FILE NOTE NO. FN.185/67(M)

MANUFACTURE OF UNLEADED GASOLINE
BONNER AND MOORE STUDY

Conclusions

(1) The study carried out by Bonner and Moore Associates, Inc, on behalf of API, although open to correction or criticism on many points of detail, arrives at a conclusion which is in line with earlier and less elaborate exercises, namely that the overall cost of producing unleaded gasolines, at today's paper quality levels, is of the order of 2-2.5 cents/USG.

(2) In choosing the bases for their exercise Bonner and Moore have been careful to try and paint a fair picture, and certainly as an independent body, they are not open to the suggestion of bias which could be levelled at earlier reports prepared by organisations with a commercial interest in motor gasoline production.

(3) Since the full Bonner and Moore Report comprises some 450 pages, including 251 tables, it is not a document which lends itself to easy digestion of the wealth of data included. Detailed study moreover reveals many instances of carelessness in copying and arithmetic, presumably the result of hurried assembly, and these detract from the confidence with which the remaining figures can be accepted. In particular, there appears to be a 25% error in the additional atmospheric distillation capacity (unleaded case) arrived at for the Mid-Continent region, ie 275,400 BPCD instead of 219,800 BPCD. Adjustment for this error reduces the overall capital investment figure by ca 8 million dollars.

(4) It should be noted that exercises of this nature are, at best, somewhat unrealistic, since they are based on the unlikely premise that a ban on lead anti-knocks is due immediately. As such, they utilise current prices, qualities and product patterns and so can do no more than give a picture, in terms of costs, that is rather less gloomy than the one that would actually have to be faced should a ban be imposed at some time in the future. Current feeling appears to be that a ban on lead, if it ever comes, is still at least 10-15 years away.

Introduction

In an earlier File Note, No. FN.124/67, (1), comments were made on a paper by S.D. Lawson, J.F. Moore and J.B. Rather (2), presented at the API Division of Refining Mid-Year Meeting, May 16th 1967, Los Angeles. This paper was a summary of a "technical and economics report consisting of several hundred pages" which was prepared by Bonner and Moore Associates, Inc, as a study carried out on behalf of the API.

Many of the comments made in FN.124/67 related to the lack of information, in the published paper, as to the compositions and qualities of the motor gasoline blends in the various "base" and "no lead" cases summarised. This information has subsequently become available to BP, since a copy of the full Bonner and Moore report (3) has now been received from New York Office. The present File Note takes account of this additional information and therefore supersedes FN.124/67.

Detailed comments on Bonner and Moore Study

(a) Basis of study - Refinery sizes and types

The object of the Bonner and Moore study was to provide an answer to a hypothetical question, broadly phrased in the following general terms:-

Problem "If the US refineries, in 1965, had produced their gasoline without lead, but without change in quality, how much added process equipment would have been needed, and how much higher would operating costs have been?"

Twelve hypothetical refineries were assumed for the purpose of this study, these "refineries" being averages of real refinery groupings in the selected areas. The areas used as a basis (representing ca 30% of US refining capacity) were designated East Coast, Mid-Continent, Gulf Coast and West Coast.

These refinery configurations were given designations such as "Gulf Coast 200", this signifying a 200,000 BPCD refinery. It should be noted that the numbers indicating the refinery sizes are purely nominal and at times, almost misleading. For the Gulf Coast 200 refinery, for example, the daily crude input for the base case was only 182.1 thousand barrels, but for the purpose of the study this was combined with 10,000 barrels of natural gasoline, thus giving a "total feed" of 192.1 thousand barrels. It would appear that although a choice of "refinery" sizes was made, based on a survey of the US oil industry, the calculated base case results did not always agree with the results of the survey (ref Table 245 of the study). Despite this disagreement, the refinery designations were kept to the numbers originally chosen and were not revised in accordance with the actual base case throughputs. Care therefore needs to be taken to ascertain the actual throughput (rather than the nominal value indicated by the refinery designation), in any calculation of, say, the percentage gasoline make on crude.

For convenient reference, the refinery designations are listed below in comparison with the actual base case liquid throughputs (crude + natural gasoline). Also included in the tabulation are the "compositing factors" (ref Table 11, page 2-12 of the study). These factors represent the numbers of refineries assigned to each size group for the region concerned, and have been adjusted to make the total gasoline production for each region (after applying these factors) correspond to the regional volume reported by the US Bureau of Mines. The overall total for the four regions is then equivalent to 90.58% of the actual US total, and is

converted to the latter basis, pro rata, ie by multiplying by 1.104 (=1/0.905C).

Refinery Region and size	Actual liquid input (base case) 1000 BPCD	"Compositing" factor (1)
East Coast 80	72.3	4.581
" " 155	134.9	5.726
Gulf Coast 50	50	9.368
" " 200	192.2	13.531
Mid-Continent 4	3.5	7.061
" " 15	12.7	17.149
" " 30	31.5 (2)	11.096
" " 55	67.6 (3)	17.149
" " 90	104.1	4.035
" " 175	167.5	3.026
West Coast 60	54.5	5.358
" " 125	112.3	7.501

Notes

(1) Number of refineries in size group, in region concerned.

(2) Incorrectly shown in the Report as 29.8 (eg Tables 55, 73 and 245).

(3) Incorrectly shown in the Report as 65.4 (eg Tables 57, 74 and 245).

Attention is drawn to Notes 2 and 3 above. Comparison of the various detailed tables in the Report revealed a discrepancy between the figures given in Table 9 (of the Report) for the additional distillation capacity required (683,000 B/D) and as deduced from Table 13 and also Tables 31 to 42, inclusive, which gave material balance summaries for the individual refineries, and suggested an increase in total liquid feed of approximately 621,000 B/D.

The figures given in the Report for atmospheric distillation capacity were therefore checked in detail against the material balance data, and agreement was noted for all regions except "Mid-Continent". This is shown in the attached Table 1, which pin-points apparent errors (see underlined figures) in the Bonner and Moore calculations, for Mid-Continent 30 and Mid-Continent 55. Throughout these calculations except for these two refineries, distillation capacity is consistently based on total liquid feed, ie "crude oil plus natural gasoline". For these two refineries, however, this has only been done for the unleaded cases, and in the base cases the distillation capacity omits the natural gasoline and is given in terms only of the volume of crude processed. In consequence, for these two refineries, a falsely high figure for additional distillation capacity is arrived at and the overall effect is an error of 25% (56,000 B/D) in the total atmospheric distillation requirement for the region (ie 275,400 instead of 219,800 B/D).

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For the record therefore, the relevant figures for additional crude distillation capacity and investment as given in the top lines of the report summary Tables 9 and 7 are reproduced below, together with the corrected values.

Additional crude distillation requirements for unleaded gasoline

	REGION*	East Coast	Gulf Coast	Mid-Continent	West Coast	US TOTAL
Additional crude distillation capacity (1000 B/D)	Bonner and Moore (Table 9)	66.6	174.8	275.4	101.9	603.0
	CORRECTED VALUES	66.6	174.8	219.3	101.9	621.7
Corresponding Investment (Million dollars)	Bonner and Moore (Table 7)	7.5	20.6	37.1	11.9	85.1
	CORRECTED VALUES	7.5	20.6	29.6	11.9	76.8

*Note: The four regions comprise 90.53% of the US Total.

On the above basis, therefore, the overall capital investment is reduced by approximately 8 million dollars. This is a significant saving for the Mid-Continent region but is of course barely noticeable in terms of the ca 4230 million investment required for the US as a whole.

The original published paper (2) gave very little information about the process plant in the 12 hypothetical refinery configurations, other than to lay stress on the fact that each refinery grouping included the predominant processes for the size and region in question. It also appeared that refineries not containing catalytic crackers and catalytic reformers were not considered. Study of the full report has confirmed that in 11 of the 12 refinery groupings, the base case plant included both a catalytic reformer and a catalytic cracker. The exception was the small, 4000 BPCD Mid-Continent refinery, for which a catalytic reformer was shown, but not a catalytic cracker, and at which premium grade gasoline was not made. Eleven of the "refineries" (ie all except the "4000 BPCD Mid-Continent") include alkylation units, and in some cases, the process units shown include coking, catalytic polymerisation, thermal cracking or visbreaking. Only two "refineries" (the two West Coast refinery groupings) have hydrocrackers in the base cases, and none of the base cases include C_5 or C_3 isomerisation. To illustrate the general order of complexity, the process units for the Gulf Coast "200" refinery included the following:-

Crude distillation	192,200 BPCD
Vacuum distillation	74,900 "
Visbreaker	7,400 "
Catalytic cracker	116,000 "
Coker	12,000 "
Reformer	26,500 "
Alkylation	14,300 "

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For the purposes of the exercise, product yields, feedstock throughputs, and motor gasoline qualities were based on data published for 1965 (eg US Bureau of Mines data). Production of aviation and motor fuels, diesel fuel, furnace oil, petrochemical feedstocks, lubricating oils and bitumen were defined as fixed requirements. Some flexibility was allowed in respect of residual fuel, coke, propanes, butanes and fuel gas. However the volume of residual fuel determined for each base case was held constant for the corresponding unleaded case.

For products other than motor gasoline, extensive use was made of fixed recipes, these being detailed in Tables 206 to 232 of the Bonner and Moore report. For some distillate products, eg Avgas, JP-4, standard blends, applicable to all models were used, but for No. 6 fuel oil, differing recipes for each refinery are quoted.

The properties quoted (Table 126 of the study) for the Aviation gasoline (115/145 grade) indicate a TEL content of 4.6 ml/USG, and the blending data given (Table 206) suggest that this amount of lead alkyl would certainly be required to achieve the necessary performance numbers. However in the various tables giving material balance summaries, the "no lead" cases show TEL usage as zero and make no reference to the TEL still obviously required (and presumably used, despite the omission) for aviation gasoline production.

Crudes appropriate to each refinery simulation were chosen on the basis of production and pipeline data for the area concerned, and a light/heavy crude ratio established which would best meet each base case product pattern. The same crude composition was then used for the "unleaded" case.

(b) "No-lead situation" - additional processing required

In considering processes which could be employed to produce blending components of high clear octane number, the study limits its choice "to those in commercial operation in at least one facility". Processes thus considered (in addition to extensions to existing units) included:-

High severity reforming
Aromatic extraction
Separation processes, eg reformate splitting
Alkylation (C_2 to C_5)
Olefin disproportionation
Isomerisation
Naphtha steam cracking
Hydrocracking

As further noted below, 'high severity reforming' covered catalytic reforming operations up to 105 RON (clear). Isomerisation units considered were confined to those processing C_5 feedstock.

The original paper (2) did not explain how the above processes were applied, and merely gave a series of bar charts which showed, for each "refinery", the changes in the percentages of aromatics and olefins in the leaded and unleaded blends. These changes are shown in detail in the attached Table 2 (based on the full report) but may be briefly summarised as follows:-

		Base Cases	Unleaded Cases
Gasoline Pool (US Average)			
Olefins	% vol	19	9
Aromatics	% vol	21	42
Premium Blends			
Olefins	% vol	17-24	0-17
Aromatics	% vol	19-30	38-57

As will be seen from Table 2, for 8 of the refineries (out of 11 making premium grade), the olefin content of the premium blend in the unleaded case is in excess of 20 vol. However, it seems likely that actual olefin contents of US marketed gasolines are slightly lower than the values quoted in Table 2. The report comments (p.2-48) that the computer solutions for the base case blends allowed a "higher olefin content in premium than indicated by survey samples". This was because the constraint on sensitivity (11 max) in conjunction with the values set for road octane number ($\frac{1}{2}$ (MON + RON)) permitted solutions with premium blends showing research octane numbers of just over 101 (ref Table 2), whereas the gasolines actually marketed in 1965 were generally not above 100 RON.

The marked increase in aromatic content for the unleaded blends is only to be expected, and as is pointed out in the published summary, "the only hydrocarbon component of gasoline having an unleaded octane substantially higher than that of current motor gasoline is aromatics" (2). Removal of olefins was achieved in a number of ways, but notably by:-

(i) hydrogenation and catalytic reforming of catalytically cracked and thermally cracked gasolines,

(ii) alkylation of amylenes.

With regard to the additional plant required to manufacture the unleaded gasolines, and hence the increase in manufacturing costs, the study showed that a plot of added costs against refinery size did not give a smooth curve, and that a better correlation of the data was obtained "by two straight lines through the points for refinery cases producing more than 18,000 barrels a day of gasoline and refineries producing less than that volume" (2). The actual cost figures, for the 6 "Mid-Continent refinery" sizes, are as follows.

Refinery "size" (1000 BPCD)		Motor gasoline rate (BPCD)	Added costs cents/USG	Gasoline make as Percentage of base case feed
MC	4	1,306*	4.74	37.3
	15	6,200	3.89	43.8
	30	18,600	2.30	59.0
	55	40,200	2.16	59.4
	90	59,300	1.96	57.0
	175	80,700	1.75	48.2

*Regular grade only.

The published summary (2) gives the impression that the authors consider the apparent discontinuity in the curve at 18,600 BPCD to be highly significant. However, in the full report (3) it is admitted that "there is no theoretical basis for this change in curvature". One factor which could well have an effect is the variation in gasoline make on feed, as indicated in the last column of the tabulation given above. A further point with regard to manufacturing costs versus refinery size is made in the Report as follows:-

"It was not until refinery case size reached 30,000 barrels (≡ 18,600 B/D gasoline) that a basic addition to the conversion processes could be made. At this size level, hydrocracking became economically feasible, which provided substantial increases in reformer charge, isobutane for additional alkylation and additional pentanes for isomerisation. Refinery cases above this size all included hydrocracking as a basic conversion process."

The above comment on the apparent value of hydrocracking as a means of providing pentanes for isomerisation is a little surprising, in view of the already high iso/normal pentane ratio in light hydrocrackate.

The major contributors to the list of new plant required to meet the "no lead" cases were as follows:-

	1000 BPCD (Total US industry)
High severity reforming	2120.7
C_5 isomerisation	664.9
Hydrocracking	549.3
Alkylation	303.7
Aromatic extraction	491.3
Splitting - Reformate	397.4
Cracked gasoline	1362.2
Depentanisation - Alkylate	394.0
Cracked gasoline	1640.4
Hydrogenation of Heavy cat. cracked gasoline	634.9

The above list does not include additional cat. reforming, cat. cracking, coking, etc capacity achieved by expansion of "existing" plant, and of course to meet all the above requirements considerable increases in atmospheric distillation capacity were needed, as is demonstrated by the figures in the attached Table 1. It was also necessary, for the unleaded case, to provide additional vacuum distillation capacity to the extent of 230,400 BPCD.

As a specific example of the expansion required at an individual refinery, the following items of new plant established for the "Gulf Coast 200" refinery may be compared with the "base case" units for this refinery, given earlier in this note.

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New plant required for GC "200" refinery, for lead-free situation

Alkylation	9,600	BPCD
Cat. gasoline depentaniser	38,600	"
Aromatics extraction	6,100	"
Cat. gasoline splitter	30,100	"
Hydrocracker	11,200	"
High severity reformer	41,300	"
Cat. naphtha hydrotreater	16,200	"
C_5 isomerisation	15,800	"
Alkylate depentaniser	13,700	"
Reformate splitter	10,700	"

(c) Unleaded motor gasolines - blend compositions

The attached Table 2 indicates, in some detail, for each refinery, the blend compositions for the premium grade gasolines in the base and "no-lead" cases. It also gives inspection data for both premium and regular grade blends. This table is based on the information given in Tables 79 to 90 of the Report (compositions) and Tables 91 to 102 inclusive (quality data).

Attention should be drawn to the fact that in extracting the blend data from Tables 79 to 90 it was necessary to correct numerous errors in the Bonner and Moore Report. Of the 92 columns of figures in these 12 tables, no less than 48 columns (52%) contained arithmetical errors. These included simple failure to arrive at correct summations, the inclusion of fictitious quantities of components, and in one case the complete omission (both in name and quantity) of some 5000 B/D of light platformate. Many figures were at variance with those in other tables in the Report and in several cases confusion was caused by transposition of individual "barrel" quantities (occasionally divided by 10) into the "percentage" columns and vice versa. This kind of carelessness seems inconsistent with the "prestige" impression obviously intended from the format and elaborate binding of the Report.

In Table 3 attached, an attempt has been made to group the blending components used in the unleaded premium blends, and also in the regular grade blends, so as to highlight, in each case, the major constituents.

The following points may be noted in Tables 2 and 3.

(1) The unleaded premium grade blends all broadly follow the same pattern, namely,

(a) front end octane number and volatility provided by a combination of isopentane and light catalytically cracked gasoline (+ butane),

(b) mid range volatility provided by alkylate,

(c) an aromatic component as the major constituent (> 40%), providing the main contribution to the octane number of the blend. For 10 out of the 11 refineries making premium gasoline, catalytic reformer operation at 105 RON clear is used to provide either total reformate or heavy reformate

as a blending component. In nine cases, aromatics extract (from lower severity reformate) is used to augment (and in one case to replace) such high severity reforming.

(2) For the unleaded regular grade blends, at approximately 95 RON, it is difficult to generalise because of the wide range of components involved. However it is of interest to note,

(a) the extensive use made of isopentane (up to 21% in one instance) for this grade,

(b) the consistent need, even for regular grade production, for high severity catalytic reformate. For nine of the blends, 103 RON (clear) catalytic reformate is used, to the extent of 20-45% of the total blend, and for two more (MC4 and WC60) 105 RON catalytic reformate is required.

(3) With regard to gasoline quality, the Report makes the point that in all cases the unleaded gasolines would "remain within the distillation envelopes" described by the Ethyl Corporation Market Surveys (1965 data). Table 2 shows that for premium grade, the unleaded blends are all very similar in terms of vapour pressure and distillation characteristics, (eg ca 10 lb RVP and ca 45% @ 100°C). As the Report points out, this similarity was only to be expected, in view of "the limited number of components that are feasible for premium blending". For the unleaded premium formulations generous use of butane and isopentane enables the front end volatility and vapour pressure to be maintained at the same level as in the base case, but the mid volatility (% @ 100°C) drops to a value which, (for European gasolines) would be regarded by BP as only just acceptable.

For the unleaded regular grade gasolines, no generalisation concerning volatility is possible. Four blends have virtually the same volatility as in the base cases, four show a marked increase in volatility (eg EC155), and four are of lower volatility than the base case blends.

(4) With regard to octane number, comment has already been made on the fact that the computer solutions gave base case research octane numbers for premium grade which were slightly higher than the average figures arrived at from the Ethyl Corporation Market Survey (ie ca 101 as against 100). For the regular grade base case blends, rather closer agreement with survey data was achieved (usually within ± 0.5 RON).

For the unleaded gasolines, the premium grade blends (with one notable exception) differ little in research octane number from the base case blends. The exception mentioned above is Mid-Continent 30, for which the unleaded blend, at 101.3 RON is two numbers higher than in the base case (99.3 RON). This marked increase in RON was obviously necessary in order to maintain the "road octane" value, ½ (MON + RON), at the same level as in the base case. This may be seen from the following figures:-

	Mid-Continent 30	
Premium gasoline	Base Case	'No-lead' Case
RON	99.3	101.3
MON	92.6	90.3
0.5 (RON + MON)	93.0	95.8

Although the road octane criterion has nominally remained unchanged, it can be questioned whether in fact this gives a realistic picture for these two blends. In view of the decrease in motor octane value by 2.3 numbers, and the increase in sensitivity from 6.7 to 11.0, it would be surprising if the unleaded blend did not show a marked decrease in road anti-knock performance.

(5) In considering the question of road octane number, it is of interest to refer to a similar exercise (also covering the US oil industry), carried out by the Ethyl Corporation in 1965 (4). In that study, the claim was made that (despite the absence of lead deposits) the "unleaded fuels are more prone to knock in cars on the road than today's leaded gasolines". This Ethyl Corporation statement was made on the basis of comparisons between leaded and unleaded gasolines of the same motor octane number, and to achieve this it was necessary, in the unleaded case, to allow the research octane numbers to rise above those of the base case (1.3 ON for premium and 3.0 ON for regular grade). In other words, for the Ethyl Corporation exercise, a deterioration in actual road anti-knock performance was claimed for the unleaded blends, despite paper increases of 0.6 ON for premium grade and 1.5 ON for regular grade according to the Bonner and Moore criterion of $\frac{1}{2}$ (MON + RON). For the Bonner and Moore study therefore, where significant decreases in motor octane number are shown for many of the unleaded cases (ref Table 2), poorer road performance seems inevitable if the Ethyl Corporation claims are accepted.

(6) It is clear from the above that Bonner and Moore ran into the same difficulty as the Ethyl Corporation in formulating their unleaded blends, namely the elementary fact that for a given research octane number, leaded blends (particularly when TML is used) tend to have lower sensitivities than clear blends of the same octane number. In other words, to maintain a fixed research octane number it is necessary to replace the lead alkyl by an increased proportion of hydrocarbons of high octane number but which also are of inherently high sensitivity (eg aromatics).

A further relevant point here is the possibility that the sensitivities of the unleaded blends, in the Bonner and Moore study, may in fact be even higher than predicted. A pointer in this direction is provided by the laboratory work, carried out by the American Oil Company, to establish the general validity of the blending values used in the calculations. The summary as presented at Los Angeles (2), stated that "satisfactory" agreement was obtained for the unleaded "models" between calculated and measured octane numbers, but made no reference to sensitivity. However, this claim was a little misleading, since determined research

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ratings tended to be higher than predicted values (on average 0.8 ON) and determined motor octane numbers tended to be lower than predicted values (on average 0.3 ON). In consequence, as is shown below, except for one regular grade blend, the predicted sensitivities were consistently low.

	Premium Blends		Regular Blends		
	1.	2.	1.	2.	3.
Sensitivity (Predicted)	9.7	10.7	10.0	10.5	7.9
" (Measured)	10.8	12.5	10.8	10.5	9.0
(Measured - Predicted)	1.1	1.8	0.8	0	1.1

(d) General conclusions of study - Comparison with Ethyl Corporation Data

Detailed comment on the cost data presented in the Bonner and Moore report is considered to be outside the scope of this File Note. Reference has already been made to the error in respect of "Mid-Continent" distillation capacity, and correction for this would reduce the total capital investment by about 8 million dollars. Allowance for this decrease (ca 0.2% on the total) would however have a negligible effect on the mean value of 2.15 cents/USG arrived at for increased gasoline manufacturing costs (US total), and it is of interest to note that this figure is in general agreement with that reached by the Ethyl Corporation in their 1965 study (4). This may be seen from the general summary given in Table 4 of this note.

The Ethyl Corporation study, which shows a lower figure than Bonner and Moore for added investment costs, was carried out on a rather more simple basis, namely a vast single refinery model covering the whole of the US oil industry. Another difference between the two studies is in connection with natural gas liquids. Both studies highlight the need to run more crude in order to make up the liquid volumes necessitated by gasoline reformulation from lower yield products (eg high severity catalytic reformate). This extra crude produces changes in the liquid/gaseous fuel balance, and throws up surplus gas and LPG. In the Ethyl Corporation study, this meant that consumption of natural gas liquids decreased to zero, with a considerable quantity of butane being downgraded in value to that of fuel. In the Bonner and Moore exercise, however, natural gasoline usage was assumed to be proportional to crude and the crude/natural gasoline ratio established for each refinery base case was maintained for the corresponding unleaded case. In other words, consumption of natural gasoline in the "no-lead" situation was higher than in the base case. To compensate for this Bonner and Moore found it necessary, in the "no-lead" case, to show a drop in purchased butanes of 119,000 tons, equivalent to a decrease of 44%.

The Bonner and Moore report does not, in its conclusions, give the overall (US industry) figures for natural gasoline usage in its two cases, but it is possible using the 'compositing' factors given on page 2-12 of the report to calculate these figures from the data given for the individual refineries. The results of these calculations may be summarised as follows:-

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Region	Natural gasoline requirement (BPCD) With lead	No lead
East Coast	Nil	Nil
Gulf Coast	142,200	149,400
Mid-Continent	122,300	132,800
West Coast	40,300	52,800
Regional Totals (90.58% of US)	312,800	335,000
Hence US Totals =	345,300	369,800

Thus, whereas in the Ethyl Corporation study natural gasoline usage drops from 579,000 BPCD to nil, in the Bonner and Moore exercise, it increases from 345,300 to 369,800 BPCD. This increase of 24,500 BPCD is included within the overall figure given by Bonner and Moore for additional atmospheric distillation capacity.

With regard to the Bonner and Moore estimate of increased requirements for platinum in a "no-lead" situation, there is an unexplained discrepancy between the figure given in the full report (2.74 million troy ounces) and that quoted at the Los Angeles meeting (3.4 million troy ounces). It is possible that the latter figure makes some allowance (approximately 25%) for reserve catalyst stocks, since the figure of 2.74 million troy ounces is specifically stated, in the full report, to cover "only in-process requirements". It would also appear that this extra platinum was only considered in the context of high severity reforming catalyst. No reference is made in the report to additional platinum required for use in isomerisation catalysts.

As a final comment, reference may be made to the sheer physical difficulty of extracting data from such a voluminous report (2 inches thick). The alternative to the full report, and indeed all that will be seen by many readers, is the short summary document presented to the API at the Los Angeles Meeting in May 1967 (2). This goes to the other extreme, in giving the minimum of useful data other than the basis of the exercise and the broad conclusions. As was pointed out in an earlier File Note (1), it left too many questions unanswered concerning such obvious aspects as motor gasoline formulations and quality.

It would seem that what is really required is an "intermediate" type of document containing more information than the Los Angeles summary, but not so unwieldy, physically, as the full report. Such a document, if it could include the basic material balances, and blending and quality data such as have been extracted for Tables 2 and 3 of this note, would be much more satisfying to any reader who wished to have an optimum but not an excess of informative detail.

References

(1) Technical Development Division File Note No. FN.124/67 dated 20.7.67.

(2) "A Look at the Economics of Manufacturing Unleaded Motor Gasoline". S.D. Lawson, J.F. Moore, J.B. Rather. Paper (Preprint No. 30-37) presented May 16th 1967 at a session on Fuels and Emissions, during the API 32nd Mid-year Meeting of the Division of Refining, Los Angeles.

(3) Report entitled "U.S. Motor Gasoline Economics. Volume 1. Manufacture of Unleaded Gasoline" prepared for the API by Bonner and Moore Associates, Inc., dated June 1st 1967 (452 pages, including 251 tables).

(4) "Evaluation of Use vs Non-use of TEL in Gasoline", Ethyl Corporation document presented at a Public Health Service Symposium in Washington, December 1965. (Oil and Gas Journal, Dec 20, 1965, pp 25-28).

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Encls: Tables 1-4

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