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Mobil Oil Corporation

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OCT 13 1966
RESEARCH AND DEVELOPMENT DEPARTMENT

S. L. MEISEL
MANAGER
APPLIED RESEARCH & DEVELOPMENT

October 10, 1966

K. L. Berry - Pan American Petroleum Corp.
W. H. Decker - Sinclair Research, Inc.
H. P. Dengler - Esso Research & Engineering Co.
R. T. Ellington, Jr. - Sinclair Gas and Oil Company
K. M. Elliott - Mobil Oil Corporation
W. L. Jensen (4) - Continental Oil Company
R. Mungen - Pan American Perroleum Corp.
N. P. Peet - Humble Oil & Refining Co.
D. C. Smith - Phillips Petroleum Company
J. H. Smith - Continental Oil Company
R. V. Smith - Phillips Petroleum Company

Gentlemen:

Attached is a copy of the minutes of the fourteenth regular Shale Oil Technical Advisory Committee meeting held in Denver, Colorado, on September 8, 1966.

S. L. Meisel

S. L. Meisel

eaw
Attachment

cc: R. H. Cramer

15/05/008/005

Minutes of the Fourteenth Regular Meeting
of the
OIL SHALE TECHNICAL ADVISORY COMMITTEE
Denver, Colorado, September 8, 1966

The meeting convened at 8:15 A. M. in Phillips' offices in the Security Life Building, with all committee members present:

S. L. Meisel	Mobil Oil Corporation
K. M. Elliott	Mobil Oil Corporation
N. P. Peet	Humble Oil and Refining Company
H. P. Dengler	Esso Research and Engineering Company
W. L. Jensen	Continental Oil Company
J. H. Smith	Process Engr.,Continental Oil Company
R. T. Ellington, Jr.	Sinclair Oil and Gas Company
W. H. Decker	Sinclair Research, Inc.
D. C. Smith, Chairman	Phillips Petroleum Company
R. P. Lehman	Phillips Petroleum Company
R. Mungen	Pan Am Petroleum Corporation
K. L. Berry	Pan Am Petroleum Corporation

It was announced that R. P. Lehman was retiring after 32 years service with Phillips and would be replaced on the TAC prior to the next meeting.

Old Business

Minutes of the 13th regular meeting of the Technical Advisory Committee were approved as distributed.

New Business

The next TAC meeting was scheduled at Anvil Points on November 8, 1966, with a plant inspection planned on November 9 for all members who can stay for the second day. Retort #3 should be in operation and mining operations in the new area will be in full swing. A dinner for Staff and Committee members is planned for the evening of November 8. The next meeting for the Technical Observers was scheduled for October 25-26 at Anvil Points.

The technical presentation was made by program manager, Bob Cramer, assisted by Messrs. Snyder, Lawson, Haworth and Bergen of his staff. This is detailed in the attached appendix. Attention is again directed to Cramer's list of major conclusions drawn during the reporting interval.

Cramer reported project Stage II expenditures as of September 1, 1966 totaled $1,538,293 which is slightly below budget. Heavy billings will occur during the last quarter of 1966, particularly in November, due to delivery of much heavy equipment which has been on order.

Warren Broman of Sinclair has now reported to the project, bringing the program manager's total staff to 24; Mobil-11, Humble-7, Continental-2, Sinclair-2, Phillips-1, and Pan Am-1. All Anvil Points technical personnel furnished by the participating parties are now on the project payroll. Cramer announced that Paul Snyder (Mobil) will leave the project on January 1, 1967. After realignment of duties this will result in a mechanical engineer vacancy which will be filled by Mobil's corporate engineering. Cramer also announced that an additional mining engineer would be needed on November 1, 1966, with Phillips being next in line to supply additional staff. He asked that any company interested in providing a mining engineer contact him.

Considerable interest was expressed by the committee in Paul Snyder's summary of bench scale studies on the effect of pressure on retort yield and the amount of naphtha in the off-gas. As the pressure in Fischer Assay type experiments is reduced from one atmosphere to 10 mm Hg., which corresponds to the partial pressure (oil) in gas combustion retorting, the total yield (-110°F. trap) increases to about 115% FA while the "oil yield" as normally defined (32°F. trap) decreases to 94% FA. This places a "ceiling" of 94% FA on the atmospheric gas combustion retorting process as now established, which is in line with project experience to date, and brought forth some discussion of the incentive for pressure retorting to increase partial pressure and raise the yield ceiling. Snyder stated that the normal (atmospheric) Fischer Assay makes about 3% naphtha (400°F. end point) as compared to about 20% naphtha at 10 mm pressure. Recovery of the 2 to 4 lbs. of C_3+ material per 1,000 SCF off-gas in atmospheric retorting is also attractive. Snyder emphasized that this corresponds to about 0.7 gal./1,000 SCF and is difficult in comparison to petroleum gas operations because the off-gas is at low pressure and is saturated with moisture. Committee members urged that larger bench scale experiments be performed to better measure and characterize the naphtha produced with inert sweep gas, to correspond with the normal retort partial pressure conditions. The committee also endorsed and encouraged the plans of the staff to evaluate naphtha recovery economics for conventional and non-conventional types of recovery methods. There was also general agreement that this type of problem could and should be considered separately by each of the companies, with any suggestion forwarded to the project. To implement this it was agreed that Mr. Cramer would provide the best available information regarding the composition of naphtha in retort off-gas.

Brief discussion during Snyder's reporting on bed height requirements and on yield relationships brought forth the interesting statement that bed height depends upon surface area mean size whereas yield depends upon weight mean size. There was interest expressed in the conclusions from economic optimum studies that the maximum size should be 2 1/2 inches rather than 3 inches, and that there is a slight advantage for three size ranges vs. two for retort feed.

Lawson's review of retorting operations brought forth a question about variability of water content of the shale feed and the suggestion that addition of steam to the recycle stream might help the recovery problem.

Cramer again reviewed major conclusions, and in response to a question stated that the studies of retort economics were based upon a mining cost of 40¢/ton but that a 10¢ differential (i. e., 50¢/ton) gave the same optimum, only making it more pronounced. From the committee a view was expressed that the major conclusion on 94% FA maximum yield was most significant and needs further consideration regarding project emphasis and pressure retorting. Reference was also made to a brief report in O. & G. J. (1943) concerning work in Australia on 400 psi retorting of 3-inch diameter shale at 700 lb. mass rate, and the hope was expressed that more information about the project might be obtained.

Regarding futures, Lawson indicated that the demonstration run in Retort #2 on full range (1/4 - 2 1/2) shale was currently running, with demonstration on 1/4-1 inch shale still remaining. For the latter, an 8-bayonet configuration and 500 lb. mass rate will be used as base and, if operable, for the demonstration. If not operable, the plan was to try dilution gas first, then low total gas rate, then try removing the liner, then try air distributor changes. Mungen suggested that further work on Retort #2 might be limited to 400 lb. mass rate.

There was some discussion and difference of views regarding the preferred order of work with the three size ranges (1/4 - 1, 1 -2 1/2, and 1/4 - 2 1/2) to be studied in Retort #3. Cramer expressed a firm opinion that initial shake-down on operation should run on the easy shale size (1 - 2 1/2), but agreed that plans could remain flexible for the period after January 1.

Gordon Haworth's review and discussion of three mining economics studies -- a preliminary study prepared earlier by the project staff, a new study just completed by the Mining Section, and one prepared for and submitted by Pan American -- aroused considerable interest. The respective cost figures are 40, 47.6 and 55.6 cents per ton, but the cases are not strictly comparable. Haworth indicated that his adjustment of the Pan Am and Project studies to the same basis gave cost figures that were very nearly equivalent (within 1¢), but that the result was preliminary and subject to change. Mungen commented that Pan Am had long felt that the earlier mining cost figures used in the project were too low, that upward adjustment by the newer study was in the right direction, that higher mining costs tended to emphasize the relative importance of increasing yield as compared to increasing mass rate, and that it was for this purpose of program guidance and emphasis that Pan Am had made their study available. He indicated that Pan Am would review the new project results which had just become available, in comparison with the Pan Am results, and report their conclusions as soon as practical. The discussion concluded with full agreement that the various mining economics studies were very valuable for pointing out areas for mining research and cost reduction.

In a brief discussion of rock mechanics research on oil shale under Ken Gray at the University of Texas, Bob Cramer indicated that the staff felt Gray's results would not be directly applicable to the Anvil Points project but that they might help later in interpreting project data or experiences.

Following completion of Bergen's report on Retort #3 rehabilitation, which is falling slightly behind schedule, a plea was made for each of the companies to assist in any way possible in preventing further slippage of delivery dates for critical equipment and instrument items on a list which will be sent to each committee member.

It was requested that any suggestions regarding new materials to be included in the corrosion and wear study program should be forwarded to Cramer immediately.

In concluding remarks Mr. Cramer indicated that "chance" visitors were becoming more of a problem and asked that TAC members clear with him any proposed visitors from their respective organizations.

Cramer also reported that the CSM Research Foundation had requested permission to have an annual dinner for its Anvil Points employees at project expense, and asked for committee guidance. After due discussion the committee concluded that any dinner at project expense for CSMRF employees should be given by the Program Manager rather than the Research Foundation, and suggested that the Program Manager proceed if he felt that benefits justified the cost.

Executive Session

The Chairman expressed the appreciation of the Committee to the representatives and management of Pan American for making available to the project the results of their mining study. The secretary also expressed appreciation for the Pan Am study, indicating that his company consultants would study the data in the light of their own experience and information and make any non-proprietary information available.

One view was expressed that it was not too early to start thinking and planning with regard to continuation or extension of Stage II.

Several points were raised and conveyed or checked subsequently with Mr. Cramer:

1) Project wind-up reporting is invariably a greater chore than anticipated and should be planned well in advance of the terminal date.

2) Product recovery work now being performed by the project is excellent and is encouraged.

3) The services of an Esso photographer were volunteered for making a documentary film of project equipment and installations, with companies wanting a copy of the film sharing in the cost. Cramer indicated that Torkelson was preparing a picture catalog which would be distributed and serve the intended purpose, but that he would have no objection to making a documentary movie at some later date.

4) The desirability of flexibility with regard to future project activities was again indicated.

5) The importance and lack of importance of mass rate in future studies was mentioned and suggested as still needing attention.

6) The importance of shale richness as indicated by previous economic studies was mentioned and suggested as still needing attention.

Mr. Lehman expressed his pleasure and pride in having been associated with an interesting and important project and extended his best wishes for future ultimate success of the activity.

The meeting adjourned at 4:45 p. m.

D. C. Smith

D. C. Smith, Chairman

S. L. Meisel

S. L. Meisel, Secretary

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APPENDIX

FOURTEENTH REGULAR TECHNICAL ADVISORY COMMITTEE MEETING, SEPTEMBER 8, 1966
DENVER, COLORADO

15\05\008\02

II. New Business

B. Technical Presentation

1. General Remarks - R. H. Cramer

The Program Manager discussed estimated expenditures through August 31, 1966, shown on Handout 1 - RHC. Program expenses are running about $13,000 under budget. The large accrued cost ($611,965) reflects orders for large scale mining equipment, contractor's construction expense, etc. It is anticipated that these accrued costs will actually be paid during November and December, 1966.

Program manpower totals 146 as of September 8 - 24 from the Participating Parties and 122 from the Research Foundation.

The budgeted staff from the Participating Parties is now complete; the last man, Warren Broman of Sinclair, reported on July 18. In addition, as of September 1, the two personnel were carried as Technical Observers had been transferred to staff status.

An opportunity exists for one of the Participating Parties to supply a mining engineer. The Program Manager asked that interested Parties contact him.

P. W. Snyder is being transferred to Mobil's Paulsboro Laboratory, effective January 1, 1967. After internal staff changes, the net vacancy which will occur is in the Mechanical

Engineering Group. Mobil will attempt to fill this vacancy.

The 16 remaining vacancies in the Research Foundation staff are concentrated in the areas of mining and crushing. These vacancies will be filled during October.

The Program Manager reviewed the Program objectives, which are:

Broad: To define and understand the Gas Combustion Retorting process in sufficient depth so that economical operation can be achieved in commercial retorts.

Specific: (Stage II)
1. Understand the Gas Combustion Process in sufficient depth so that results achieved on Retort No. 2 can be scaled up to Retort No. 3
2. Develop sufficient understanding so that Retort No. 3 results can be scaled to commercial operation.
3. Develop sufficient understanding of mining so that results can be scaled to commercial operation.

The Program Manager then reviewed the major conclusions arrived at since the June 23, 1966, meeting. These are presented on Handout 2 - RHC.

2. Retort Program

a. Discussion of Shale Feed Fractionation Economics and Theoretical Aspects - P. W. Snyder

1. Theoretical Aspects

Major conclusion is that the low oil partial pressure of the Gas-Combustion retort coupled with cracking of oil or kerogen to naphtha limits the

Gas-Combustion Process to a yield of about 94 Vol % raw shale Fischer Assay.

a. Effect of Pressure on Yield From Fischer Assay Retorting

(1) Total C_3^+ oil recovered increases to about 115% of the standard Fischer Assay when retorting at 10 mm Hg because of more efficient conversion of kerogen. (Handout 1 - PWS)

(2) But the oil collected in the normal 32° F trap declines to about 94% at 10 mm Hg because the conversion is primarily to naphtha and the low partial pressure will not condense this light material at 32° F. (Handout 1 - PWS)

(3) Effect of the presence of fines on yield at 10 mm Hg:

(a) Fines reduce yield because of cracking of oil - retorted only fines being worse as was found at atmospheric pressure. (Handout 2 - PWS)

(b) Again the conversion appears to be to C_3^+ naphtha since ultimate yield increases. (Handout 2 - PWS)

(4) C_3^+ analyses of the gas from Retort No. 2 support the 10 to 25% additional yield potential indicated by the reduced pressure Fischer Assay experiments. (Handout 2 - PWS)

(5) Conventional and unconventional naphtha recovery schemes are being appraised - initial calculations are not encouraging. (Handout 3 - PWS)

b. Bed heights required for constant offgas temperature correlates linearly with the surface mean diameter and with mass rate. This correlation predicted the bed height required for both the 1 to 2 1/2 inch and 1/4 to 2 1/2 inch demonstration run within 1/2 foot. (Handout 4 - PWS)

c. Effect of Process Variables on Yield

(1) Simple Linear Regression Analyses:

(a) Even though very simple correlation it has a 86% correlation coefficient - but inacurrate for small shale. Correlation has a standard deviation of $\pm$ 2 Vol % Fischer Assay. (Handout 5 - PWS)

(b) The significance of variables are:

(1) Weight Mean Diameter - $\sim$4% yield loss when retorting 1 to 2 1/2 inch shale versus 1/4 to 1 inch

(2) Size Range - $\sim$ 4 1/2% yield loss when retorting full range 1/4 to 2 1/2 versus the composite yield from three fractions. The current run in progress indicates this may be much less.

(3) Recycle Gas Rate - +1.3%/MSCF

(4) Mass Rate - 1.1%/100 lbs/(hr)(ft^2)

(c) Ability to predict yields:

Using the regression analyses to adjust prior yields for small changes in particle size predicted the 1 to 2 1/2 inch demonstration run yields about 1% low. However, the predicted yields for 1/4 to 2 1/2 demonstration yields appear to be 3% low. Part of this difference may be due to processing a slightly narrower range than desired.

(2) Prior Experience

(a) Yields increase about 1/2%/gal increase in raw shale Fischer Assay.

(b) Air distributor design can influence yield.

(c) Bed heights reduced below the point to produce the minimum offgas temperature ($\sim$135°F) reduces yield.

(d) Total gas rate is most likely the prime variable when recycle gas rate is varied.

(3) Additional work on the Regression Analyses is in progress - results just obtained indicate an equation which fits the data even better can be developed.

d. Operability Limits

Although from an economic viewpoint, it is desirable to increase recycle rate and mass rate

there is a gas velocity - mass rate limit above which operability over a long period of time becomes questionable. The operability limits encountered with various shale sizes are summarized in Handout 6 - PWS.

2. Maximum Shale Size and Size Fractionation Economics

a. Conclusions

(1) The optimum maximum shale size is between 2 and 2 1/2 inches - we should work with the 2 1/2 inch maximum anticipating the optimum will move toward the 3 inch maximum as technology improves. (Handout 7 - PWS)

(2) The optimum number of shale fractions appears to be three; however, because of the flatness of the economics and the time available for Retort No. 3 operation we plan to demonstrate the principle of, and the requirement for size fractionations by running the full range and the two fraction split. (Handout 8 - PWS)

b. Key Bases

(1) 50,000 B/D of raw shale oil.

(2) Nordberg size distribution.

(3) 95% screening efficiency - permits more fines charged to retort with full size range than with fractionated size.

(4) Retort Yields: (Handout 9 - PWS)

(a) Initial estimates of range effect used for maximum size analyses.

(b) Additional data indicating a more detrimental effect of range was used in fractionation analyses.

(5) Incorporated effect of bed height requirements on costs - $300,000/ft.

(6) Incorporated effect at gas rates on costs.

(7) Reworked crushing cost - 9 1/2 to 14¢ per ton, still being developed.

(8) No costs for incremental screening and conveying with fractionated feed - except it is less than 1¢/Bbl.

b. Summary of Retort Program Results, July/August - J. E. Lawson

1. Operability Studies - 3/4 to 1 1/2 inch shale

(a) Studies made necessary by retort bridging during check run on standard quality shale. Failure mechanism was unique - shale flow stoppage in absence of pressure drop increase.

(b) Only difference was air distributor. This created differences shown in Handout 1 - JEL.

(c) Program was planned as outlined to eliminate possible causes. Results in Handout 1 - JEL.

(d) Conclusions - Increased bayonet length was causative factor - Hypothesis - Different shale flow characteristics in retorting and combustion zones.

2. Shale Richness

(a) Studies on 35 gallon per ton 3/4 to 1 1/2 inch shale made with 8-bayonet - 21 inch air distributor. Three yield periods obtained with results shown in Handout 2 - JEL.

(b) Retort with this distributor had worked well. However, rich shale operations were characterized by bridging. Pressure buildups also forced reduction in gas rates and lower yields.

(c) Conclusion - This operation failed to reproduce results obtained in Retort No. 1. Would require further operations to develop completely satisfactory results.

3. Miscellaneous Studies

(a) Bed Height Study - Large Shale

(1) Bed height correlation prepared by E. E. Turner and discussed earlier by P. W. Snyder indicated possible lack of bed height in Retort No. 3 to process 1 1/2 to 2 1/2 inch shale at 135° F offgas.

(2) Study made in Retort No. 2 to check this point - results in Handout 3 - JEL.

(3) Conclusion - Bed height correlation was confirmed. Retort No. 3 bed height would be slightly shy for 1 1/2 to 2 1/2 inch (not 1 to 2 1/2 inch), but this would not be significant since offgas temperature would increase only slightly.

(b) Yield Results - 1/4 to 1 1/2 Inch Shale

(1) Preliminary yield correlations indicated that mid cut-point of two fraction system was optimum at 1 1/2 inch. This assumed range effect was negligible in smaller particle sizes.

(2) Yield study on 1/4 to 1 1/2 inch was carried out to check this conclusion. Results shown in Handout 3 - JEL.

(3) Conclusion - Range effect is appreciable even with small sizes - optimum mid cut-point is 1 inch - two fraction system is 1/4 to 1 inch and 1 to 2 1/2 inch. Yield on 3/4 to 1 1/2 is 90.5%.

4. Air Distributor Studies - 1/4 to 1 inch shale

(a) Operations with 8-bayonet distributor on small shale not completely satisfactory.

(b) Studies planned to investigate use of better air distribution to provide needed improvement.

(c) First study was with 12-bayonet to combat clinkering tendency of small shale. This configuration resulted in poorer operability. Analysis showed very high temperatures at center and cold walls - thought to be caused by slow shale flow in center.

(d) Second study was with 10-bayonet - 12-bayonet modified to open up center to speed shale flow. Results disappointing - operability still very poor.

(e) Yields very good - approximately 91% - for material balances obtained.

(f) Observations during course of these studies have made failure mechanism less certain.

(g) Possible causes -

(1) Clinkering - Fusion of particles around air distribution points due to excessive temperatures. Solution - dilution gas or better air distribution or open up to handle clinkers.

(2) Bridging - clinker preceeded by oil-dust-shale agglomerate which subsequently falls onto air distributor and is fused. Solution - process conditions less conducive to flooding and bridging.

(3) Liner malformation - severe malformations of liner have occurred during these failures. Possible solution - remove liner.

(h) Further studies were postponed on 1/4 to 1 inch shale at this point to permit demonstration runs on 1 to 2 1/2 inch and 1/4 to 2 1/2 inch before crusher shutdown.

(i) Some 600 tons of 1/4 to 1 inch shale stored to permit 1/4 to 1 inch studies to continue during crusher outage.

(j) Confident on solution to problem.

5. Demonstration Runs

(a) 1 to 2 1/2 inch shale

(1) Results shown in Handout 4 - JEL.

(2) Operations during run were continuous for a period of approximately six days with exception of period of one hour when shale feed system was out of service. Unit returned to operation without difficult after this incident.

(3) At initial conditions, 1 to 2% oil left in spent shale; slightly increase in air rate cured this condition. Indicates 4-bayonet distributors not quite adequate for this shale fraction. Considering using smaller spacing in Retort No. 3.

(4) Operation entirely satisfactory and stable for this fraction. Shale flow rough but normal.

(b) 1/4 to 2 1/2 inch shale

(1) Demonstration run currently in progress. Preliminary results shown in Handout 4 - JEL.

(2) Run being made with 8-bayonet distributor.

(3) Operability satisfactory. Some flooding evidenced by high ΔP in retorting zone.

c. Summary of Major conclusions - R. H. Cramer

The Program Manager restated our major conclusions listed on Handout 2 - RHC.

d. Future Plans - J. E. Lawson

(1) Retort No. 2 Immediate Program (Handout 5 - JEL)

(a) 1/4 to 2 1/2 inch demonstration run - in progress.

(b) 1/4 to 1 inch operability.

(1) Will be resumed after above demonstration.

(2) 8-bayonet distributor will be returned to and following runs made:

(1) 500 mass rate, 4,400 air, 15,000 recycle (standard conditions)

(2) Above with dilution gas.

(3) Low total gas rate (similar to Run 454 conditions).

(4) Standard conditions with liner out.

(c) If above is satisfactory in obtaining solution, demonstration with 1/4 to 1 inch shale will proceed otherwise studies of air distributor hardware will be continued.

(d) No Category "C" studies, including richness and fines, now planned because of uncertainty of time available.

(2) Retort No. 3 Program (Handout 5 - JEL)

(a) Retort completion now scheduled October 7.

(b) Operator training and mechanical checkout anticipated to take two weeks.

(c) Startup therefore on about October 21.

(d) Shakedown expected to be accomplished in two months - complete about January 1. Shakedown will be on large shale.

(e) Following this the first demonstration period will be started on large shale.

(f) Period will total about 10 weeks, after one week for maintenance, broken down as follows:

(1) Optimization - 3 weeks.

(2) Demonstration at constant conditions - 4 weeks.

(3) Extension of demonstration or determination of response to and recovery from upsets - 3 weeks.

(g) Following large shale, other shale sizes will be subjected to same demonstration except that upset period may be omitted on 1/4 to 2 1/2 inch shale.

(h) This plan leaves slack time of approximately 50 days which may be used in one of several ways:

(1) (1) Extension of demonstration.

(2) Additional problem solving as required.

(3) Studies of attractive hardware and/or process variations.

3. Mechanical Models - J. E. Lawson

(a) Air Distributor Studies (Movie and Handout 6 - JEL)

(1) Studies made in small model to illustrate effects of bayonet length on shale flow at point of air distribution.

(2) Movie illustrates differences in flow at two bayonet heights.

(3) A number of heights were studied and results plotted in Handout 6.

(a) These results indicate that, because of the influence of supporting horizontal member, shale flow at air entry is different at different bayonet lengths. Shale flow better at greater lengths.

(b) This work does not prove hypothesis, but does illustrate a factor which is variable with bayonet length.

(b) Bin Design Studies (Movie)

(1) Movie shows development of design for internals of 100 Ton bins.

(2) Objective was to creat live bin so as to increase capacity and minimize segration of shale charged to Retort No. 3.

(3) Approach was to use conical and annular inserts, rather than single level drawoff, since latter would have required too much height.

(4) Technique is largely cut and try since prediction of placement and site is uncertain at best.

(5) Final result has been installed in 100 Ton bins and field adjustment to achieve best flow is in progress.

(c) Mist Studies (Movies and Handout 7 - JEL)

(1) Mist studies are now completed and final report should be issued shortly

(2) Final section of study dealt with impaction of mist in pipe and fittings.

(3) Movies and Handout 7 illustrate following factors -

(a) High velocity upflow pipe - high impaction of mist and counter current flow of liquid to gas

(b) High velocity horizontal - Low impaction and liquid pooling at bottom of pipe.

(d) Movies Available - 1 copy per company will be made and sent to TAC - By mid October.

4. Mining Program - G. R. Haworth

(a) Mining Cost Study

The basic objective of the cost study was to up-date the original one carried out in 1964. The overall cost has increased from 40¢ per ton in the original study to 47.6¢ per ton. This cost includes a 10% return on the investment.

(1) Major differences between the two studies (Refer to Handout 1 - GRH)

(a) The capital cost of production equipment has decreased, the difference is due principally to the reduction in the number of mines worked to produce 84,000 tons per day.

(b) The life of the mining equipment has been reduced to a more realistic figure of 5 years (average).

(c) The cost of operating supplies has more than trippled, tire costs have been doubled, it is felt that the original estimate of supply requirements was too low.

(d) Maintenance labor and supply costs have increased. In the present study the maintenance cost is calculated as 90% of the depreciation cost of the equipment being maintained. This is a standard rate used in cost estimating by the mining industry.

(e) Operating manpower requirements have been reduced due to increased capacity of the equipment, mechanical scaling and the introduction of pneumatic loading of ANFO.

(f) There is no escalation of labor and supply costs in the present study. This has been left up to the individual policies used on escalation.

(g) Plant overhead has been increased because mining is labor intensive and 1.5% of investment per year was too low.

(2) It was brought to the attention of the committee that the present study is based on a hypothetical ore body. Capital and operating costs would have to be adjusted to take care of changes in the locality of the property, the configuration of the property and the thickness of the minable beds of shale.

(3) Bases for estimating operating costs in present study (Refer to Handout 2 - GRH)

(a) Scaling is to be done mechanically

(b) Drilling
- In the headings 3 inch diameter holes, 30 feet long, are drilled with rotary drills assuming a penetration rate of 10fpm.
- Bench drilling is carried out with rotary drills putting down 3 1/2 inch drain holes at 10 fpm. The bench is 34 feet high.

(c) Blasting
- Heading blasts assume a 25 foot round with 0.7 pounds ANFO per ton shale.

- Bench blasting assumes blasting on a continuous basis using 0.4 pounds ANFO per ton shale.

(d) Roof bolting - 6 feet long bolts have been put in on a 7 foot x 7 foot pattern.

(e) Loading issto be done by 10 cubic yard front end loaders.

(f) Hauling is to be done by 80 ton trucks.

(g) Ventilation is provided by means of a 1.5 million cfm main fan with portable fans feeding fresh air to the working faces.

Note: Each of the assumptions given above was followed up with the brief reasoning for making that assumption.

(b) Mine Development at Anvil Points (Refer to Handout 3 - GRH)

(1) Work in haulage ramp is 2 1/2 weeks behind schedule. If there are no serious problems the instrument tunnel will be complete two weeks behind schedule. The instrumentation program will not be seriously affected by the delay.

(2) Adit No. 5 is 5 weeks behind schedule mainly due to maintenance problems on the Bureau of Mines equipment and to the delays in delivery of new equipment ordered last April.

(3) It is planned to put the mining on a 24 hour per day, 7 day per week basis in early October to bring forward the date of completion of development work and prevent any delays in supplying Retort No. 3 with shale.

(4) The roof of Adit No. 5 appears in satisfactory condition. The sag rods which have been installed show that no movement of any significance has taken place over the last 2 months.

(5) The four narrow sections on the mine road have been widened. Gravel is being spread and resurfacing work should be complete by the end of September.

(c) Preliminary Schedule for Mining During Stage II

(Refer to Handouts 4 and 5 - GRH)

(1) Description of heading operations.

(2) Description of benching operations.

(d) Overcoring - Preliminary Conclusions

(1) The principal stress is in a vertical direction, of a magnitude approximating that which would result from the weight of the overburden.

(2) There is a slight restraining force in the direction parallel to the cliff face.

(3) There is little or no horizontal stress in the direction perpendicular to the cliff face.

The above conclusions are very preliminary, they are based upon the borehole deformation measurements and a rough estimate of the elastic constants.

(e) Bench Scale Test Program

Terrametrics have their equipment set up and are ready to start testing during the week of September 12. The elastic strain and compressive strength work will take approximately two weeks to complete: The plastic strain work will take 10 - 12 months to complete.

5. Stage II Rehabilitation - W. S. Bergen

(a) Staffing

Staffing for Stage II at Anvil Points has developed in accord with our operating needs. Handout No. 1 - WSB shows the status as of September 1. You will note that the technical staff is at full strength.

The Research Foundation staff has been increased as needed. The major portion of manpower yet to be hired are for the mining and crushing effort. These people are needed when shale is being transferred from the mine to the crushing plant for Retort No. 3 operation. While, there has been an acceleration in hiring from original projections, we foresee, at present, no need to exceed the total manpower levels forecast.

(b) Rehabilitation of Retort No. 3 and Supporting Facilities

Retort No. 3 and its supporting facilities are beginning to shape up into a recognizable process unit. Design work is about complete. All major equipment and most materials have been specified and ordered, and construction is progressing with an average of 50 men on site over the last two months.

However, in spite of the above, the construction completion date projected for October 7 is not going to be realized. Data just developed, would project construction completion more realiastically as October 21. This includes necessary tests of operating equipment.

Reviewing the status of the work as of September 1, please refer to Handout No. 2 - WSB.

Engineering is better than 90% complete. To have met our completion date, engineering should have been completed by September 1. In reviewing the additional engineering requirements, several items appear. These include the addition of the new pan feeder and crusher plant electrical system, and the complexity of several systems such as the raw shale feed control and spent shale handling. Equipment such as the line burner and spent shale feeder also were developed only after considerable difficulty.

In general many other problems and extra effort were associated with applying high accuries to measurements of the shale, oil, and gas flows. Throughout our unit, we are also utilizing specialized techniques, for shale production and handling and some equipment innovations. These have made it necessary to educate to a degree not only Torkelson's designers, but also equipment suppliers. Engineering of remaining minor details will be completed by September 15.

Construction has progressed in accord with the arrival of design drawings and equipment. Colorado Macco, the constructor, is performing well to date.

Most of the cold gas piping has been installed. The recovery equipment has been installed, as has the retort shell and brickwork, recycle and offgas distributors, recycle compressor and high voltage transformers. The liquid storage tanks have been cleaned and the LACT system is being placed. The single level spent shale drawoff system has also been installed.

Work is progressing in rehabilitating the crushing plant including installation of a new pan feeder, revamping of the primary crusher, and the new crusher plant electrical system.

Other systems now being installed include:

1. The gas and liquid piping.
2. The shale control system.
3. The raw shale inlet system.
4. The spent shale handling system
5. The unit electrical system.
6. The instrument panel. Instrumentation will start soon.

With full construction crews for the next six weeks, the work will be completed and tested by October 21.

Material deliveries, have been better than expected. However, several problems have developed. First, delivery of the three star feeders is uncertain. Part of the Fuller Company plant has been on strike with no immediate prospects of a settlement. Three weeks of construction plus one week of delivery remain to complete this order after settlement of the strike. We will modify the feeders of Retort No. 2 for Retort No. 3 operation.

The line burner will not be shipped until September 23. This will be installed early October.

Instruments will be a major problem due to a month's delay in their delivery from the Fischer - Porter Company. All efforts are being made to either speed their delivery or improvise if necessary - completed ship-

ment is scheduled for October 19. The controls will be shipped October 10 and computor systems October 19. It will still be possible to fire the retort October 22 if these deliveries are met.

The slusher is scheduled for shipment the middle of October but will not delay startup.

Torkelson is making every effort to expedite material deliveries. Again if no additional equipment delays develop, the October 21 completion date will be realized.

I have attempted to estimate the final cost of the work - this is shown on Handout No. 3 - WSB. The final cost should approach $725,000. $725,000 has been budgeted for this work - three estimates are listed - Stage II - Torkelson's estimate of May 1966 - my estimate of September 1. The major incremental cost increase in in engineering cost. Again increased complexity in the various systems has contributed to the increased cost.

We see no pending over-run of the budget figure.

Reviewing a few of the construction details and special tests we have:

First - tests have been made of the new Allis-Chalmers crusher. Crushing capacity tests have also been made. 1/4 to 2 1/2 inch shale has been produced at rates exceeding 30 tons per hour - our projected rate. 1 to 2 1/2 inch shale has been produced with difficulty due to poor screening efficiencies. We have tried a closed circuit system and obtained low capacities. The closed circuit system involves recirculating the second day crusher product back to the primary crusher.

We project that our rates will be produced by an open circuit system. All product from the secondary crusher over a single deck secondary which cuts out undersize - oversize being regulated by the secondary roll spacing.

1/4 to 1 inch shale is produced at low rates with our present rolls. Allis-Chalmers will supply a new set of rolls for production of 1/4 to 1 inch shale.

The Allis-Chalmers crusher is of concern. It is underweight and of flimsy construction. Problems have been experienced keeping the unit together. We are undertaking a program to beef the unit up, to change most of the bolting arrangements and rebrace the crusher. The Allis-Chalmers service engineer is on site to work out these problems. It is our opinions that the crusher performs well but the unit supplied is of inferior construction.

2. Configurations for the air distributors were agreed upon during August. Two sets of headers and manifold riser combinations were designed and ordered. Handout No. 4 - WSB shows possible installation combinations with shale sizes.

The riser layout selected is governed by burning intensity and shale flow needs.

The 84-riser layout conforms with the 12-risers in Retort No. 2 and is projected for 1/4 to 1 inch shale.

The 48-riser layout conforms with the 8-risers in Retort No. 2 and is projected for 1/4 to 2 1/2 inch shale.

Tests for shale flow will be made in the large mechanical model of the 36-risers on 15 by 12 3/4 inch spacing. This layout is projected for the 1 to 2 1/2 inch shale.

These layouts are adaptable to larger retorts.

3. The completed brickwork was tested as you know. The retort shell was out of plumb and warped badly.

The completed brickwork was to be plumb and rectangular. Final dimensions show offsets no more than 1/4 inch from the vertical for any wall in the 24 feet of height. A rectangular form was fabricated and pushed down through the retort to test rectilinearity.

4. A prototype screw conveyor was fabricated and tested on the large mechanical model unit.
Shale flows equivalent to 700 mass rate were run with 1/4 to 1 and 1 to 3 inch shale. No stoppages occurred. Power requirements were in line with manufacturer designs. The 1/4 to 1 inch shale flowed easier than the 1 to 3, as was expected.

5. The Kopper's precipitator was installed by Koppers last month. They have met their delivery schedules and are to be commended.

6. Internals were installed in the 100 ton bins to liven the walls. The configuration was developed using plastic models.

Shale flow was reasonably as predicted with the large shale 1 to 2 1/2 inch. The 1/4 to 1 and 1/4 to 2 1/2 inch shale tended to flow through the middle.

Corrective center baffle rings are being fabricated.

Additional experimentation in the large mechanical model will test air and recycle header layouts. This unit is a half section of Retort No. 3. Already installed and being tested in the large model are half sections of Retort No. 3 shale inlet and shale outlet configurations.

Corrosion Study

A corrosion and materials test program is being initiated at Retort No. 3. At the last Technical Observers meeting, goals, techniques, and materials to be tested were reviewed in detail. L. W. Skowronek of our technical staff will head this program, he will work closely with the Mobil Oil Corporation corrosion group in this effort. Reports will be available of the progress of this work as it develops.

We expect that all Participating Parties will review their needs for the corrosion program.

Stage II Office

You will recall, that work was initiated last May to renovate the retort engineer offices, the analytical offices, and the mine office and change rooms. This work was completed and we are happy to report the retort engineers did have the benefit of air conditioning this summer.

STAGE II ESTIMATED EXPENDITURES TO AUGUST 31, 1966

Actual Cash Disbursements to 8/31/66	$ 926,328
Accrued Costs	611,965
Estimated Expenditures to 8/31/66	1,538,293
Budget to 8/31/66	1,551,265
Variance - Favorable	$ 12,972

MANPOWER 9/8/66

Participating Parties	24
Research Foundation (Authorized)	122
Total	146

RHCramer
9/7/66

MAJOR CONCLUSIONS SINCE THE JUNE TECHNICAL ADVISORY COMMITTEE MEETING

1. Low oil partial pressure combined with conversion of kerogen to naphtha appears to be restricting yields from the Gas-Combustion retort to a maximum of about 94 Vol % of raw shale Fischer Assay.

2. The following variables have a significant effect on yield:

   a. Weight mean diameter of raw shale feed.
   b. Size range of the raw shale.
   c. Shale mass rate.
   d. Gas ratio, SCF/T.

3. The economic optimum maximum size shale feed to the retort is about 2 1/2 inches.

4. Shale size fractionation is slightly more attractive than retorting the 1/4 inch plus full range shale.

5. A two fraction feed, 1/4 to 1 inch plus 1 inch to 2 1/2 inch, and the corresponding one fraction feed, 1/4 inch to 2 1/2 inch, should be demonstrated on Retort No. 3.

6. Required retort bed height can be predicted as a function of the surface mean diameter (APD) and mass rate.

7. Commercial mining costs at the 84,000 tons per day level are estimated to be about 48¢ per ton including a 10% discounted rate of return on investment. This was not factored into the current retort economic study.

8. The 1 inch to 2 1/2 inch fraction should be demonstrated on Retort No. 3 using the air distributor configuration with the risers spaced on 15 inch by 12 3/4 inch centers.

9. Retort No. 3 reconstruction cost is currently estimated to be within 5% of the original estimate. Completion of construction may be delayed by late equipment deliveries.

10. There is an adverse effect on operability from the interaction of air distributor riser height with the narrow dimension of Retort No. 2.

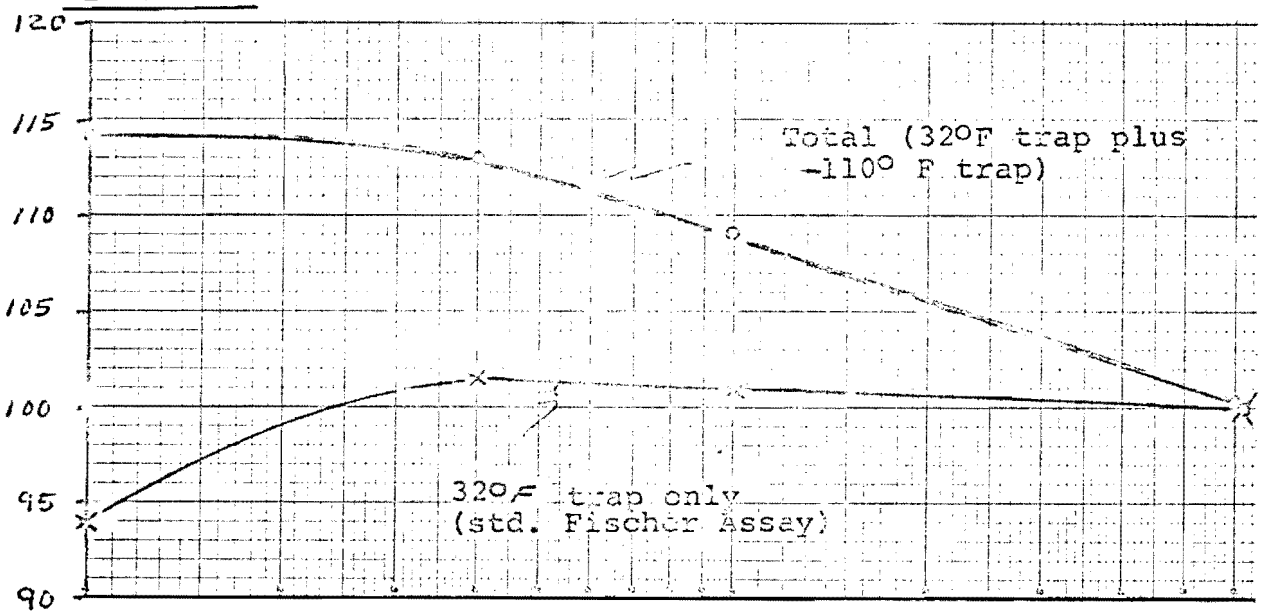
Note: At the request of H. P. Dengler of Esso Research and Engineering the following statement is included:

"These conclusions have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses."

RHCramer
9/7/66

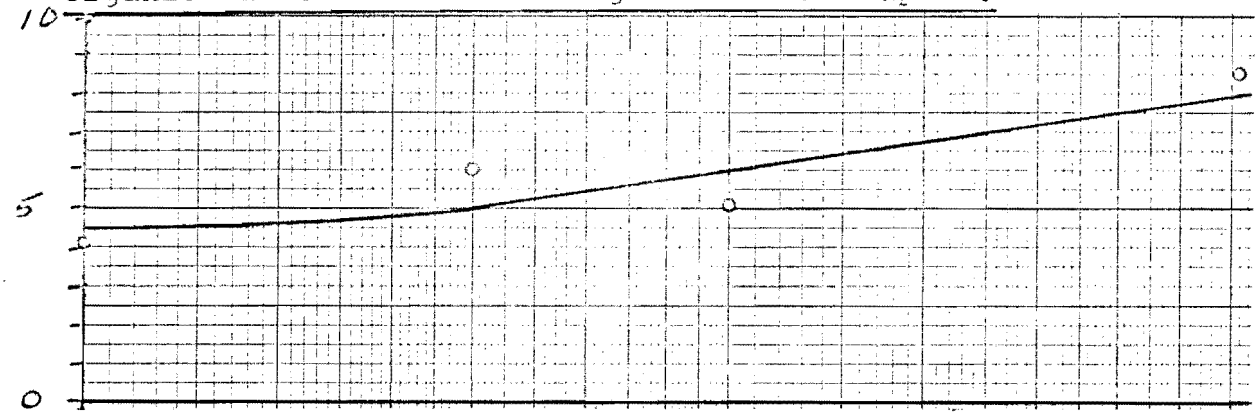
EFFECT OF PRESSURE ON YIELD FROM FISCHER ASSAY

Oil Yield:



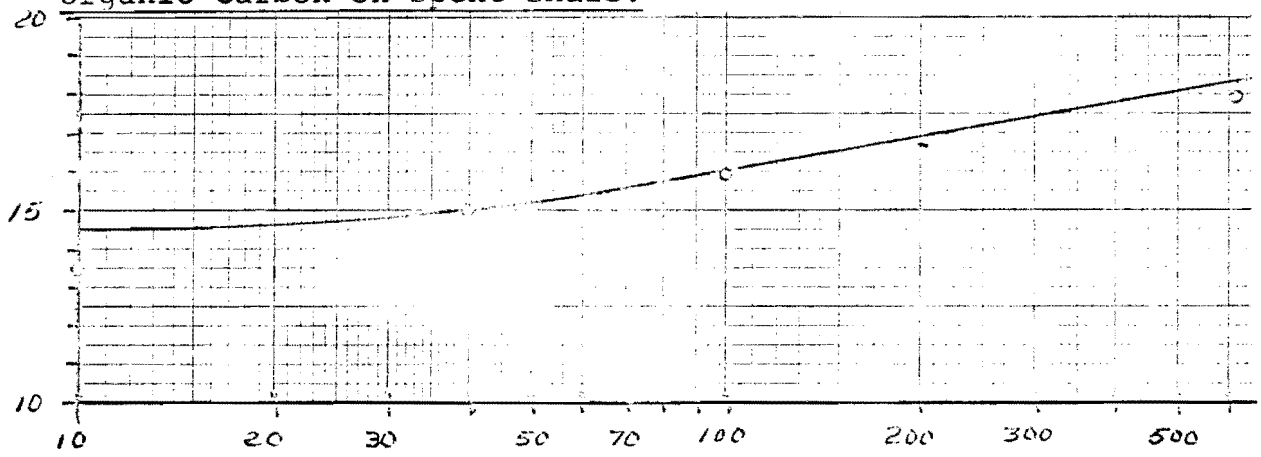
Vol % Normal Fischer Assay

Organic Carbon in Gas Leaving - 110° F Trap(1):



% Organic Carbon in Raw Shale

Organic Carbon on Spent Shale:



% Organic Carbon in Spent Shale

(1) Assumes same composition as standard Fischer Assay gas.

PWSnyder & DCotrupe
9/6/66

EFFECT OF FINES ON YIELD FROM FISCHER ASSAY WHEN RETORTING AT 10mmHg

Condition Being Simulated	Fines Not Present	Combustion Zone Fines Present	Retorted-Only Fines Present
Amount, Wt % charge	0	25	25
Source	--	Gas-Combustion Spent Shale	Fischer Assay Spent Shale
Oil Yield, Vol % Std Fischer Assay			
In 320° F trap	94	90	86
In - 1100° F trap	20	27	33
Total	114	117	119

PWSnyder
9/6/66

SCHEMES FOR RECOVERING NAPHTHA VAPORS FROM RETORT GAS

A. Conventional:

1. Increase pressure of offgas.
2. Cool the offgas.
3. Use adsorbents:

    a. Activated Charcoal
    b. Silica Gel
    c. Sorbead H
    d. Molecular Sieve
    e. Activated Alumina

4. Use Absorbents:

    a. 500° F+ shale oil.
    b. 500° F+ clean distillate.

5. Combination of the schemes above

B. Unconventional:

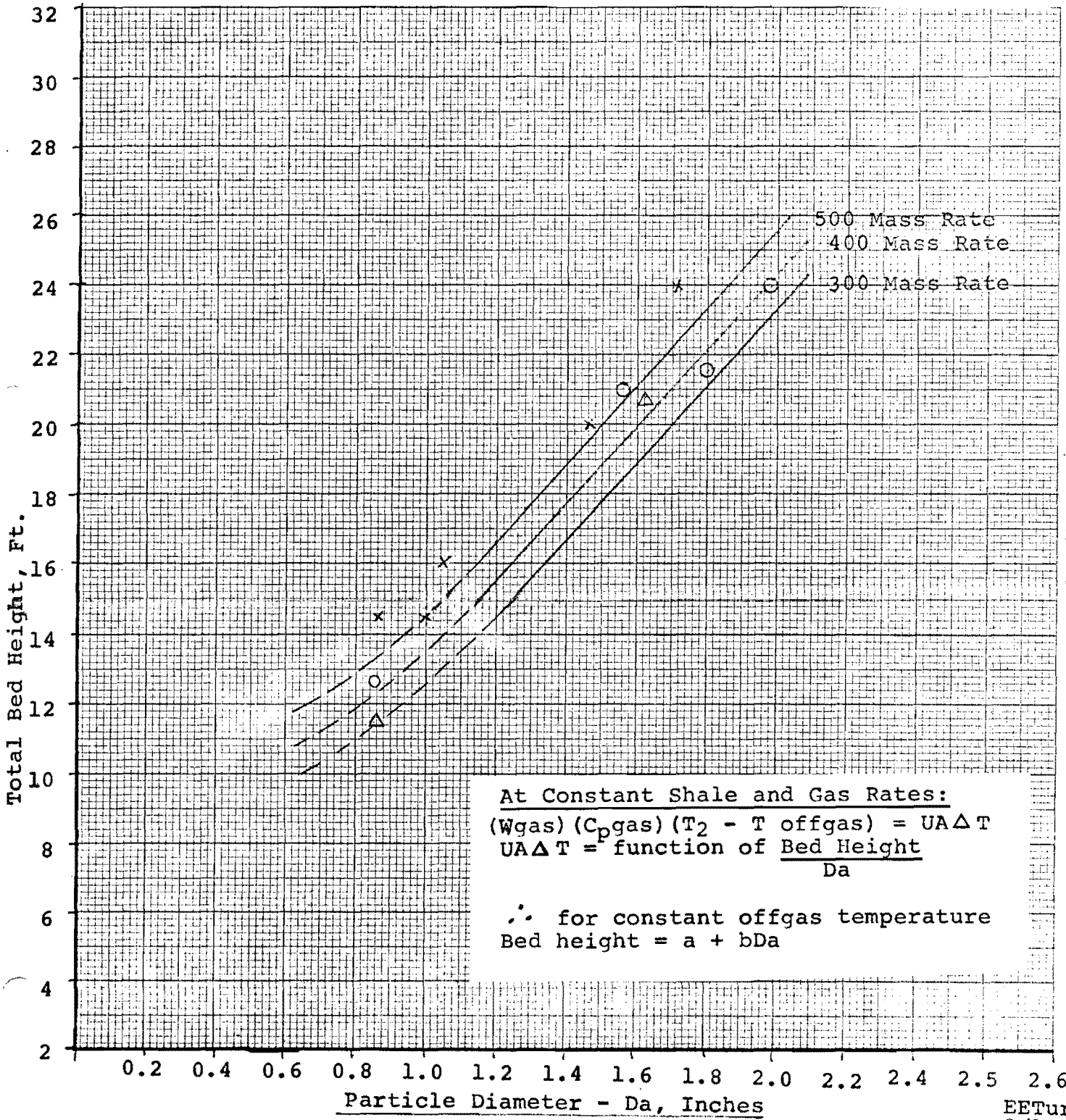
1. Polymerization of olefinic portion of naphtha using highly active catalyst such as aluminum chloride.
2. Acid extraction.
3. Review literature for selective absorbent or solvent.
4. Circulate 500° F^+ shale oil as the liquid scrubbing agent in conventional wet type mist recovery units (scrubbing tower or venturi type). This would replace the existing cyclone.
5. Process changes:

    a. Use high specific heat recycle gas to permit lower gas-to-shale ratios and thus higher partial pressures of the naphtha.
    b. Pressure retorting to raise partial pressure of naphtha.
    c. Improvements to reduce the conversion of kerogen to naphtha.

PWSnyder
9/6/66

PRELIMINARY BED HEIGHT REQUIREMENTS FOR CONSTANT 135°F OFFGAS TEMPERATURE

X - 500 lbs/(hr)(ft^2)
O - 400 lbs/(hr)(ft^2)
Δ - 300 lbs/(hr)(ft^2)



EETurner
8/15/66

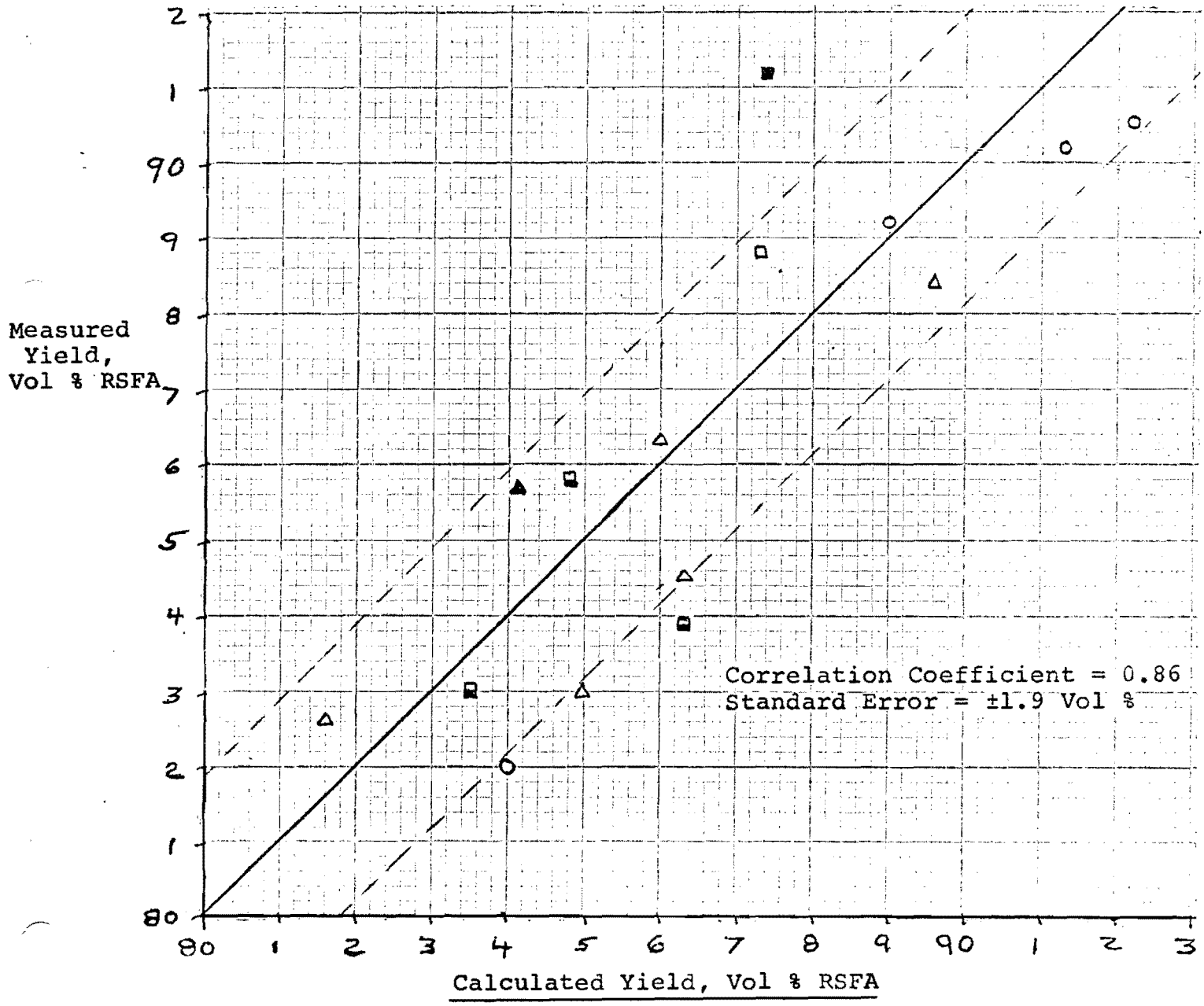
LINEAR REGRESSION ANALYSIS FOR YIELD RELATIONSHIP

$$YIELD = 92.22 - 2.366\ D_V^2 - 12.00\ \sigma_g + 1.341\ R - 0.01096\ M$$

where: D_V = Weight mean average particle diameter, inches.
σ_g = Geometric standard deviation of size distribution ($(\mu + \sigma)/\mu$).
R = Recycle gas rate, MSCF/T.
M = Shale mass rate, lbs/(hr)(ft^2).

Experimental Data:

Nominal Size	D_V	σ_g	R	M	Symbol
3/4 - 1½	0.9 - 1.1	1.2 - 1.3	11 - 15	300 - 500	○
1½ - 2½	1.7 - 1.9	1.1 - 1.4	13 - 15	300 - 500	△
1/4 - 1½	0.8	1.5	15	500	□
1/4 - 1	0.6	1.4	14	500	■
1/4 - 3	1.0 - 1.2	1.6	14 - 15	300 - 500	▣



PWSnyder
8/12/66

OPERABILITY LIMITS ENCOUNTERED IN RETORT NO. 2

Mass Rate, lb/(hr)(ft^2)	500	600
Shale Size		
1/4 - 1	Good-Conditional	Inoperable for sustained periods
3/4 - 1 1/2	Excellent	Questionable
1/4 - 2 1/2	Good	Inoperable
1 1/2 - 2 1/2	Good	Operable-Low yields

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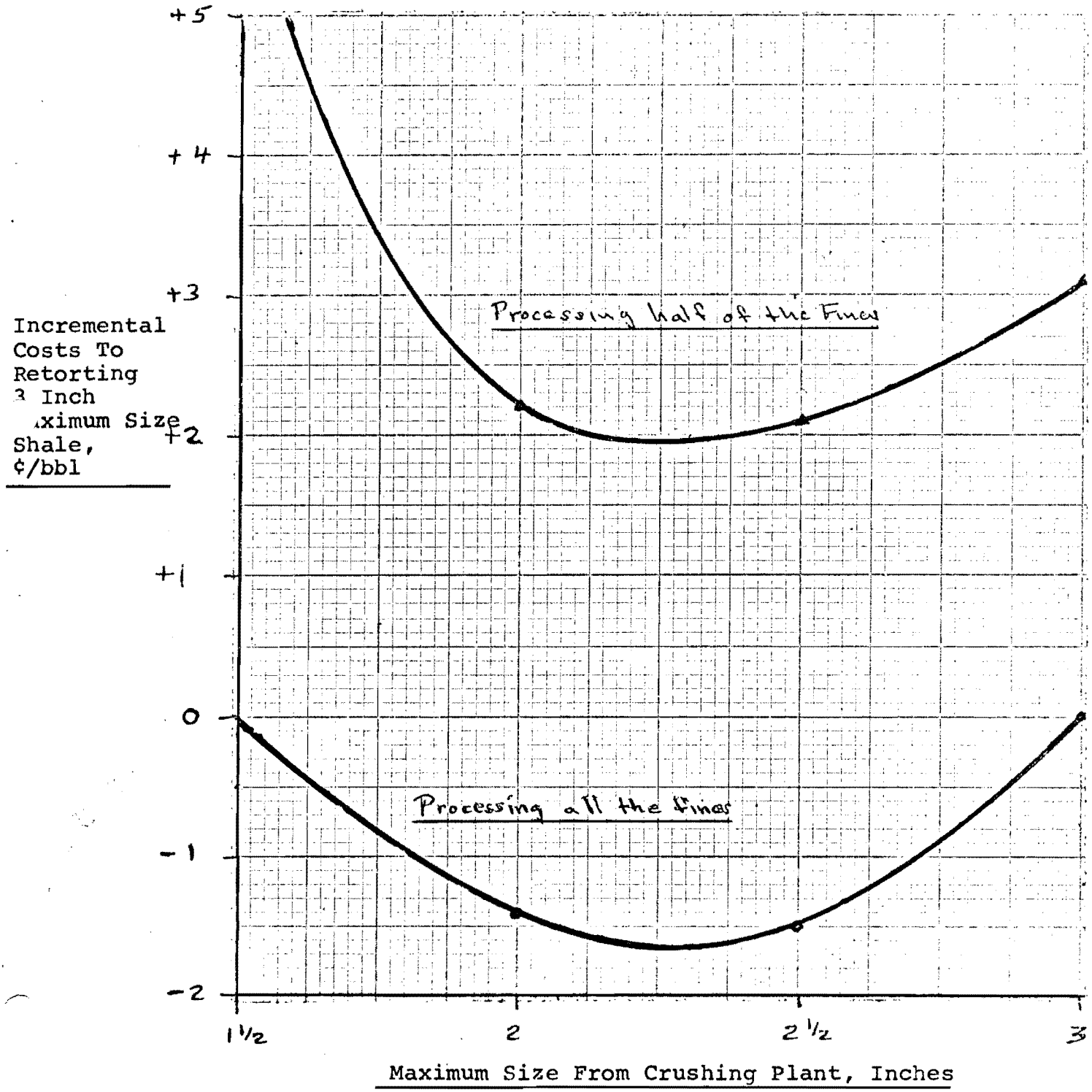
9/7/66

CALCULATED OPTIMUM MAXIMUM SHALE SIZE



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8/12/66

OPTIMUM SHALE SIZE FRACTIONATION
RETORTING 2 1/2 INCH MINUS SHALE

(Nordberg Size Distribution-13% less through 1/4 inch)

CASE:	I One Fraction	II Two Fractions Cut at 1/4 Inch and 1 Inch	III Two Fractions Cut at 1/4 Inch and 1 1/2 Inch	IV Three Fractions Cut at 1/4, 3/4 and 1 1/2 Inch
A. Processing All Fines				
Incremental Cost, ¢/bbl at:				
500 MR for Large Shale Fraction	Bases	- 2.5	- 1.7	- 3.3
400 MR for Large Shale Fraction	+ 0.5	- 2.3	- 1.2	- 2.9
Oil Yield on Mine Run, Vol % FA at;				
500 MR for Large Shale Fraction	83.5	86.5	85.7	87.5
400 MR for Large Shale Fraction	85.0	87.9	86.6	88.4
B. Processing Half The Fines				
Incremental Cost, ¢/bbl at:				
500 MR for Large Shale Fraction	Bases	- 1.0	- 0.6	- 2.0
400 MR for Large Shale Fraction	+ 0.9	- 0.8	- 0.0	- 1.6
Oil Yield on Mine Run, Vol % FA at:				
500 MR for Large Shale Fraction	80.0	81.4	81.1	82.3
400 MR for Large Shale Fraction	81.5	82.9	82.0	83.2
Fines Discarded, Wt % Mine Run	4.2	5.9	5.4	6.1

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9/6/66

YIELDS USED IN ECONOMIC ANALYSIS OF OPTIMUM MAXIMUM SIZE AND NUMBER OF FRACTIONS

Number of Fractions	1	2				3		
		A		B				
Nominal Size Range	1/4-Max	1/4-1	1-Max	1/4-1 1/2	1 1/2-Max	1/4-3/4	3/4-1 1/2	1 1/2-Max
A. Yields for Maximum Size Analysis, Vol % RSFA(1)								
1 1/2" Max Size								
500 MR	89.5	91.6	89.2	---	---	92.1	89.5	---
400 MR	90.5	92.1	90.6	---	---	92.4	90.8	---
2 1/2" Max Size								
500 MR	84.0	91.6	83.6	89.5	82.6	92.1	89.5	82.6
400 MR	86.5	92.1	87.0	90.5	86.7	92.4	90.8	86.7
3" Max Size								
500 MR	79.8	91.6	79.6	89.5	79.0	92.1	89.5	79.0
400 MR	83.4	92.1	84.4	90.5	84.4	92.4	90.8	84.4
B. Yields For Fractionation Analysis, Vol % RSFA(2)								
2 1/2" Max Size								
500 MR	83.4	91.6	84.8	87.6	83.8	93.1	90.8	83.8
400 MR	85.1	92.1	87.0	88.3	86.0	93.7	91.1	86.0

(1) Based on best yield data available as of July 24, 1966.

(2) Based on best yield data available as of August 5, 1966.

PWSnyder
9/7/66

OPERABILITY STUDIES - 3/4 x 1 1/2 INCH SHALE

CONDITIONS: 4,400 Air, 15,000 Recycle Gas
9 Foot Bed Height Above Air Distributor

Configuration	Bayonet Length, Inches	Bed Height Below, Feet	Air Dist. Relation To Manhole, Inches	Operability
Demo. Run 817	21	5.5	34	Very Good
1	39	7.0	16	Inoperable
2	21	5.5	34	Very Good
3	39	7.0	16 (Welded up)	Inoperable
4	21	7.0	16	Very Good
5	21	5.5	16	-----

JELawson
9/6/66

SUMMARY OF RESULTS
RICH SHALE RUNS PTB-924, B-924, AND B-925

Run Number	PTB-924	B-924	B-925
Air Rate, SCF/T	4,100	4,430	4,390
Recycle Rate, SCF/T	13,300	12,100	13,800
Bed Height, Feet	9	9	9
Raw Shale Fischer Assay, Gal/Ton	33.8	35.1	34.2
Oil Yield, Volume Percent RSFA	85.7	87.3	93.0
Organic Carbon Balance, Wt %	89.1	95.2	96.4
Carbonate Decomposition, Wt %	30.8	29.0	29.4
Comments	Retort was bridged for 35 minutes in middle of period. Lowered recycle and increased air at time of bridge.	Reduced air rate 2 hours before end of period because of deterioration of shale flow quality.	Quality of shale flow continued to deteriorate and finally the retort was shutdown by bridging.

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9/6/66

MISCELLANEOUS STUDIES - RETORT NO. 2

	Bed Height Study	Shale Range Effect
Run Numbers	941 - 946	932 - 936
Nominal Shale Size, Inches	1 1/2 x 2 1/2	1/4 x 1 1/2
DA, Inches	1.82	0.68
DV, Inches	2.05	0.88
Shale Rate, lb/(hr)(ft^2)	402	502
Air Rate, SCF/T	4,430	4,280
Recycle, SCF/T	14,900	14,300
Bed Height Above, Feet	14	8
Bed Height Below, Feet	7	5.5
Offgas Temperature, ^oF	140	136
Yield, Vol % Fischer Assay	86.3	88.8
Spent Shale Temperature, ^oF	300	300

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9/6/66

DEMONSTRATION RUNS - RETORT NO. 2

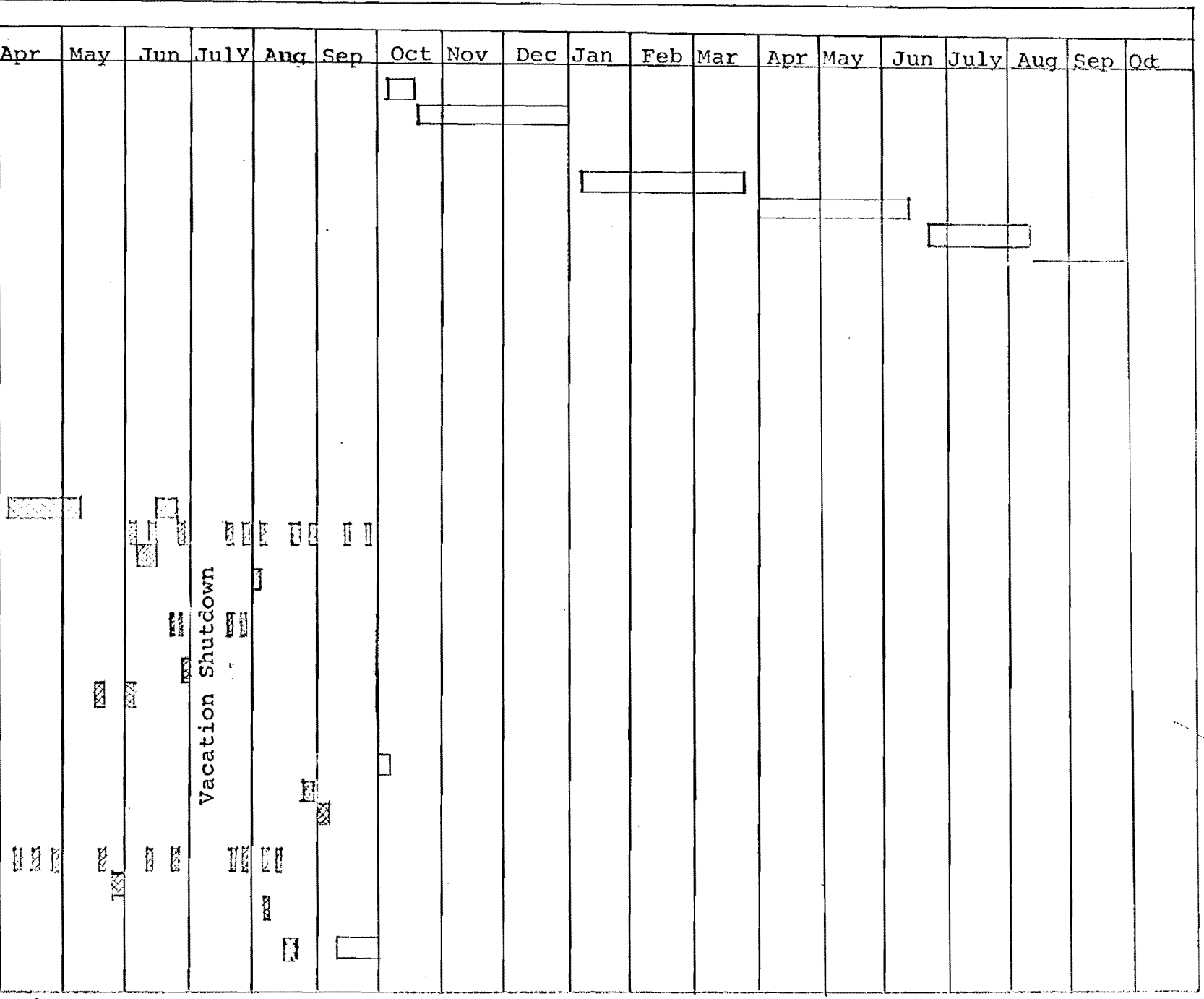
	1 x 2 1/2 Inch Shale		1/4 x 2 1/2 Shale (Preliminary)
	952A-D	952E-L	953A-E
Shale Rate, lb/(hr)(ft^2)	407	403	499
Air Rate, SCF/T	4,360	4,560	4,320
Recycle, SCF/T	15,900	15,900	15,100
Bed Height Below, Feet	7.0	7.0	5.5
Bed Height Above, Feet	12.5	12.5	10.0
No. Bayonets	4	4	8
Yield, Vol % Fischer Assay	85.5	88.1	86.4
Spent Shale Fischer Assay, gpt	0.8	0.2	--
Offgas Temperature, ^{o}F	135	137	138
Spent Shale Temperature, ^{o}F	273	268	316

JELawson
9/6/66

TABLE 1

STAGE II RETORTING PROGRAM

Planned Completed



stimate.

utilized during prolonged Retort No. 3 downtime.

RESmith
8/12/66

HANDOUT 5 - JEL

		Days
A.	Retort No. 3	
1.	Operator Training	14
2.	Shakedown	72
3.	Optimization and Demonstration Runs[1]	
	a. 1 to 2 1/2 inch Shale	81
	b. 1/4 to 1 inch Shale	81
	c. 1/4 to 2 1/2 inch Shale	49
4.	Slack Time To Be Allocated in Future	52
	a. Contingencies in Basic Program, and/or	
	b. Equipment Studies, and/or	
	c. Process Variations and Operability Studies	
		349
B.	Retort No. 2 - High Priority	
1.	Process Variable Study	
	a. Shale Size Mass Rate	50
	b. Raw Shale Screening & Handling	--
	c. Optimization	10
	d. Shale Size Range Effect (1/4 to 1 1/2 Inch)	4
2.	Check Point and Operability Studies-3/4 x 1 1/2 inch	10
3.	Shale Richness	4
4.	Fines (Retort No. 1)	12
5.	Final Shale Fractions Demonstration	
	a. 1/4 to 1 inch Shale	7
	b. 1 to 2 1/2 inch Shale	7
	c. 1/4 to 2 1/2 inch Shale	7
6.	Fines Processing	--
7.	Startup Studies	--
8.	Horizontal Distributors	7
9.	Bed Height Study (For Retort No. 3)	4
10.	Operability Studies - 1/4 x 1 inch	30
11.	Category "C" Studies[2]	--
		152

(1) Stream efficiency has not been included in e

(2) Category "C" Studies on Retort No. 2 will be

ORDER OF PRIORITY OF STAGE II RETORTING STUDIES

	Objectives	Reason For Study	Type of Change
dy	Draw preliminary conclusion on: 1. Maximum economical particle size 2. Optimum particle size range 3. Optimum shale rate for each particle size	Maximum particle size, optimum particle size range, and optimum shale rate for each are important economic parameters which must be developed in program.	Process Variable and Equipment
	Develop procedures and equipment modifications required to produce narrow size ranges.	Debug potential screening and large shale handling problems.	Equipment
	Provide final answers on maximum particle size, optimum size range and optimum shale rate and optimize each particle size with respect to air and recycle gas rates, bed heights, and air distributor hardware.	Final answers must be obtained to permit optimization of economics of a commercial venture.	Process Variable and Equipment
	Confirm the size range effect derived from preliminary correlations.	Confidence in the economics relating to the selection of shale fractionation schemes would be improved by using actual data.	Equipment
	Reconfirm or check 3/4 to 1 1/2 inch base point prior to richness studies and determine causative mechanisms of the inoperability of the base point check.	Raw shale specifications currently provide for a slightly larger shale than prior 3/4 to 1 1/2 inch shale. Also retort configurations had been modified. Determination of the failure mechanism was necessary before studies could be resumed.	Equipment and Retort Configuration

Order of Priority	Study
1	Process Variable
	A. Shale Size and Rate Stu (Completed)
	B. Crushing and Screening Plant Evaluation
	C. Optimization Studies (Completed)
	D. Shale Size Range Effect (1/2 to 1 1/2 inch) (Completed)
2	Check point and Operability Studies (Completed)

Determine bed height requirements with 1 1/2 to 2 1/2 inch shale.	Retort No. 3 construction timing and economic studies of shale fractionation dictated the need and criticality of these data.	Process Variable and Equipment
Establish a more successful startup procedure.	Smoothest startup must be achieved because of penalty for poor startup of a large retort.	Process Variable
Evaluate the value of more uniform air distribution and establish whether a horizontal air distributor design is feasible.	More uniform distribution may increase operability and improve yield on some shale sizes.	Equipment
Demonstrate final shale fractions selected and full range shale.	Provide a base point for Retort No. 3 and demonstrate the theory of shale fractionation	Process Variation and Equipment
Improve operability on small shale fractions.	Clinkering and bridging more severe with small shale. Must solve problems before demonstration of shale fractionation principle can proceed.	Process Variable and Equipment
Investigate economic methods of processing raw shale fines.	Success would mean significant decrease in costs predicted for shale oil production.	Process Variable and Equipment
Confirm initial results obtained on Retort No. 1 and make a minimum effort to search for operating conditions which will permit retorting a 40 gal/ton shale.	Increased shale richness significantly reduces overall costs if unit mining and crushing costs do not increase significantly.	Process Variable
Establish suitablity of hardware selected, including problem solving as necessary; refine test procedures; and establish precision of test results.	This work must be done before demonstration can proceed.	None required except to solve problems.

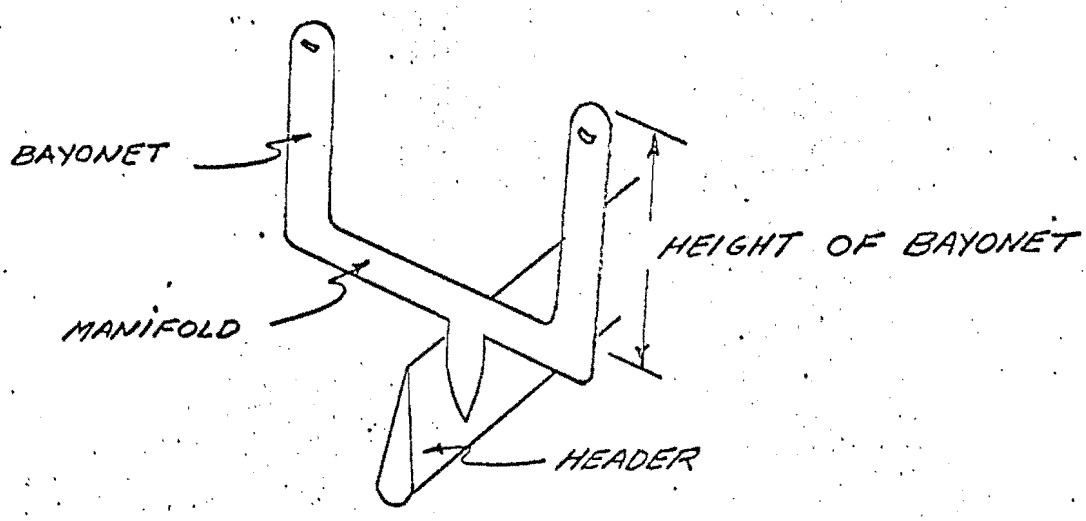
3	Bed Height Study For Retort No. 3 (completed)
4	Startup Studies (Documentation effort only)
5	Horizontal Air Distributor (Completed)
6	Final Shale Fractions Demonstration (1 x 2 1/2 inch Complete)
7	Operability Studies - 1/4 x 1 inch Shale
11	Fines Processing
10	Shale Richness Studies
8	Shakedown - Retort No. 3

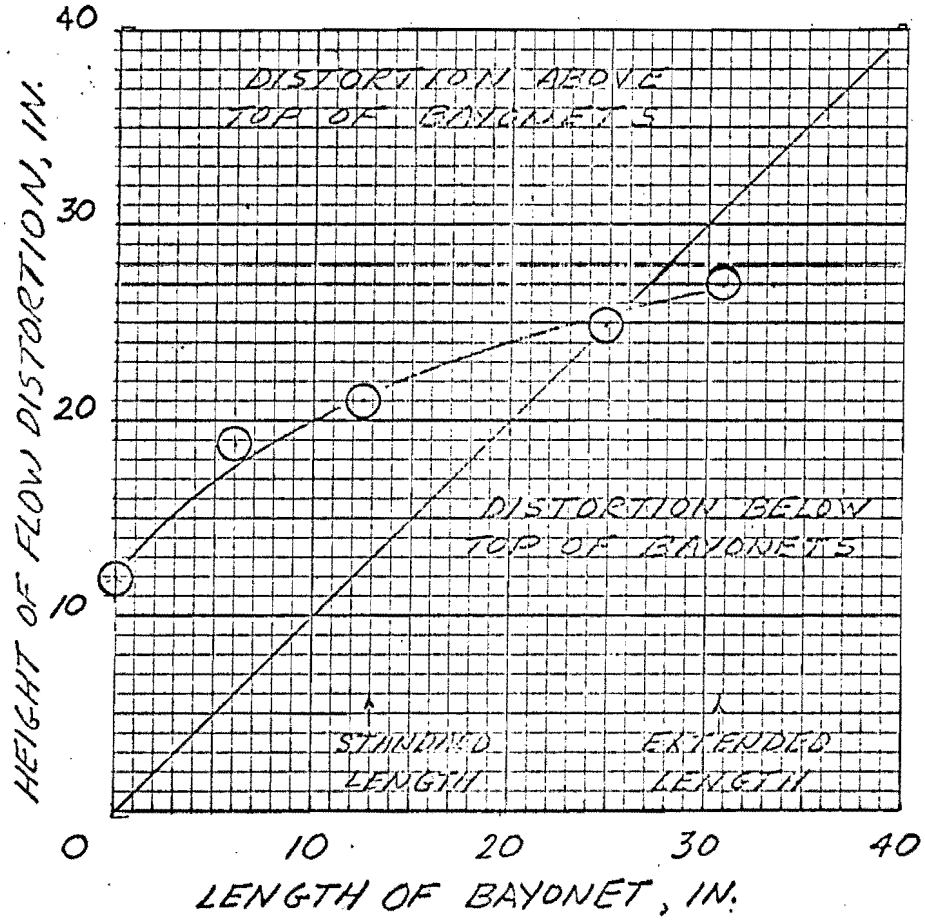
Demonstrate scale up of process to large unit by showing results equivalent to Retort No. 2 at selected process conditions and demonstrate long-term stability of process.	Establish confidence in ability to scale process as required for commercial application.	Process Variable and Equipment
Make evaluation of alternate hardware systems and/or process conditions.	Establish commercial feasibility of alternate hardware and process conditions to provide greater latitude in retort design.	Process Variable
Basic preliminary studies in Retort No. 2 relating to these process modifications.	Provide a broader understanding of the Gas Combustion Retort and improve its economics.	Process Variation and Equipment

JELawson
9/6/66

SHALE FLOW DISTORTION VS. BAYONET HEIGHT IN RETORT NO. 2

3/4 - 1½ IN. SHALE





NOTE: TOP OF MANIFOLD IS BASE FOR ALL MEASUREMENTS

TC1YNS R-LL

BASIC FLOW STUDY RESULTS

Pipe Configuration	Velocity ft/sec	Average Overall Impaction Efficiency Eo, %
Vertical - Straight - 10 Ft (Up Flow)	12.9	0
Vertical - Straight - 10 Ft (Up Flow)	64.7	53.7
Horizontal - Straight - 10 Ft	64.7	0
90° Ell	64.7	24.3
90° Ell	43.5	7.6
Vertical - Straight - 10 Ft (Down Flow)	64.7	15.6

TABLE 3

COMPARISON OF THE TWO MINING COST STUDIES

STUDY	MONTHLY PROGRESS MEMO JULY - AUGUST 1964	PRESENT STUDY
Investment		
Equipment	$ 8,300,000	$ 6,800,000
Offsites Development	1,300,000	2,300,000
Buildings, Utilities, & Inventory	1,900,000	1,900,000
Total Investment (Initial)	$11,500,000	$11,000,000
Project Life	15 years	15 years
Depreciation	15 SYD on entire investment	15 years SYD on offsites 5 years SYD on equipment
Initial distribution of investment	16% 1st year 42% 2nd year 42% 3rd year	16% 1st year 42% 2nd year 42% 3rd year
Size of operation	84,000 tons per day	84,000 tons per day
Grade of oil shale	30 gpt.	30 gpt.
Operating Supplies	$1900 per day	$5948 per day
Maintenance Supplies	$1600 per day	$2980 per day
Fuel	$1620 per day	$1313 per day
Power	$1500 per day	$ 719 per day
Explosives	$2100 per day	$1916 per day
Direct Manpower		
Operating	540	287
Maintenance	115	282
Total	655	569
Supervision cost	10% operating labor	20% operating labor
Benefits	30% of labor	30% of labor (less overtime)
Escalation	1% per year on wages 1% per year on plant overhead 0.5% per year on material	Escalation factors have been left out
Operating labor wages	$3.00 per hour	$3.50 per hour plus 2% overtime
Plant overhead	1.5% investment per year equivalent to $420 per day	10% operating maintenance labor equivalent to $1612 per day

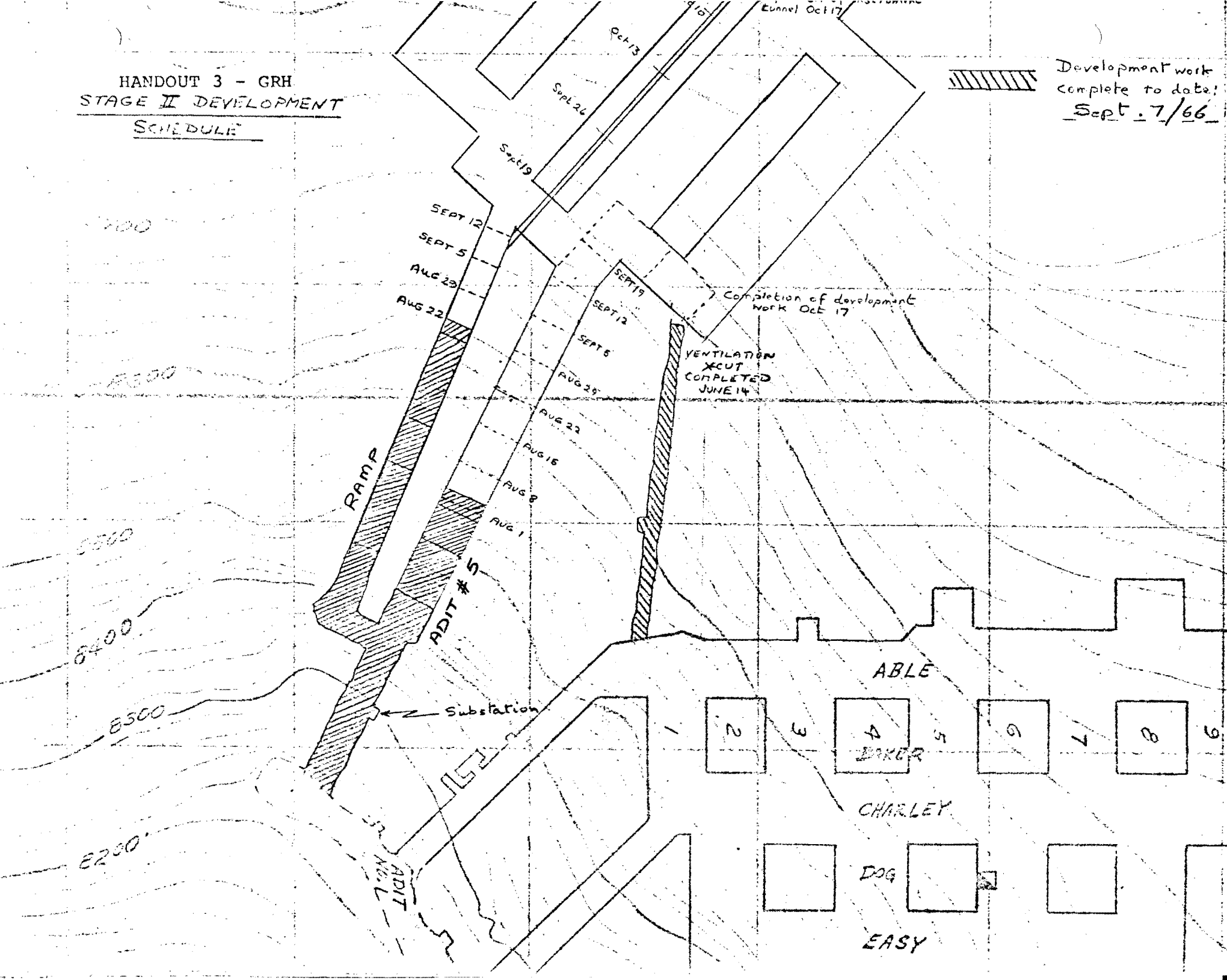
Miscellaneous Supplies	1% of investment per year	3% of investment per year
Insurance & Taxes	1.5% of investment per year	1.5% of investment per year
Mining Cost (include 10% return investment)	approximately 40¢ per ton	47.6¢ per ton

SUMMARY OF MINE OPERATING COSTS FROM TECHNICAL MEMORANDUM NO. 66-5

Note: (1) Cost centers are principal working areas.
(2) Equipment owning costs are included in each cost center.
(3) Maintenance labor is not distributed to individual cost centers.

Scaling	1.11 cents/ton
Drilling	5.13 cents/ton
Powdering and Blasting	5.43 cents/ton
Rockbolting	0.95 cents/ton
Loading	3.40 cents/ton
Hauling	8.67 cents/ton
Ventilation	1.65 cents/ton
Supplies handling	0.76 cents/ton
Road Maintenance and Inspection	0.76 cents/ton
Electrical Maintenance Labor and Services	1.59 cents/ton
Mechanical Maintenance labor and Services	3.04 cents/ton
Transportation	0.14 cents/ton
Surface Facilities	0.27 cents/ton
Supervision and Administration (20% labor)	2.41 cents/ton
Miscellaneous Supplies (3% investment per year)	1.08 cents/ton
Benefits (30% labor and supervision)	4.37 cents/ton
Plant Overhead (10% labor, supervision, & benefits)	1.92 cents/ton
Insurance and Taxes (1.5% investment per year)	0.54 cents/ton
Ownership of offsite facilities	0.91 cents/ton
TOTAL DIRECT COST OF MINING	44.1 cents/ton
Less tax advantage from depreciation allowance and investment credit	1.1
	43.0
Plus 10% return on investment	4.6
TOTAL COST INCLUDING RETURN ON INVESTMENT	47.6 cents/ton

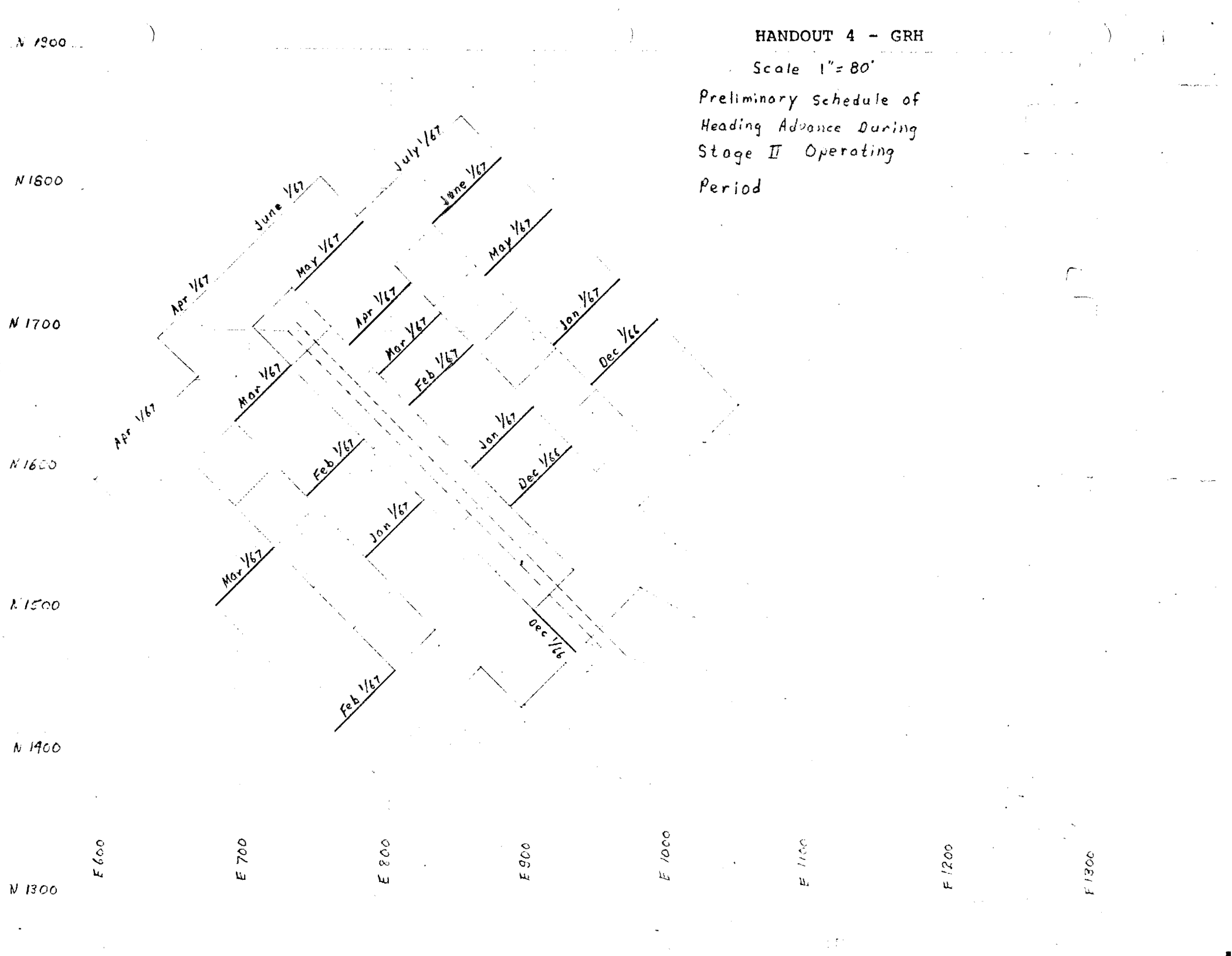
GRHaworth
9/6/66


HANDOUT 3 - GRH
STAGE II DEVELOPMENT
SCHEDULE
Development work complete to date:
Sept. 7/66
Oct 13
Sept 26
Sept 19
Tunnel Oct 17
SEPT 12
SEPT 5
AUG 29
AUG 22
SEPT 19
SEPT 12
SEPT 5
AUG 29
AUG 22
AUG 15
AUG 8
AUG 1
Completion of development work Oct 17
VENTILATION X-CUT COMPLETED JUNE 14
RAMP
ADIT #5
Substation
ADIT #4
8600
8500
8400
8300
8200
ABLE
BAKER
CHARLEY
DOG
EASY
1
2
3
4
5
6
7
8
9

HANDOUT 4 - GRH

Scale 1" = 80'

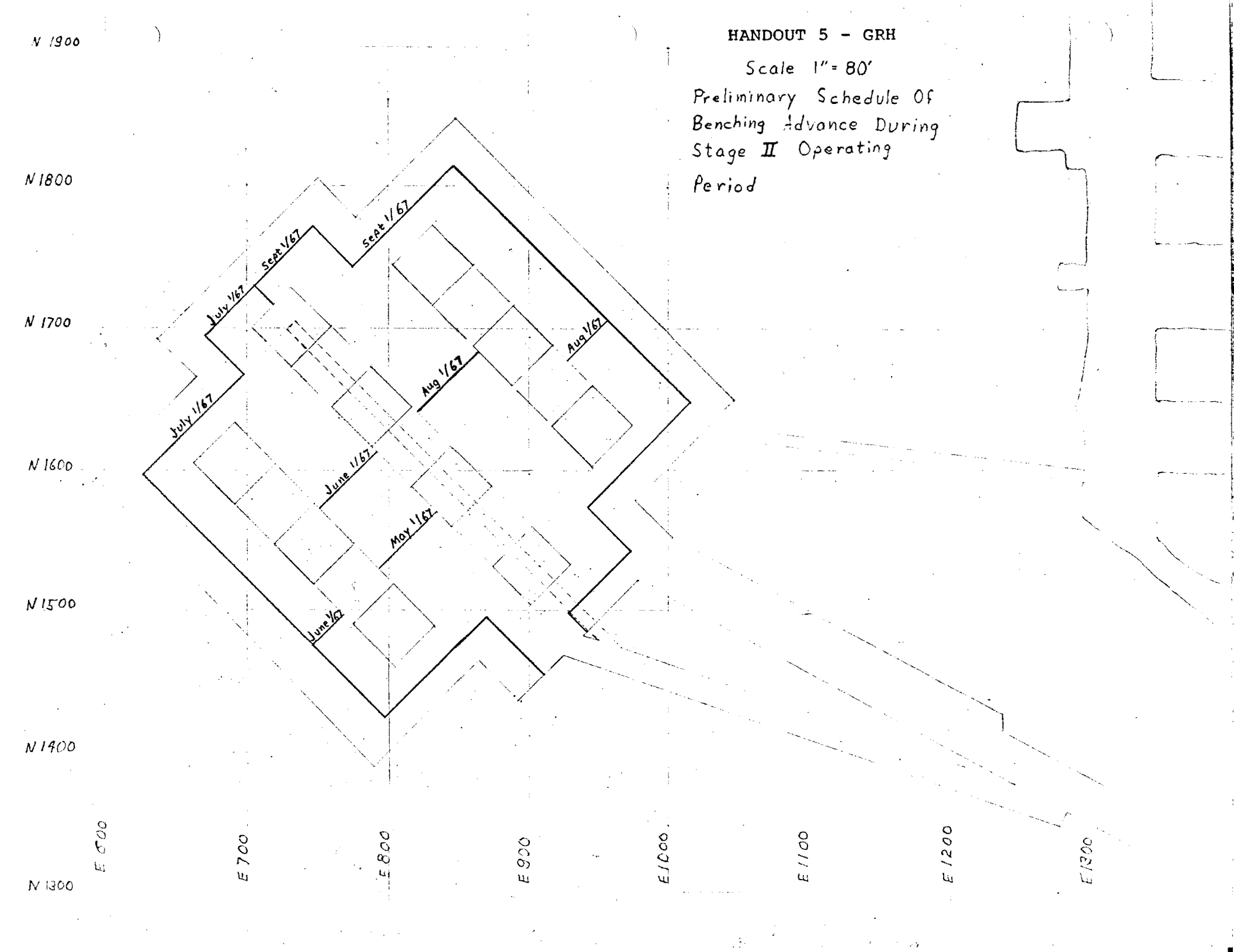
Preliminary Schedule of Heading Advance During Stage II Operating Period



HANDOUT 5 - GRH

Scale 1" = 80'

Preliminary Schedule Of Benching Advance During Stage II Operating Period



STAGE II - PERSONNEL BUILDUP

Participating Parties	Stage II Final Personnel	Stage I Personnel	Sept. 1, 1966 Personnel	Remaining To Be Hired	
Administration	2	3	2		
Technical Staff	20	17	20		
Secretaries	2	1	2	-	
Total	24	21	24	0	
Research Foundation					
Administrative Service	29	23	28	1	
Shops	27	19	27		
Mining	32	10	20	12	
Crushing	9	3	7	2	
Retorting	17	16	17		
Analytical	7	6	7		
Utilities	15	11	16	1	(Two Temporary Laborers on Staff)
Total	136	88	122	16	

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9/6/66

HANDOUT 2 - WSB

RETORT NO. 3 - STATUS REPORT

September 1, 1966

Engineering			Construction			Procurement			
Est. Cost	Est. Exp. To Date	Est. Percent Completion	Est. Cost	Est. Cost To Date	Est. % Completion	Est. Cost	Est. Commitments To Date	Est.% To Date	Est.% Deliv
7,460	11,000	95	40,979	20,000	60	44,562	35,000	95	50
7,999	12,000	95	33,650	15,000	30	74,200	60,000	95	25
15,532	21,000	90	70,961	35,000	65	162,728	150,000	90	65
12,388	11,000	90	30,666	12,000	45	48,808	40,000	90	25
s 4,052	3,000	95	29,430	18,000	85	10,800	5,000	95	80
26,610	25,000	80	15,932	38,000	75	5,100	4,000	80	
74,041	83,000		221,618	138,000		346,197	295,000		
5,180	5,800		15,530	9,700		24,200	20,600		
79,221	88,800		237,148	147,700		370,397	315,600		

imated Expenditures to date - 552,100
udget 725,000

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9/6/66

1. Crusher Plant and Storage

2. Shale Flow Control and Instrumentation

3. Piping, Recovery Equipment, Blowers, and Internals

4. Spent Shale and Liquid Product

5. Demolition, Utilitie Equipment Rental

6. Supervision General Expense

Subtotals

Fee

Totals

Total Est
Project B

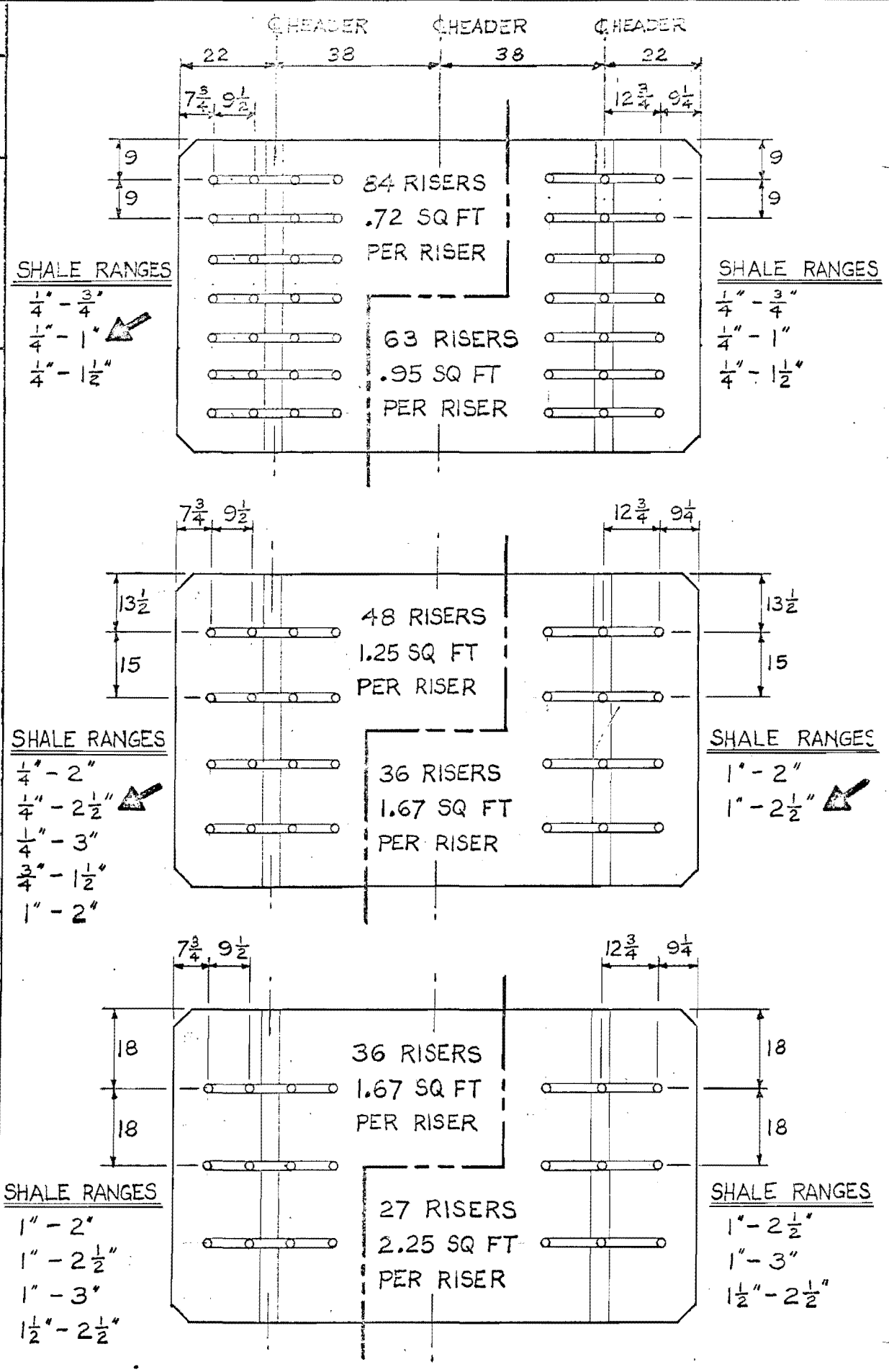
RETORT NO. 3 - COST PROJECTION

PROJECT CONSTRUCTION BUDGET - $725,000

	Stage II Scoping Study Feb. 28, 1966 Estimate	Torkelson Co. May 1966 Estimate	Sept. 1, 1966 Estimate
1. Engineering & Construction Supervision	47,000	74,000	100,000
2. Materials - Equipment	373,500	346,000	350,000
3. Construction & Construction Supervision	203,500	222,000	230,000
4. Contingiency	51,000*	38,000	-----
5. Fee	50,000	45,000	47,600
Total	$725,000	$725,000	$727,600

*Contingiency - $34,000 Materials
Split $17,000 Construction

WSBergen
9/6/66



D397 (8-55)

NO.	DATE	PRINT ISSUE TO

ANVIL POINTS
OIL SHALE RESEARCH CENTER
RIFLE, COLO.
PROJECT MANAGER-SOCONY MOBIL OIL CO., INC.

APPROVED | JOB NO. | CHARGE

PROCESS | DESIGN | SAFETY

SCALE 3/8" = 1'-0" | DRAWN BY Joe Hamilton | STARTED 9-6-66 | COMPLETED 9-6-66 | DIMENS.

RETORT NO. 3
AIR DISTRIBUTOR LAYOUT

LOCATION

DRAWING NO. RE 53

HANDOUT NO. 4 W.S.B.