9	3.1	3.0	2.7
Corrected Miles per Gallon	24.3	24.5	23.0	20.8	18.1

Table 34(1) D Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio 13.8

Average Molecular Weight 83

Mixture Density relative to Air 1.05

Speed in m.p.h.	29.0	37.9	47.1	56.8	66.7
Compression Temperature	405	394	374	355	335
" " Pressure	10.1	10.5	11.5	13.15	15.8
Volumetric Efficiency	.239	.255	.295	.355	.452
Ditto to std. Basis	.229	.246	.286	.345	.441
Theoretical Air/Fuel Ratio	9.9	10.9	11.9	13.1	14.7
Air/Fuel ratio (exh. anal.)	-	-	12.85	-	-
Weight of exhaust gas per gallon of fuel	85.5	93	101	110.5	123

Table 34(1) E Heat Balance

Speed in m.p.h.		29.0	37.9	47.1	56.8	66.7
Heat available from fuel	CHU/gal %	81680 100	81680 100	81680 100	81680 100	81680 100
Heat to tractive effort	CHU/gal %	15400 18.8	18900 23.1	21500 26.3	23100 28.3	23700 29.0
Heat to exhaust (a) Sensible	CHU/gal %	7450 9.1	10650 13.0	14050 17.2	16750 20.5	20800 25.4
(b) Latent	CHU/gal %	3600 4.4	3900 4.8	4250 5.2	4600 5.7	5160 6.3
(c) Unburnt gases	CHU/gal %	?	?	6860 8.4	?	?
Heat to Cooling water	CHU/gal %	30900 (37.9)	27000 (33.0)	22600 (27.6)	18600 (22.7)	15150 (18.5)
Unaccounted for	%	(29.8)	(26.1)	15.3	(22.8)	(20.8)

FUEL No. 35

Mixture by volume of:-

20 parts ETHYL ALCOHOL

70 " PETROL

10 " BENZOL

Fuel Data

Composition by weight

Carbon - 79.0 %

Hydrogen - 13.7 %

Oxygen - 7.3 %

Higher Calorific Value

77,960 C.H.U. per gallon

10,240 C.H.U. per lb.

Specific Gravity

.761

Latent Heat

105 C.H.U. per lb.

Kinematic Viscosity

$.00690(1-.0120 \overline{T-20})$

Vapour Pressure

Temperature	10 C	20 C	30 C
V.P. in mm. of Hg	75	140	250

Distillation

Percent distilled	10%	50%	End point
Temperature	52	65	155

Fuel No.35. 20% Alcohol-70% Petrol-10% Benzol

Table 35A.

8.30. A.M. Barometer-24.708 ins Hg Dry bulb-61.0 F Wet bulb-55.9 F
3.00 P.M.   "   24.559 "   "   "   " 77.9 F "   " 59.8 F

Approx. load   340 lbs
Initial tyre pressures, lbs/sq ins- Front 28, back 27.5.

Av. speed mph.	time of run min.sec.	Wind press. insH₂O	Exh. temp. galvo	Water temp. F	In.man. vacuum ins Hg	Air temp. F	Mileages:- Begin	End	Diffx10
N 29.0	4-54.3	2.6	290	148	12.7	80	59.28	51.65	23.7
S 29.1	5-39.5	0.7	285	155	13.9		52.3	55.04	27.4
N 28.6	5-7.1	2.0	280	151	12.8		55.27	57.7	24.3
S 28.8	5-47.4	1.1	270	158	14.0		58.28	61.06	27.8
N 28.8	5-58.7	3.2	290	150	12.8		61.21	63.8	23.9
S 28.9	5-48.2	0.7	275	159	14.0		64.26	67.06	28.0

Tyre pressures:- Front 28.5
                  Back 29.

N 37.7	3-44.7	3.9	380	157	12.7	82	67.7	69.55	23.5
S 37.9	4-22.2	1.3	370	161	13.7		70.21	72.98	27.7
N 37.5	3-46.7	3.0	440	162	12.3		73.24	75.6	23.6
S 38.5	4-19.7	1.9	390	161	13.0		76.32	79.1	27.8
N 38.6	3-38.1	4.5	460	158	12.4		79.3	81.64	23.4
S 38.5	4-21	1.6	370	162	13.8		82.31	85.1	27.9

Tyre pressures:- Front 29
                  Back 30.

N 47.0	2-37	6.0	580	163	11.6	83	85.36	87.41	20.5
S 47.5	3-9.6	2.0	550	166	11.9		88.16	90.66	25.0
N 47.9	2-37.6	5.3	580	165	11.0		91.1	93.2	21.0
S 47.5	3-6.3	3.4	540	166	12.4		93.9	96.36	24.6
N 48.9	2-43.6	6.6	570	164	10.9		96.72	98.85	21.3
S 47.8	3-14.3	2.8	560	168	11.8		99.52	02.1	25.8

Tyre pressures:- Front 30   Sample 3.
                  Back 30

N 57.3	1-59.6	7.8	560	170	7.3	83	02.5	04.4	19.0
S 57.9	2-20	4.0	620	169	9.5		05.24	07.49	22.5
N 58.2	1-57.6	7.7	650	168	8.0		08.1	10.0	19.0
S 58.0	2-18.3	4.7	630	171	9.8		10.94	13.17	22.3
N 56.6	2-1.5	9.0	660	170	7.9		13.77	15.63	19.1
S 57.7	2-18.4	3.8	630	173	9.6		16.53	18.75	22.2

Tyre pressures:- Front 30
                  Back 31.

N 67.7	1-25.1	11.7	740	174	4.5	83	19.68	21.28	16.0
S 67.4	1-43.7	7.3	700	176	6.7		22.24	24.18	19.4
N 67.0	1-27.6	10.0	740	175	4.2		25.14	26.77	16.3
S 67.5	1-46.1	7.2	710	177	6.5		27.71	29.7	19.9
N 67.5	1-26.9	11.0	760	176	3.8		30.77	32.4	16.3
S 67.4	1-42.5	8.0	700	178	6.5	83	33.39	35.31	19.2

Tyre pressures:- Front 31.5
                  Back 32.5

Acceleration tests

Direction	N	S	N	S	N	S
Accel. time in seconds	22.0	21.0	21.3	21.1	21.7	

TABLE **35** B. Summarised Results of Table A.

Mean Barometric Pressure
corrected for altitude. Ins of Hg   24.97
Vapour Pressure of moisture
in atmosphere (Average). Ins of Hg   0.376

Car Speed in m.p.h.		28.9	38.1	47.4	57.6	67.4
Wind Pressure,	N	2.6	3.8	6.0	8.2	10.6
inches of water.	S	0.8	1.6	2.7	4.2	7.5
Absolute Wind Velocity in direction of motion, m.p.h.		8.3	3.2	9.4	9.5	6.2
Mean Tyre Pressure, lbs/sq ins		28.2	29.1	29.8	30.2	31.2
Mean Air Temperature °Cent.		27.2	27.8	28.3	28.3	28.3
Miles per gallon	N	24.0	23.5	20.9	19.0	16.2
	S	27.7	27.8	25.2	22.3	19.5
Simple Mean M.P.G.		25.8	25.6	23.0	20.6	17.8
Inlet Manifold Pressure,	N	10.3	10.7	12.0	15.5	19.2
inches of Hg absolute	S	9.1	9.6	11.2	13.6	16.7
Average.		9.7	10.1	11.6	14.5	17.9
Exhaust Gas Temperature	N	330	470	577	650	710
degrees Centigrade.	S	320	430	566	627	685
(above atmospheric) Average.		325	450	571	638	697
Cooling Water Temperature	N	150	158	164	169	175
at entrance to radiator, degrees Fahrenheit.	S	157	161	167	171	177
Average (converted to Cent.)		67.5	70.8	74.2	76.7	80
Temperature Difference, water to air, Degrees Cent.		40.3	43.0	45.9	48.4	51.7
Acceleration Time (seconds)	N	21.7				
	S	21.0			Average:-	21.3

Exhaust Gas Analysis 14.2 %CO₂ - %O₂ 1.6 %CO
                 0.3   %H₂ (estimated) 84.5 %N₂ (by diff)

Remarks:-

TABLE **35** C   M.P.G. converted to Standard Basis.

Car Speed in m.p.h.	28.9	38.1	47.4	57.6	67.4
Reciprocal Mean M.P.G. of North & South runs.	25.8	25.5	22.9	20.5	17.7
% Correction for:- a) Wind	2.0	1.7	1.8	1.5	0.5
b) Weight	-0.4	-0.3	-0.3	-0.2	-0.2
c) Barometer	-	-	-	-	-
d) Air Temp.	-2.4	-3.0	-3.4	-3.6	-3.9
e) Tyre Press.	-0.1	-0.3	-0.3	-	-
Total correction- %	-0.9	-1.9	-2.2	-2.3	-3.6
Corrected Miles per Gallon	25.6	25.0	22.4	20.0	17.1

Table **35** D   Volumetric Efficiency & Air/Fuel Ratio

Ideal Air/Fuel Ratio   13.5

Average Molecular Weight   75.5

Mixture Density relative to Air   1.049

Speed in m.p.h.	28.9	38.1	47.4	57.6	67.4
Compression Temperature	436	427	399	367	346
" " Pressure	9.5	9.7	10.85	13.15	15.7
Volumetric Efficiency	.208	.217	.260	.343	.435
Ditto to std. Basis	.210	.221	.265	.351	.450
Theoretical Air/Fuel Ratio	9.9	10.2	11.0	13.2	14.5
Air/Fuel ratio (exh. anal.)	)-	-	13.15	-	-
Weight of exhaust gas per gallon of fuel	82.7	85	91.2	108	118

Table **35** E   Heat Balance

Speed in m.p.h.		28.9	38.1	47.4	57.6	67.4
Heat available from fuel	CHU/gal %	77960 100	77960 100	77960 100	77960 100	77960 100
Heat to tractive effort	CHU/gal %	16200 20.8	19300 24.8	20900 26.8	22200 28.5	22400 28.7
Heat to exhaust (a) Sensible	CHU/gal %	6850 8.8	9970 12.8	13900 17.8	18600 23.8	22400 28.8
(b) Latent	CHU/gal %	3850 4.9	3960 5.1	4250 5.5	5030 6.5	5500 7.0
(c) Unburnt gases	CHU/gal %	?	?	2440 3.1	?	?
Heat to Cooling water	CHU/gal %	3080 39.5	27700 35.5	23550 30.2	19750 25.3	16200 20.8
Unaccounted for	%	(26.0)	(21.8)	(16.6)	(15.9)	(14.7)

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