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Mobil Oil Corporation

RESEARCH DEPARTMENT
PAULSBORO, NEW JERSEY 08066

S. L. MEISEL
MANAGER
APPLIED RESEARCH & DEVELOPMENT

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December 14, 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 Petroleum 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 fifteenth regular Shale Oil Technical Advisory Committee meeting held in Denver, Colorado, on November 8, 1966.

S. L. Meisel
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ses
Attachment

cc: R. H. Cramer

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Minutes of the Fifteenth Regular Meeting
of the
OIL SHALE TECHNICAL ADVISORY COMMITTEE
Anvil Points Oil Shale Research Center
November 8, 1966

The meeting convened at 8:30 a. m. at the Anvil Points Oil Shale Research Center with committee attendance as follows:

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

Mr. R. V. Smith of Phillips was welcomed as a new member of the committee replacing R. P. Lehman

Old Business

Minutes of the 14th Regular Meeting of the Technical Advisory Committee were approved as distributed.

New Business

Dr. R. Mungen of Pan Am Petroleum Corporation was designated as chairman of the committee for the next six months.

The next audit of project books will be conducted by Mobil and Humble representatives in January.

The next meeting of the Technical Advisory Committee will be hosted by Pan Am in Tulsa on January 12. The next meeting of the Technical Observers will be held at Anvil Points on January 4-5.

The technical presentation was made by program manager, Bob Cramer, assisted by members of his staff. Full details of the presentation are attached as an appendix. Attentinn is directed to Cramer's major conclusions drawn during the reporting interval.

New Business (Continued)

Cramer reported a $71,000 overrun in expenditures during the reporting period due mainly to (1) crushing plant costs (2) late deliveries of equipment which resulted in increased construction time for rehabilitation of retort No. 3, and (3) higher than expected electrical costs on retort No. 3. Total project manpower is expected to be held at the present level of 162 for the next several months.

Paul Snyder reviewed economic studies, indicating that the computer program which had been used in his studies could be made available upon request. Results will be issued later as a memo. Cost sensitivities relative to a base case show an advantage for a fractionated shale feed when processing 50% of fines (assuming 85% FA yield), relative to discard of fines. The incentive for processing all fines is in the range of 4¢/bbl., but there is no technology for processing 100% fines. In contrast there is at least a "lead" for processing the larger 50% portion of the fines. Fines were assumed to be 9% less than 1/4" when crushing to 2½"; actual size distribution data will be developed later by Allis Chalmers.

No economic method has been found for recovery of naphtha from retort off-gas, which was estimated in the range of 4,000 to 13,000 B/D for a 50,000 B/D plant. Recovery studies by some of the participating parties also indicates that recovery of this naphtha is uneconomic. This means that the gas combustion process now being used has about 95% FA maximum yield.

A crushing study contract has been signed with Allis Chalmers at a cost of $17,000. A primary crusher test will be scheduled in Florida sometime during January, with all parties given notification in ample time to arrange for representatives to be present. Secondary crusher tests will be performed in facilities at Oak Creek, Wisconsin, and Allis Chalmers will also prepare a design for a commercial crushing plant.

In reporting on the retorting program, Ken Jagel indicated that a start-up manual had been prepared for use with retort No. 3. Copies can be made available upon request, but the manual will be issued later in final form. Start-up date for retort No. 3 is November 14. In committee discussion it was suggested that operability on the demonstration run with 1/4" - 2 1/2" shale might be improved by use of manual control on the spent shale draw-off. Interest was also indicated in pulsating vapor flow. This has been considered by project personnel, but no action has been taken in view of the difficulties involved.

The demonstration runs on retort #2 have been successfully concluded. For 1/4" to 1" shale, yield was 90.8% FA with good operability; for 1" to 2 1/2" shale, yield was 88.1% FA with good operability; and for 1/4" to 2 1/2" shale, the yield was 86.4% FA with operability rated as fair to good. Exploratory runs with rich shale (33 G/T) gave somewhat poorer yields, with poorer operability.

In reviewing future plans John Lawson indicated that operation of retort #3 would start on November 15, using 1" to 2 1/2" shale. If operability is established a demonstration run on this size shale will be made during the period December 15 to February 15, and would consist of 2-3 weeks of start-up and optimization followed by four weeks of lined-out operation plus upset studies. A demonstration run on 1/4" to 1" shale would follow in the period beginning February 15, with work on a full range 1/4" to 2 1/2" shale comprising the third demonstration run. After considerable discussion the committee agreed that start-up of retort #3 should be made on 1" to 2 1/2" shale, but wished to reconsider the order of the demonstration runs at the January 12 meeting on the basis of results obtained as of that date.

Tom Lyons reviewed model study results, indicating that the internal hardware design for retort #3 appeared entirely satisfactory on the basis of model work. It was also indicated in the discussion that the project model work represented a significant advance in technology in the area of solids flow.

A request for presentation of a paper on project model work at the 1968 fall meeting of ASME was considered by the committee. The vote was unanimous, with one abstaining, that no commitment should be made to present a paper.

Gordon Haworth reviewed mining operation, indicating generally satisfactory progress. In response to questions he estimated that water consumption was about 250 gallons per round for drilling, with an additional 100 gallons used in mucking-out operations. It was indicated that all of the assumptions used in the previous mining costs study had not yet been demonstrated, but still appeared valid on the basis of progress to date.

Bill Bergen reported that total cost for rehabilitation of retort #3 was now estimated at $895,000. This is $170,000 above the original estimate and will cut short Stage II operations by approximately one month.

A complete set of drawings for retort #3, prepared by Torkelson at a cost of $40 per set, was provided each committee member. A booklet of photographs showing construction of retort #3 will be provided each company later. Bergen indicated that Torkelson had worked efficiently in preparing retort #3 engineering drawings, using an average of 60-65 man-hours per drawing as compared to 100 man-hours which is assumed as a general engineering standard.

It was suggested by the committee that the components in retort #3 that were most likely to fail should be identified and spares provided. Bergen indicated that one air blower had already gone out during test, and that attention was being given to the matter of spare replacement units.

In concluding the technical presentation Mr. Cramer indicated that final reporting on Stage II would comprise three levels of reports. The first level, consisting of a single volume, will be an executive summary type of report. The second level will consist of a more comprehensive five to six volume report for middle management. The third level of reporting will be the raw data distributed by the project. At the January 12 meeting Cramer will report an estimated termination data for Stage II of the project.

In concluding discussions by the committee the following subjects were considered:

1) The use of recycle through the shale draw-off tubes of retort #3 was suggested.

2) The question of interest in a possible extension of Stage II was raised, with the following positions stated:

    a) Bearish on shale, must complete Stage II as prerequisite to semiworks project.

- b) Intention is to complete Stage II as planned.
- c) See what develops before considering extension.
- d) Must evaluate results as they accrue.
- e) Will consider any proposal for extension on the merits of the proposal.
- f) Must have a completely operable process, as a basis for continuing.

3) The importance of retorting fines was stressed, indicating that this affects costs by as much as 20¢/bbl, according to a Pan American estimate.

4) The use of external heating (with 10% internal combustion) can be considered and should be studied in retort No. 2 as time permits.

5) A separate project on retorting fines should be considered.

6) The demonstration runs made by the project represent excellent accomplishment.

7) The two mining cost studies prepared by the project and submitted by Pan Am are being reviewed. Indications are that after slight adjustments the reports will be in agreement, with estimated mining costs being close to 50¢/T.

The meeting adjourned at 4:30 p. m. for visits of committee members to the plant facilities.

D. C. Smith
D. C. Smith, Chairman

S. L. Meisel
S. L. Meisel, Secretary

FIFTEENTH REGULAR TECHNICAL ADVISORY COMMITTEE MEETING
NOVEMBER 8, 1966 - RIFLE, COLORADO

II. New Business

D. Technical Presentation

1. General Remarks - R. H. Cramer

The Program Manager discussed estimated expenditures through October 31, 1966, shown on Handout 1 - RHC. Program expenses are running $71,895 over budget. This unfavorable variance is due to a substantial over-run on the cost of rehabilitating Retort No. 3, although this has been partially offset by lower-than-anticipated materials purchases to date. W. S. Bergen will discuss Retort No. 3 costs in detail. The large accrued costs ($606,000) primarily reflect Retort No. 3 rehabilitation and mining equipment expenses incurred but not yet billed.

Program manpower totals 162 as of November 8; 25 from the Participating Parties and 137 from the Research Foundation. Phillips supplied Fred W. Brackebusch, a geological engineer, on November 1 in response to the Program Manager's request at the previous meeting. Stage II staffing is essentially complete.

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 September 8, 1966 meeting. These are presented on Handout 2 - RHC.

2. Retort Program

   a. Discussion of Engineering and Economic Analyses - P. W. Snyder

      1. Optimum Mass Rate, Maximum Shale Size and Size Screening

         (a) Method: An IBM 1620 computer located at Mesa College was programed and used by R. A. Reitz to calculate the many cases examined.

         (b) Conclusions:

            (1) The desirable maximum size is between 2 and 2 1/2 inch; the penalty for going from 2 to 3 inch is less than 1½¢/Bbl while it costs about 4¢ more per barrel to crush to 1 1/2 inch. (Handout 1 - PWS)

            (2) All shale fractions should be retorted at the highest mass rate consistent with good operability. This appears to be 500 lbs/(hr)(ft^2) for the fractions we are working with - there is only a 1¢/Bbl maximum penalty for going to 400 mass rate with the large-size-fractions of the two or three fraction case. (Handout 2 - PWS)

            (3) A two fraction feed is ½¢/Bbl to 3½¢/Bbl more attractive than a one fraction feed - resulting from a 2 to 4½ Vol % raw shale Fischer Assay yield improvement. (Handout 3 - PWS)

(4) The incentive for yield improvement is about 1.2¢/Bbl/% yield.

(5) The incentive for fines processing, at a cost which is about 40% greater than for 1/4 inch plus shale, is 4 to 8¢/Bbl. (Handout 1 - PWS)

(c) Bases

(1) Process (Handout 3 - PWS)

(a) 50,000 B/D from 30 gal/ton shale

(b) Crusher product size (McLanahan data) - 9% less than 1/4 inch for 2 1/2 inch maximum size.

(c) 95% screening efficiency.

(d) 1/2 of fines are retorted at 200 mass rate with 85% yield.

(e) Gas rate limitation is a function of particle size and mass rate.

(f) Bed height is a function of particle size and mass rate.

(g) Yield is a function of recycle rate, particle size, size range, and assay. (Does not include the 1/4 to 1 inch demonstration). An example of the differences which exist between estimated commercial contiguous fractions and the fractions actually run in Retort No. 2 as well as the effect on yield are shown in Handout 4 - PWS.

(2) Costs (Handout 5 PWS)

(a) 10% cost of capital and 1¢/KWHr for power (including distribution cost).

- (b) Mining - 47.6¢/Ton.
- (c) Crushing - 13 to 16¢/Ton.
- (d) Screening - Incremental - 0.4 + 0.1¢/Ton over two fractions.
- (e) Retorting:
  - (1) Base - function of mass rate and yield.
  - (2) Δ Gas Compression - function of retort pressure loss and gas ratios.
  - (3) Bed height - 0.3¢/Bbl/Ft.
- (f) Spent shale disposal - 3¢/Ton (~5¢/Bbl).

(3) Sensitivity (Handout 6 - PWS)

- (a) All and no fines processing.
- (b) Increased mining cost 10¢/Ton (16¢/lb increase in total cost; <½¢/Bbl change to incremental costs.
- (c) Vary crushing cost ± 5¢/Ton (insignificant effect).
- (d) Nordberg distribution (increase total cost 2¢/Bbl).
- (e) More effective screening, 2% fines in full range instead of 5%: (0.1 to 1¢/Bbl improvement).
- (f) Incomplete studies will investigate the effects of shale assay, crushing cost, cost of capital, and latest regression analysis on yields.

2. Naphtha Recovery From Retort Offgas (Handout 7 - PWS)

(a) Amount in Gas

2½ lbs C_3^+/MSCF of dry gas - 4,000 to 13,000 B/D on a 50,000 B/D plant.

(b) Economic Screening of Recovery Schemes

- (1) Compressing mist free offgas - excessive power and cooling surface ~$75/Bbl of recoverable naphtha.
- (2) Cooling the offgas - excessive exchanger surface - did not look at direct contacting with cooled liquid.

(3) Adsorbants - excessive vessel and adsorbent costs - evaluated moving as well as fixed beds.

(4) Lean Oil Absorbtion - 20 to 50 barrels of lean oil per barrel of naphtha recovered - costs still being developed.

(5) Polymerization - excessive tower requirements with solid catalyst and excessive moisture present for $AlCl_2$.

(6) Retorting With Steam - insufficient sensible heat in raw shale to condense steam.

(7) Major Process Changes - such as pressure retorting have not been evaluated.

(3) Status of Crushing Program

(a) Allis-Chalmers

(1) Contract is signed to carry out:

(a) Primary in Florida on 6-inch plus (in January).

(b) Secondary tests by Allis-Chalmers at Oak Creek, Wisconsin.

(c) Develop module flow sheet design with costs.

(2) Wear and maintenance information will be developed on secondary roll crusher here at Anvil Points

(b) Nordberg - nothing developed - possible cone crushing tests next summer with portable crushing plant here at Anvil Points.

b. Summary of Retort Program Results - K. I. Jagel

1. Retort Studies Completed Since last Technical Advisory Committee Meeting

(a) Process conditions have been developed for retorting 1/4 to 1 inch shale.

(b) Demonstration runs were completed, retorting:

(1) 1/4 to 1 inch shale.

(2) 1 to 2 1/2 inch shale.

        (3) 1/4 to 2 1/2 inch shale.

    (c) A shale richness study was made using Retort No. 2.

    (d) Status of Bench Scale Studies:

        (1) Effect of Fischer Assay product recovery temperature was determined.

        (2) The Mini-Retort was shaken down and evaluated as a research tool.

    (e) Crushing capacity test with new rolls in secondary crusher was made.

    (f) Retort No. 3 Work

        (1) Operations manual has been developed.

        (2) Training program is in progress.

        (3) Pre-operations calibrations program is developed.

(2) Detailed Discussion

    (a) Development of Operating Conditions For Retorting 1/4 to 1 Inch Shale (Handout 1 - KIJ)

        (1) High yield at relatively low total gas rate.

        (2) Operability improved and higher total gas rate possible with constant shale drawoff rate.

    (b) Demonstration runs retorting 1/4 to 1 inch, 1 to 2 1/2 inch and 1/4 to 2 1/2 inch shales are summarized on Handout 2 - KIJ.

    (c) Shale richness effects (Handout 3 - KIJ)

        (1) 33 gallon per ton comparison of yield and operability.

            (a) 1/4 to 1 inch - good operability

            (b) 1 to 2 1/2 inch - fair operability

            (c) 1/4 to 2 1/2 inch - poor operability

        Yields are inconclusive because of short runs and failure of the electrostatic precipitator.

    (d) Bench Scale

(1) Effect of Fischer Assay pressure and recovery system temperature is summarized on Handout 1 - KIJ.

(2) Comparison of base point data for fixed bed Mini-Retort with Fischer Assay data is summarized on Handout 5 - KIJ.

(e) Crusher capacity tests are summarized on Handout 6 - KIJ.

(3) Summary of Conclusions

(a) 1/4 to 1 inch shale can be satisfactorily processed by reducing the total gas rate and by withdrawing the shale from the retort at a constant rate. This has been demonstrated in a nine-day run in Retort No. 2.

(b) 1 to 2 1/2 inch and 1/4 to 2 1/2 inch shale have also been satisfactorily processed in five-day demonstration runs in Retort No. 2.

All of these operations can be carried out in Retort No. 3.

(c) Better operability is obtained at 33 gallon per ton assay level using the fractionated shale system (1/4 to 1 inch and 1 to 2 1/2 inch) rather than the full range (1/4 to 2 1/2 inch).

(d) Fischer Assay yields at comparable recovery system temperature and oil vapor partial pressure are the same or lower than those obtained with the Gas Combustion process.

(e) Mini-Retort yields are lower than Fischer Assay yields because of secondary oil cracking which is presumably related to poor lateral heat transfer.

(f) Crusher capability has been demonstrated for:

        (1) 1 to 2 1/2 inch size.
        (2) 1/4 to 2 1/2 inch size.
        (3) 1/4 to 1 inch size is yet to be demonstrated.

c. <u>Future Program - Retorting</u> - J. E. Lawson

  1. Review of background for program (Based on Retort No. 2 Experience).
      (a) Economic Factors (Handout 1 - JEL)
      (b) Operability Factors (Handout 2 - JEL)
  2. Review of Program.
      (a) Description of Program (Handout 3 - JEL)
          (1) Based on assumption of smooth operations.
          (2) Description of typical operating period.
              (a) Optimizing - three weeks.
              (b) Demonstration - four weeks.
              (c) Attempts to upset and recover - three weeks.
      (b) Review of rationable behind sequence of shale sizes selected.
          (1) Takes advantage of best economic and operating factors by placing first in program.
          (2) Telescopes shakedown and first demonstration run.
          (3) Initial operation with easiest shale fraction.
          (4) Maximizes continuous operations.
          (5) Provides long run very early in program.
          (6) Demonstrates Shale fractionation.
      (c) Flexibility
          (1) Program planning based on Retort No. 2 experience - Only thing available at this time.
          (2) Decision points - in particular, one at January 1 - Indicates need for re-examination of program based on Retort No. 3 operating experience and estimated

time available during the remainder of Stage II.

(3) Only real decision at this time is shale size to use in shakedown.

(4) Expect to be able to lay more definitive plans about January 1.

3. Mechanical Models - T. C. Lyons

(a) Introduction

The bulk of our recent model work has been in full-scale equipment as opposed to the small scale model work we have done in the past.

I might briefly mention the areas of our activity and I'll comment further on this later.

(1) Our major effort has been that of making a final check of the shale flow through the Retort No. 3 hardware in the 1/2 SECTION MODEL.

(2) The shale flow in the 100-ton storage bins has been improved by use of "corrective inserts". (Can be considered another triumph of miniature models).

(3) A number of the model movies have been edited and will be distributed within a matter of weeks. Commentaries to supplement the movies have also been prepared.

(4) I attended the recent AICHE Materials Handling Symposium and I still feel that our solids flow program was sound. And last,

(5) An Erosion-Corrosion program has been prepared and has been factored into Retort No. 3.

(b) Operation of 1/2 - Section Model of Retort No. 3:

Late in summer - revised our large flow model - now a 1/2 section of Retort No. 3 - including shale feed and drawoff systems.

Purpose of Revision - two fold.

(1) Make final check of proposed spacing of internal hardware.

(2) Have a tool to use for trouble shooting Retort No. 3 if necessary.

Before checking the hardware spacing, it was necessary to establish a base case w/o internals.

Flow pattern with 1 to 2 1/2 inch shale shown in Handout 1 - TCL .

Can see it's a near perfect pattern - particles from wall to wall flow down uniformly - and it holds to within three feet of the retort floor.

Except for a slight wall lag, flow pattern with the small 1/4 to 1 inch shale is almost as good - shown in Handout 2 - TCL .

These patterns are really the culmination of our efforts in the shale flow area. An almost perfect uniformity of flow over a large area is achieved when drawing from a single outlet. Same hardware is effective for a wide range of shale sizes.

Next step was to begin a systematic check of proposed hardware.

(1) Recycle Distributors

Installed four recycle gas distributors and flow remained near perfect. Pattern for large shale is shown in Handout 3 - TCL. (Equally as good for 1/4 to 1 inch shale).

The lack of distortion is attributed to shape of the element with sharp leading edge. (Will recall that position and shape was initially determined from miniature model studies).

(2) Air Distributors

The complete air distributor assembly proposed for large shale was then added to the system (36 risers).

Wall clearances appeared adequate - no evidence of large voids or loosening of the bed in the distributor area.

However, hardware does have a pronounced influence on flow pattern. (Handout 4 - TCL)

Distortion approximately 2 1/2 feet above top of risers - deteriorates rapidly as level passes into riser assembly - slow center - fast walls.

(3) Effect in Retort

Don't know the extent that this would affect the retort operation - if it would affect it at all.

Since distortion is in bottom section - effect is limited to heat recovery section. If heat transfer or gas channeling in the lower section can upset the combustion or retorting zones, this could be a problem.

Summary:

Would expect to have distortion - don't like it -but don't think it's serious enough to hold back on Retort No. 3 startup - and want to find a way of solving or minimizing the problem.

Recent studies have revealed two likely causes:

(1) Risers assembles themselves - remove riser candalabra results in a pattern that is surprisingly uniform.

(2) Symmetry of air headers with respect to the recycle headers. Center air header is between two recycle headers, and outer air header is above a recycle header.

Have concentrated on improving the symmetry and this has been effective. (Handout 5 - TCL)

Pattern is much improved - only particles that lag are those directly over the "line of hardware."

Want to be prepared to recommend a change down the road if it's deemed necessary.

Most likely - Will adjust drawoff in Retort No. 3.

We have also had an opportunity to observe the wide range 1/4 to 2 inch shale in the shale feed system Although we have no quantitative results, the small and large particles were distributed uniformly across the retort. No cores of certain sizes as we observed before our modification is encouraging news for the wide range.

(c) 100-Ton Bins

You're all familiar with our efforts to reduce segregation by improving flow in the 100-ton storage bins.

Movies of our 1/12 scale model were shown to you at your last meeting.

We have now had the opportunity to observe the full-scale bins in operation with the recommended internals.

We have concluded that they act very similar to the scale model as far as:

(1) flow pattern

(2) sensitivity to hardware change

(3) even shale size - rather anoying when you consider 1/12th scale of 1/4 inch particle is 1/48 inch - getting to be a fine powder.

Bins now acceptable with large shale and the full range which is the major concern from standpoint of segregation.

Small shale is still undergoing evaluation.

In addition to the benefit to the retort, this can be considered a valuable study in that it gives further confidence in the scaleup from miniature models.

May be very useful to the various companies in their own efforts later on.

(d) Model Movies

Recently, there has been considerable interest in the movies which we have shown from time to time.

Therefore, we have made a concerted effort to get these out to the various companies.

The approach we have taken:

(a) edited each film and given it a consecutive number.

(b) prepared a detailed commentary which we issue as a Technical Memorandum.

(c) cross reference film in memo in film.

(d) where applicable, will include figures and talks in commentary - a combination film-report.

Have completed three films and commentaries:

(a) Mist Studies - supplement to Phil Gifford's report on his work (commentary is an appendix to his report).

(b) 1/12th Scale Model of Retort No. 3 - timely as it will be helpful to show your people the basic design of Retort No. 3.

(c) Development of a Riser Air Distributor for Large Shale in Retort No. 2 - excellent example of use of scale models to solve full scale problems.

Films are currently out being copied - expect to have them distributed to the companies in a matter of weeks.

(e) AICHE Meeting

In September, I had the privilege of attending the AICHE Symposium on Materials Handling.

I'd like to briefly mention some of my impressions of that session.

First, it was obvious that the mass flow bin idea is no fluke - has helped many people out of difficult flow situations - most widespread problems have been:

(1) complete flow stoppages bringing arching vessel.

(2) loss of live bin volume.

(3) erratic rates of discharge.

The term uniform flow among most materials handlers generally meant uniform rate of discharge not uniform velocity as we use the term.

We ask, then, why was the mass flow bin not applicable for our use? - The answer seems to be:

> That we impose more stringent requirements on our retort vessel.

Of course, we did use mass flow approach when we installed a smooth liner to minimize bridging in retorting zone. Desired an "ideal live bin" - where the particle velocity is uniform from wall to wall throughout the major portion of the bin volume. A mass flow bin cannot give this and stay within reasonable height requirements.

As a result of my attendance at this symposium, I am convinced that significant knowledge has been developed at Anvil Points which is not generally known in the solids flow community. Examples are:

(1) Velocity profiles in vessels with a single outlet including mass flow bins.

(2) Use of multiple outlet or manifolding techniques to obtain uniform flow velocity in large vessels.

(3) Placement and shape of internals and their effect on flow.

(4) Use of vertical calming height to insure uniform velocity at the outlet of a vessel.

(5) Scale-up from miniature models to full scale vessels with reasonable confidence.

(6) Particle segregation when charging a vessel through a single inlet.

I believe that Dr. Jenike also realizes this as he asked for our participation in a three day ASME Symposium on Materials Handling scheduled for the fall of 1968.

(f) Erosion-Corrosion Program

The last area of activity in the group is our erosion-corrosion efforts.

Basically, program will include:

(1) low temperature corrosion test racks in gas streams.

(2) high temperature corrosion test racks in the combustion zone.

(3) Erosion test panels in shale flow zones.

(4) Corrosion test racks in liquid product vessels.

(5) Thorough unit inspection periodically.

Program has been set up and will be handled by Les Skowronek. Les has a wealth of experience in commercial unit inspection.

4. Mining Program - G. R. Haworth

(a) Discussed status of mine development work in Adit No. 5 haulage ramp and instrument tunnel. (Handout 1 - GRH)

(b) Reviewed oil shale inventory.

(c) Described mining of haulage ramp and instrument tunnel.

(d) Discussed sag rod measurements taken in roof of Able and Adit No. 5.

- (e) Installation of trial extensometers.
- (f) Photoelastic gauges do not yet show any signs of measurable stress changes.
- (g) The bench scale test program on the physical properties of the shale has been delayed due to delivery of instruments.
- (h) Truco aerial platform:
  - (1) Design problem - one section of extension was underdesigned - Truco is replacing it.
  - (2) Performance satisfactory.
- (i) Koehring's skooper performance satisfactory but requires skill to operate affectively.
- (j) Mack 40-ton truck:
  - (1) Performance - good.
  - (2) Aluminum body - welding problem developed and solved.
    - advantages are its light weight.
- (k) Gardner-Denver Drill Jumbo:
  - (1) Experimental work on drill:
    - (a) Penetration rate.
    - (b) Bit Life.
  - (2) Blasting results:
    - (a) Misfires due to presence of ground water.
    - (b) experimental rounds were discussed.
- (l) Dust control in mine and measuring procedure were discussed.

5. <u>Stage II Rehabilitation</u> - W. S. Bergen

Construction of Retort No. 3 is essentially complete with equipment testing in progress. There are minor additions being made at present but nothing effecting the unit operating potential. This morning, the Retort Group went on shift for their Pre-operations training and tests.

The retort is scheduled for firing November 14. This completion date represents a one-month delay from the scheduled completion of October 11. Many additions were found necessary as the design and construction progressed, extending construction time. Delays in deliveries of vital equipment also made it impossible to complete construction at an earlier date. In fact, we are still awaiting delivery of several computor circuits from the Fischer Porter Company.

In meeting this completion date, it was necessary to deadline the Torkelson Company mechanical construction work as of Friday, October 28, and their electrical work as of Sunday night, October 30. This action gave us the opportunity to finish instrumentation, test equipment, and assist factory service representatives with our manpower. This we feel was a very valuable training tool for our shop and instrument personnel.

On Monday, October 31, a detailed work schedule using the CSMRF personnel was put into effect to complete Retort No. 3 by November 6. Manufacturers representatives from our major equipment suppliers were also at Anvil Points last week to put their equipment into service.

All work by the Research Foundation and the manufacturers' representatives was completed when scheduled. The Research Foundation personnel, supervisory, tradesmen, crusher, and analytical, who assisted in this one-week completion program did an excellent job and are to be highly commended. Most men worked on a 12-hour schedule during this period, and put out effort above the expected norm.

You will recall that major delivery problems existed with the Fuller Company rotary feeders and the Fischer Porter Company instrumentation.

The rotary feeders were shipped October 21. It was necessary, therefore, to install the old feeders of Retort No. 2 to complete Retort No. 3. Plans are to install the new feeders on Sunday, November 13, followed by a breakin period.

Fischer Porter Company continues to be a major problem. Repeated contacts by most companies represented here today plus telephone discussions with Mr. Fischer, the Company president, have not produced complete order. The order is now 18 weeks in processing. Fischer Porter Company has not even met delivery schedules promised your purchasing agents during late September and early October. We have wired our control systems with missing equipment jumped out of the circuits.

(1) Cost Status

As reported in the October 15 Progress Report, costs have escalated to the $895,000 level. This represents an overrun of some $170,000.

Handout No. 1 reviews estimates prepared at various times for this job. Basically, the one extra month of construction with associated design materials, and supervision overheads account for most of the cost increase.

Handout No. 2 lists many of the necessary additions to this job. These are in two main catagories:

(a) Field decisions; when detailed inspections showed the existing equipment had to be replaced or new facilities added to insure operating reliability.

(b) Process changes; new equipment was added because process changes where formulated after the original estimate.

A major construction cost factor was the delivery of materials up to three weeks late making it necessary to stagger construction - for instance, valves and intake valves were late making piping an intermittant operation.

One direct cost underestimate was the electrical cost. Reviewing our electric estimates, I find that the estimate was at least $40,000 low on most labor. The productivity level of many of the traveling electricians was also low. Of the total $60,000 electrical contractors cost, (labor only) I would judge about $6,000 was due to poor productivity levels of the traveling electricians. Electricians were difficult to obtain and were pulled from Arizona, Utah, Wyoming, and the eastern slope when available.

Summarizing the cost problems then, the overrun was caused by a combination of:

(a) Prolonged and late deliveries making it impossible to complete whole systems at one time.

(b) Additions to the scope of the work and additions due to field conditions.

(c) A low estimate of the electrical work materials.

(2) <u>Performances of various contractors and material suppliers</u>:

(a) Torkelson has done a good job. Their staff is small and it was also recognized at the time the contract was signed that they were light in process experience. However, the job did move rapidly. And, in all fairness to Torkelson, had the scope of the work not changed and had materials arrived when promised, both the time and cost schedules would have been realized.

(b) Colorado Macco of Grand Junction was the general contractor. They also performed well. Their foremen were particularly effective in getting work accomplished properly.

(c) Midwest was the electrical contractor. They maintain a skeleton crew and hire travelers. As jobs develop, Midwest's skeleton crew had about twice the productivity level of most of the travelers. However, electrical help in this area is limited and any construction would depend on travelers.

(d) Suppliers have cooperated fairly well. Notable exceptions have been Fischer Porter Company and General Electric. Fischer Porter Company has been discussed previously. General Electric has the order for a 70 HP motor for our slusher.

This is in the process of being cancelled as we have picked up a reconditioned motor. By and large, most suppliers have been within two to three weeks of meeting promised deliveries. This, in these times of severe material shortages due to the Viet Nam War is very good. However, these two to three delays were enough to hurt our tight construction schedule.

(3) Design Drawings:

We have prepared booklets of the drawing for this job. A copy will be available today for each Technical Advisory Committee member for your company use. These have been produced by photographing the drawings and enlarging them on an 8 1/2 x 14 inch Mylar. We are also preparing a book with photographs of the progress of the job. A copy will be prepared for each company.

(4) Staffing levels are shown on Handout No. 3. All personnel have been authorized except one clerk in the office group of the Research Foundation.

E. Other - R. H. Cramer

1. A request to publish some of our solid flow work was refused by the Technical Advisory Committee on the basis that it was valuable knowhow which the companies would like to keep proprietary as long as possible.

2. The plan to finalize the project reporting into three groups of reports was presented by R. H. Cramer as follows:

(1) One single summary report covering all areas of work (mining, crushing, retorting, etc.,) aimed at reporting to top management.

(2) Six more detailed summary volumes covering each of the major areas of development. These would present only enough detailed discussion and data to provide believability.

(3) Data already given or to be given to each company in the form of raw data; progress memoranda and technical memoranda.

STAGE II ESTIMATED EXPENDITURES TO OCTOBER 31, 1966

Actual Cash Disbursements to 10/31/66	$1,622.025
Accrued Costs[1]	606,000
Estimated Expenditures to 10/31/66	2,228,025
Budget to 10/31/66	2,156,130
Variance - Unfavorable	$ (71,895)

[1] Includes accrued costs as follows:

Rehabilitation of REtort No. 3	$283,982
Mining Equipment	117,600
Operating	204,418
	$606,000

ESTIMATED MANPOWER NOVEMBER 8, 1966

Participating Parties	25
Research Foundation (Authorized)	137
Total	162

CJVerdeur
11/7/66

Handout 2 - RHC

MAJOR CONCLUSIONS SINCE THE SEPTEMBER TECHNICAL ADVISORY COMMITTEE MEETING

1. Completely satisfactory demonstration runs in Retort No. 2 have been finished retorting 1/4 - 2 1/2 inch, 1/4 - 1 inch and 1 - 2 1/2 inch shale sizes.

2. I believe that fractionated shale feed is the most probable commercial operation because of improved overall operability and yield.

    a. Good operability and about 91% yield was achieved when retorting 1/4 - 1 inch shale by using a low recycle gas rate and a more uniform shale drawoff rate.

    b. Two fraction feed is more operable than one fraction wide-range feed when retorting rich shale (33 gal/ton).

    c. The two fraction feed is ½¢/Bbl to 3½¢/Bbl more attractive than corresponding one fraction feed because of a 2 to 4½% yield advantage.

3. Retort No. 3 will be fired November 14, 1966.

4. 1 - 2 1/2 inch shale should be used to "shakedown" Retort No. 3 since this fraction is the most easily processed. It is insensitive to shale flow stoppages and difficult to clinker.

5. Full scale mechanical model shale flow studies indicate that the design and spacing of proposed Retort No. 3 internals (feed system, air distributor, recycle distributor and drawoff system) are satisfactory for initial operations, adjustments in shale flow uniformity, if needed, are possible by varying the recycle distributor spacing.

6. Retort No. 3 construction cost is estimated to overrun the original estimate by about 22% because of additional equipment installed which was not in the original estimate, a lower than anticipated productivity from some of the trades, and late materials delivery.

7. There is about a 10% yield loss from Fischer Assay retorting when raising the oil recovery system temperature from 32° F to a typical Gas-Combustion retort recovery temperature of 130° F.

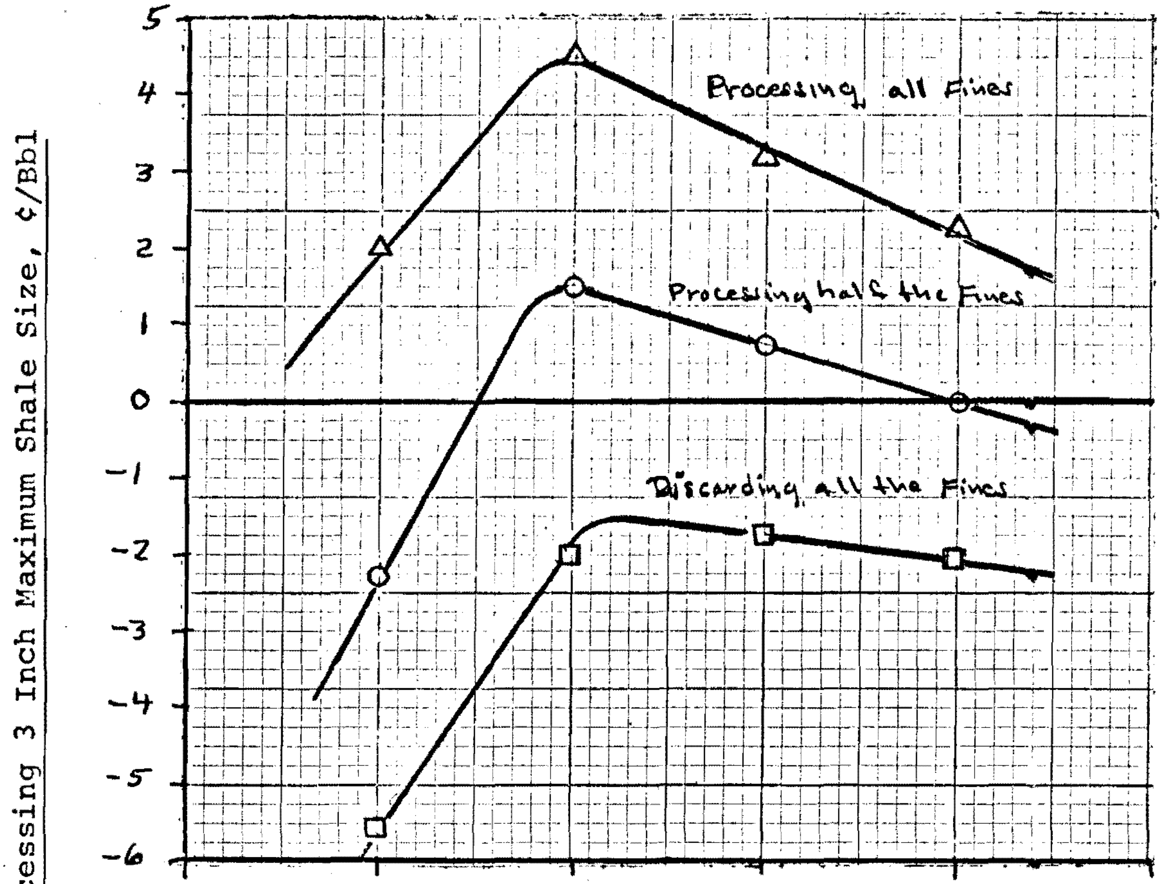
8. All major mining equipment has been received and is in operation.

"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."

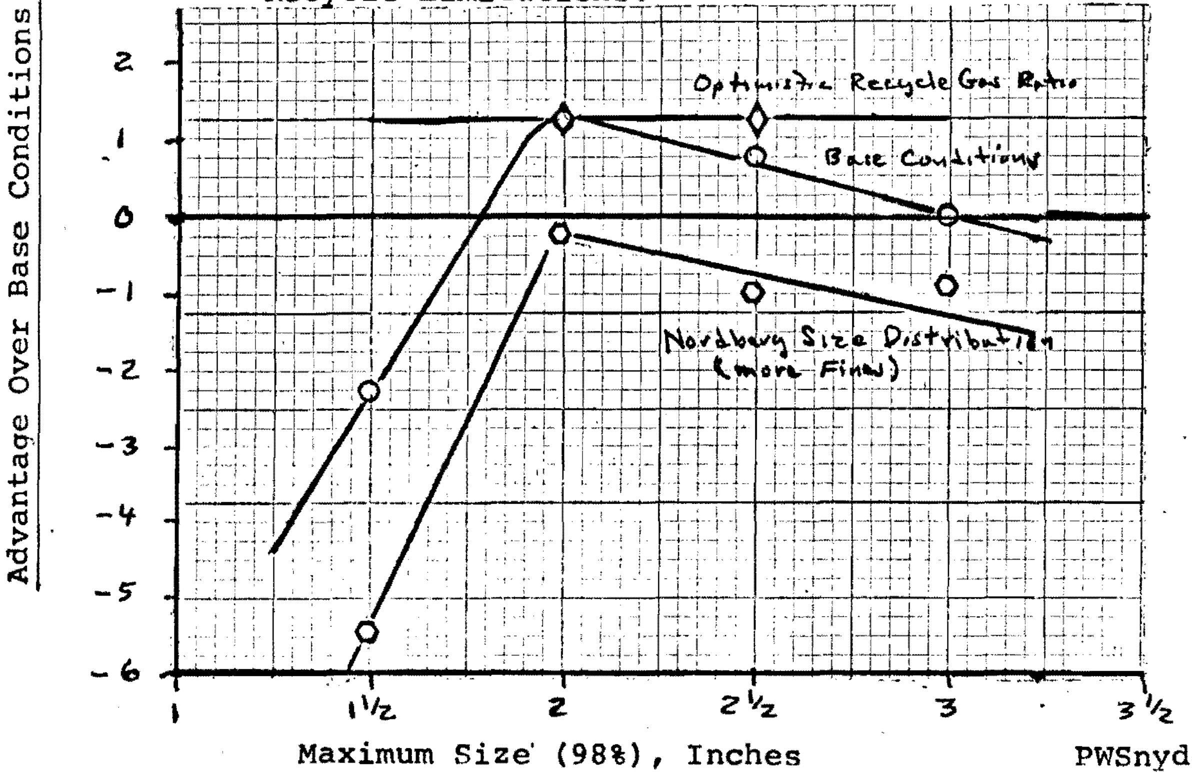
Handout 1 - PWS

ECONOMIC OPTIMUM MAXIMUM SHALE SIZE
(Retorting 30 gallon per ton oil shale to produce 50,000 barrel per day of shale oil)

A. Effect of Fines Processing:



B. Effect of Amount of Fines and Use of Higher Recycle Limitations:

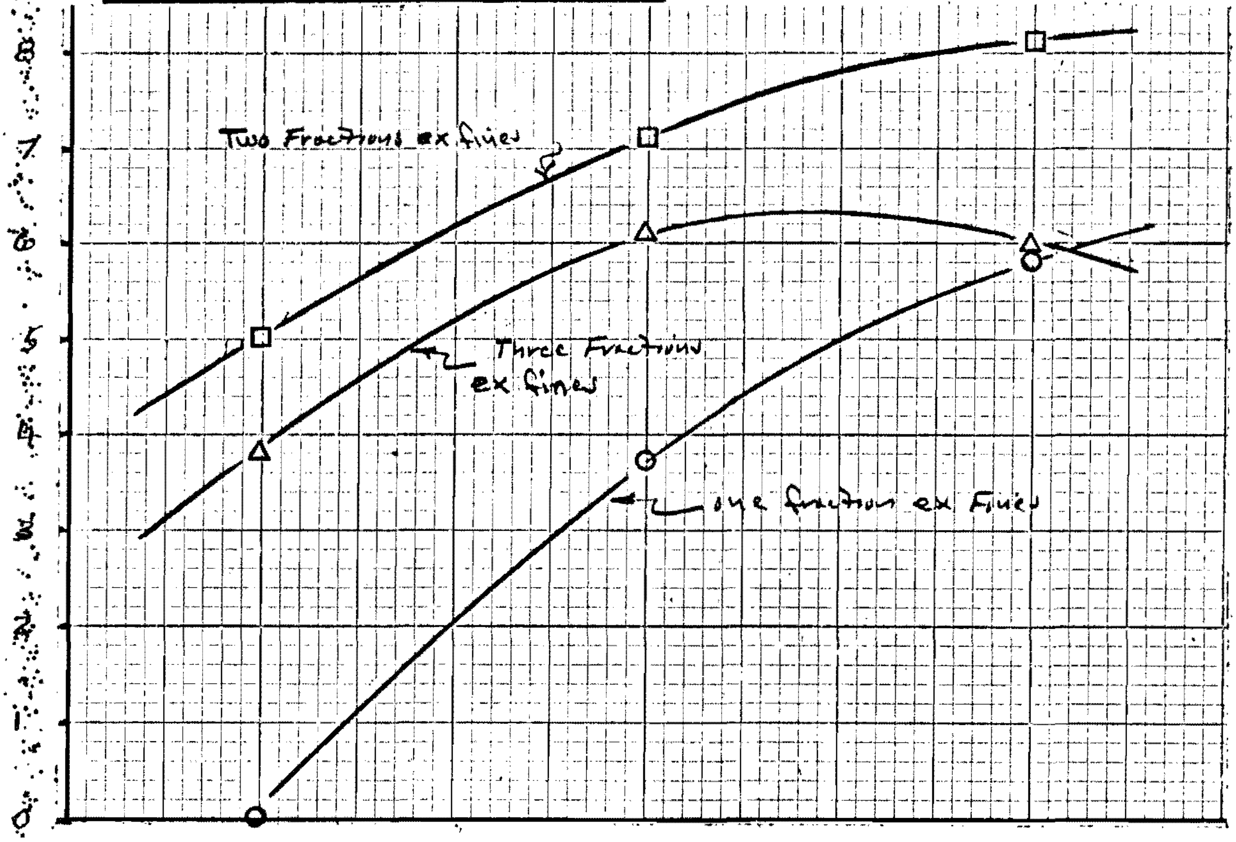


PWSnyder
10/14/66

ECONOMIC OPTIMUM SHALE MASS RATE AND NUMBER OF SIZE FRACTIONS

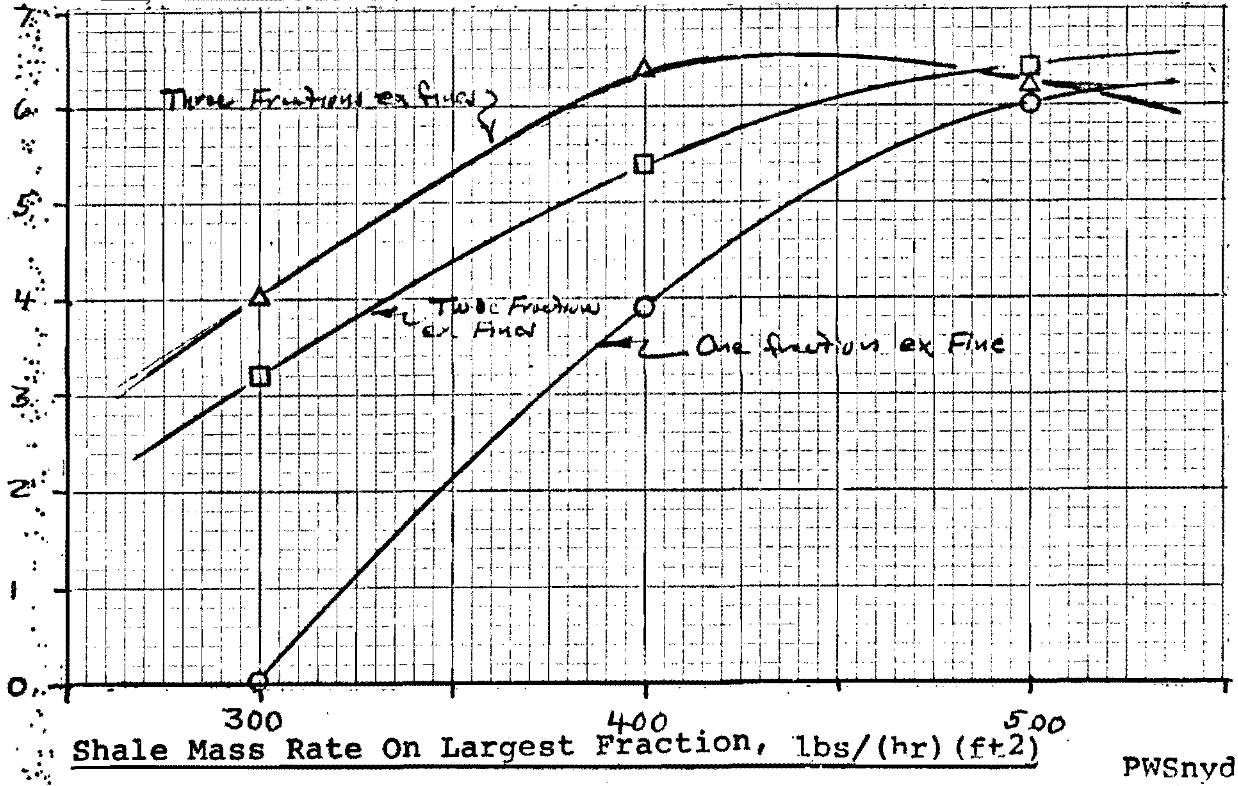
(Retorting 30 gallon per ton 3 inch maximum shale
to produce 50,000 barrel per day of shale oil)

A. Processing 1/2 The Fines:



Advantage Over Retorting One Fraction at 300 lbs/(hr)(ft^2), ¢/Bbl

B. Discarding All The Fines



PWSnyder
11/4/66

Handout 3 - PWS

PROCESS BASES FOR BASE CASES

1. Mining enough 30 gal/ton oil shale to produce 50,000 Bbl/D of raw shale oil.

2. Crusher Product Size Distribution:

98% Passing Through:	3"	2 1/2"	2"	1 1/2"
Less Than 1/4 Inch, %	7.5	9.0	12.0	15.6

3. Screening Efficiency

   5% of product is undersize.

4. Retorting the 8 Mesh to 1/4 Inch Fines at 200 mass rate achieving 85% yield.

5. Latest estimate of gas rate limitation as shown on Figure 13 of October Monthly Progress Memorandum.

6. Bed height required as shown in Figure 22 of September Monthly Progress Memorandum.

7. Latest yield analysis based on demonstration runs and the following regression:

$$\Delta Y = 1.39\Delta R - 1.20\Delta Dv^2 - 7.71\Delta(Dv/Da) + 0.07\Delta M + 0.36\Delta A$$

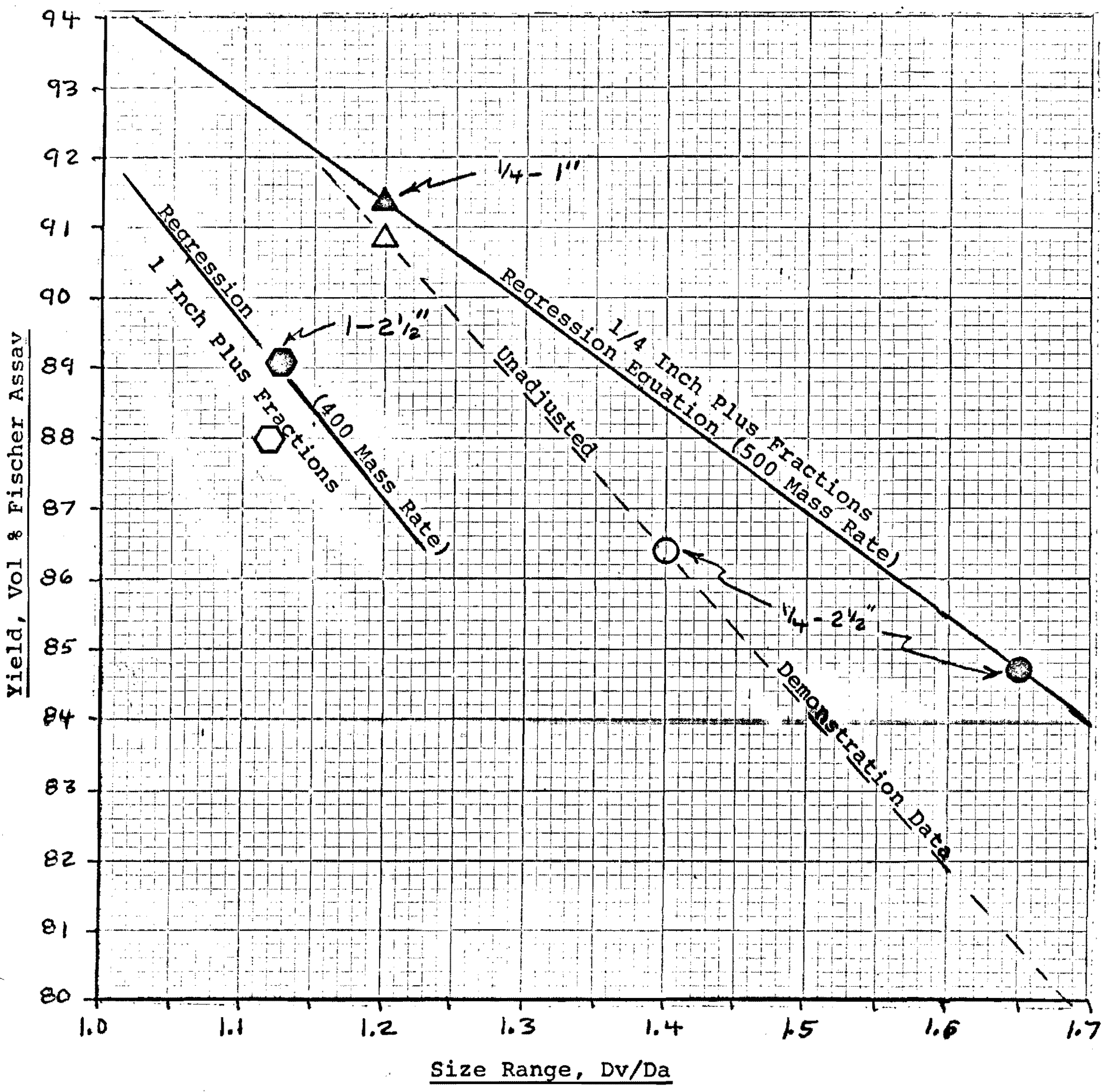
Standard deviation about regression = ± 1.2% yield.

Where: Dv = weight mean shale size, inches
Da = surface mean shale size, inches
R = recycle gas rate, MSCF/T
M = shale mass rate, 100 lbs/(hr)(ft^2)
A = Fischer Assay of raw shale, gal/ton

PWSnyder
11/2/66

COMPARISON OF CALCULATED VERSUS DEMONSTRATION RUN YIELDS AT ESTIMATED COMMERCIAL CONDITIONS

Size:	1/4 - 2 1/2"		1/4 - 1"		1 - 2 1/2"	
Basis	Demo	Comm	Demo	Comm	Demo	Comm
Fischer Assay, gal/ton	27.8	30.0	27.1	30.0	27.5	30.0
Dv, Inches	1.36	1.42	0.66	0.60	1.68	1.75
% Undersize	2	5	6	5	8	5
Dv/Da	1.40	1.65	1.20	1.20	1.12	1.13
Recycle, MSCF/T	14.5	14.3	12.0	12.5	15.1	15.0
Mass Rate, lbs/(hr)(ft^2)	490	500	490	500	400	400
Symbol	○	●	△	▲	⬡	⬢



PWSnyder
11/4/66

COST BASES FOR BASE CASE

Operation — **Basis**

1. **Mining:** $40,000/CD (47.6¢/Ton) scaled with the 0.8 power of production rate.

2. **Crushing:**

Product Maximum Size:	3"	2 1/2"	2"	1 1/2"
Cost ¢/Ton	13.4	13.9	14.4	16.2

$/CD are scaled with the 0.6 power of crusher throughput.

3. **Screening:**

Fractions Produced	2	3	4	5
Additional Cost ¢/Ton	- 0.4	Basis	+0.1	+1.4

4. **Retorting:**

Base: Cost fractions of mass rate and yield based on costs in August 20, 1965 Progress Memorandum.

Gas Compression: Cost adjusted for retort pressure loss from a base of 2PSI compression and for variation in air and total gas rates.

Bed Height: Investment adjusted for variation in retort bed height from 18 feet at a cost of $300,000/ft.

Spent Shale and Fines Disposal: Cost at 3¢/Ton for disposing of 68,510 Tons/CD; $/CD scaled by the 0.6 power of amount disposed.

PWSnyder
11/2/66

BASES FOR SENSITIVITY ANALYSIS

A. Analyses Complete

1. Process all the fines at 200 mass rate achieving 85% yield.

2. Discarding all the fines.

3. Increasing mining cost by 10¢/Ton.

4. Varying crushing cost by ±5¢/Ton.

5. Using the Nordberg crusher product size distribution which is 30% more fines i.e. 12% less than 1/4 inch for 2 1/2 inch maximum instead of 9%.

6. More effective screening for removing fines i.e. where the base case retorting 2 1/2 inch maximum has 4.8% of the maximum 9.0% fines in the full range feed to the retort; the sensitivity looks at the full range containing 2.4% of the maximum 9.0% fines.

B. Analyses Not Complete

1. Increase assay of shale mined to 35 and 40 gallons per ton with varying mining cost penalties.

2. Yield sensitivity based on regression analyses to be run using all the demonstration run data weighted heavier than other data.

3. Using crushing cost differential between maximum size as follows:

Condition	Cost Over Producing 3" Maximum, ¢/Bbl		
	2 1/2	2	1 1/2
Base	+0.5	+1.0	+2.8
Low	+0.3	+0.7	+2.0
High	+1.1	+2.3	+5.7

4. Increase the cost of capital to 20% DCF rate of return.

PWSnyder
10/24/66

Handout 7 - PWS

NAPHTHA RECOVERY FROM RETORT OFFGAS

A. C_3^+ In Gas

2 1/2 lbs. C_3^+/MSCF

4,000 - 13,000 B/D on a 50,000 B/D plant

B. Economic Screening

1. Compressing Mist-free Offgas - excessive power and cooling surface.
2. Cooling the Offgas - excessive exchanger surface required.
3. Adsorbents - excessive vessel and adsorbent costs - evaluated moving as well as fixed beds.
4. Lean Oil Absorbtion - 20 to 50 barrels of 500° F^+ shale oil per barrel of naphtha recovered - cost still being developed.
5. Polymerization - excessive tower requirements with solid catalyst and excessive moisture present for $AlCl_2$. — think a new one. $AlCl_3$
6. Retorting with Steam - insufficient sensible heat in raw shale to condense steam. ?

PWSnyder
11/2/66

Handout 1 - KIJ

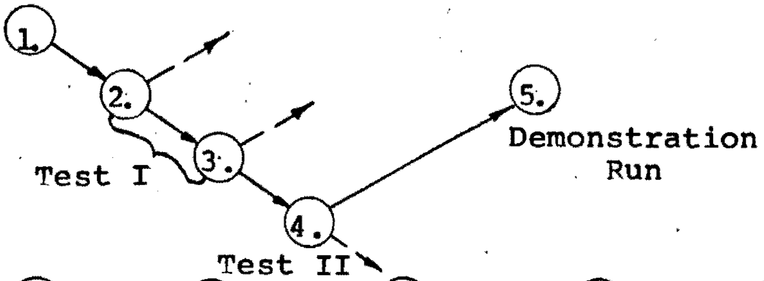
PROCESSING OF 1/4 TO 1 INCH SHALE

① Poor Operability

Hypotheses
Poor Operability
is Due to -

I. Excessive Local Combustion Zone Temperatures.

II. Excessive Gas Flow Causing Dust/Oil Bridge Which is a Precursor to Observed Clinker.



	①	②	③	④	⑤
Operating Conditions					
Raw Shale Rate, lbs/(hr)(ft^2)	496	489	(500)	492	492
Fischer Assay, Gal/Ton RS	30.1	29.5	(28)	27.7	27.1
Air, SCF/Ton RS	4,400	4,240	(4,700)	4,910	4,860
Recycle, SCF/Ton RS	15,600	15,100	(13,000)	11,700	12,800
Dilution, SCF/Ton RS	--	--	(1,500)	--	--
Total Gas Leaving Top of Retort, SCF/Ton RS	20,900	20,700	(21,900)	18,000	19,100
Shale Control Mode(1)	V	V	V & C	V	C
Air Distributor Design	8 Riser	12 Riser	8 Riser	8 Riser	8 Riser
Results					
Yield, Vol % RSFA	89.6	90.6	Inconclusive	90.4	90.8
Overall Operating Performance	Poor (Clinker When Shut Down)	Poor (Bridge Required Shut Down. Clinker Observed)	(2)	Fair to Good	Good

(1) V - Varying speed shale drawoff
C - Constant speed shale drawoff

(2) Three attempts were made to run this condition. These experiments were plagued with either startup problems or mechanical failures.

KIJagel
11/3/66

Handout 2 - KIJ

DEMONSTRATION RUNS

Nominal Shale Size Range	1/4 - 1"	1 - 2 1/2"	1/4 - 2 1/2"
Duration of Continuous Operation, Days	12	6	8.5
Time at Demonstration Run Conditions, Days	5	3	5
Operating Conditions			
Raw Shale Rate, lb/(hr)(ft^2)	492	402	494
Fischer Assay GAL/Ton	27.1	27.5	27.7
Air, SCF/TON RS	4,860	4,650	4,470
Recycle, SCF/TON RS	12,800	15,800	15,300
Total Gas Leaving Top of Retort, SCF/TON RS	19,100	22,200	21,300
Shale Control Mode (1)	C	V	V
Air Distributor Design	8 - 21" Risers	4 - 39" Risers	8 - 21" Risers
Bed Height, Ft			
Above A/D	5.5	12.5	9.5 - 10.0
Below A/D	5.5	7.0	5.5
Results			
Yield, Vol.% RS FA	90.8	88.1	86.4
Overall Operating Performance	Good	Good	Fair To Good

(1) V - Varying Speed Shale Drawoff.

C - Constant Speed Shale Drawoff.

KIJagel
11/2/66

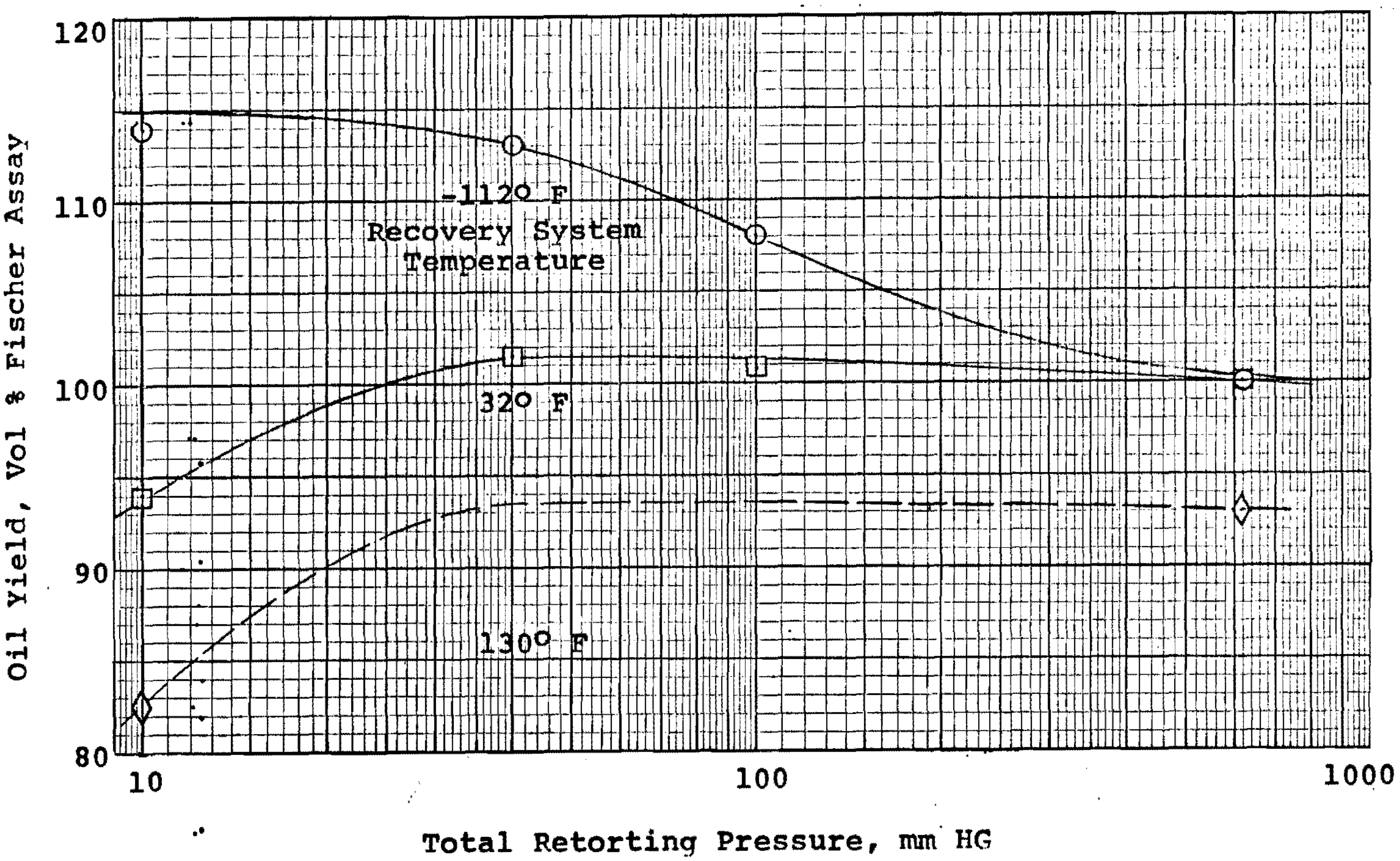
33 G/T SHALE PROCESSING

	1/4 - 1"	1 - 2 1/2"	1/4 - 2 1/2"
Operating Conditions			
Raw Shale Rate, lb/(hr)(ft^2)	480	399	493
Fischer Assay GAL/TON RS	33.3	33.7	32.6
Air, SCF/TON RS	5,210	4,460	4,690
Recycle, SCF/TON RS	12,300	15,700	13,600
Results			
Yield, Vol.% RS FA	86.9 (1)	87.1	81.3
Unretorted Oil in Spent Shale Vol.% RS FA	2.3	0.2	0.6
Overall Operating Performance	Good	Fair To Good	Poor

(1) ESP Failed at Beginning of This Test Series.

KIJagel
11/2/66

OIL YIELD (FISCHER ASSAY RETORT) AS A FUNCTION OF TOTAL PRESSURE AND RECOVERY SYSTEM TEMPERATURE



KIJagel
11/3/66

Handou 5 - KIJ

COMPARISON OF FISCHER ASSAY AND MINI RETORT DATA

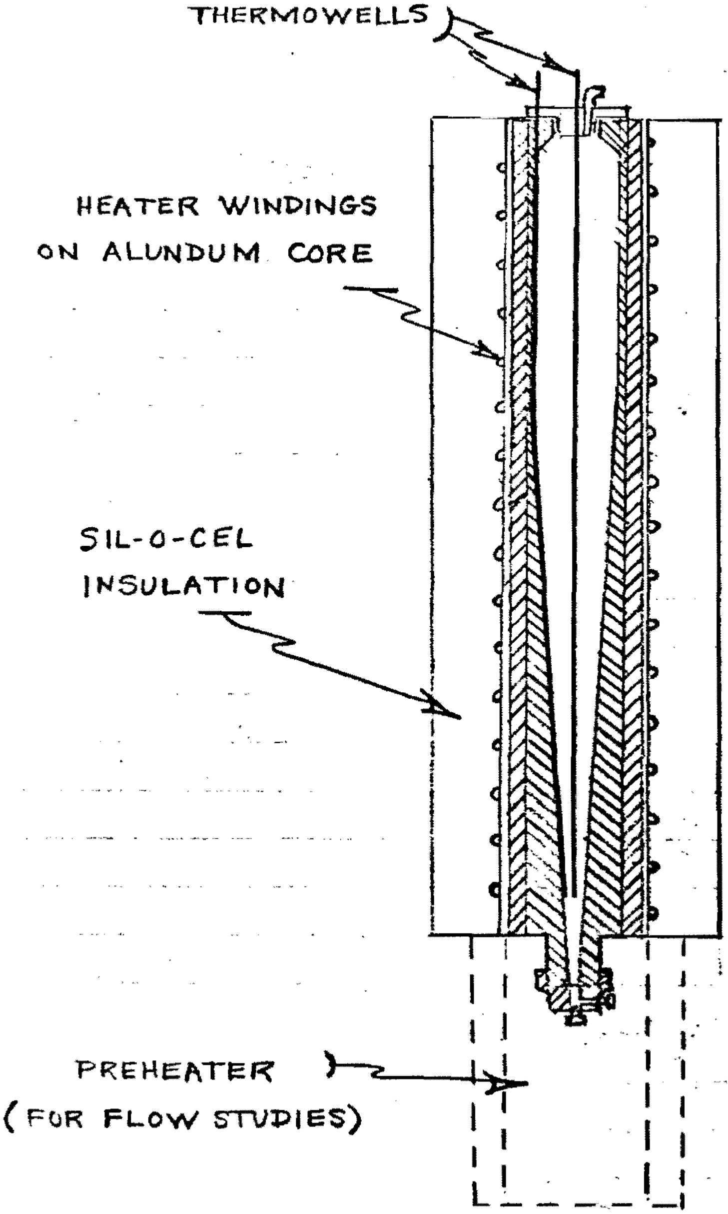
▧ STAINLESS STEEL RETORT BLOCK

▨ MILD STEEL SLEEVE

Run	Fischer Assay	Mini Retort	
Oil Yield Gal/Ton	28.3	24.2	(85.5 Vol % FA)
H_2O, Wt %	1.3	1.5	
Spent Shale, Wt %	85.7	85.8	
Gas + Loss, Wt %	2.3	3.5	
Oil Specific Gravity 60/60° F	0.911	0.902	
Raw Shale Organic Carbon on Spent Shale	18.3(1)	22.1	

(1) Estimated from correlation relating organic carbon on spent shale with oil yield.

KIJagel
11/3/66


THERMOWELLS
HEATER WINDINGS
ON ALUNDUM CORE
SIL-O-CEL
INSULATION
PREHEATER
(FOR FLOW STUDIES)

CRUSHER PLANT CAPACITIES

	1/4 - 1"	1 - 2 1/2"	1/4 - 2 1/2"
Closed Circuit Crushing			
Average Production Rate, T/Hr	20	25	31
Crusher Feed Rate, T/Hr	(26)	(42)	(35)
Open Circuit Crushing			
Average Production Rate, T/Hr	-	33	-
Crusher Feed Rate, T/Hr	-	53	-

KIJagel
11/2/66

Handout 1 - JEL

ECONOMIC FACTORS AFFECTING RETORT DESIGN

Factor	Good	Bad
Gas Rate	High	Low
Mass Rate	High	Low
Maximum Size	2 1/2 inches	>2 1/2 inches<
Size Range	Narrow	Wide
Assay	High	Low

JELawson
11/2/66

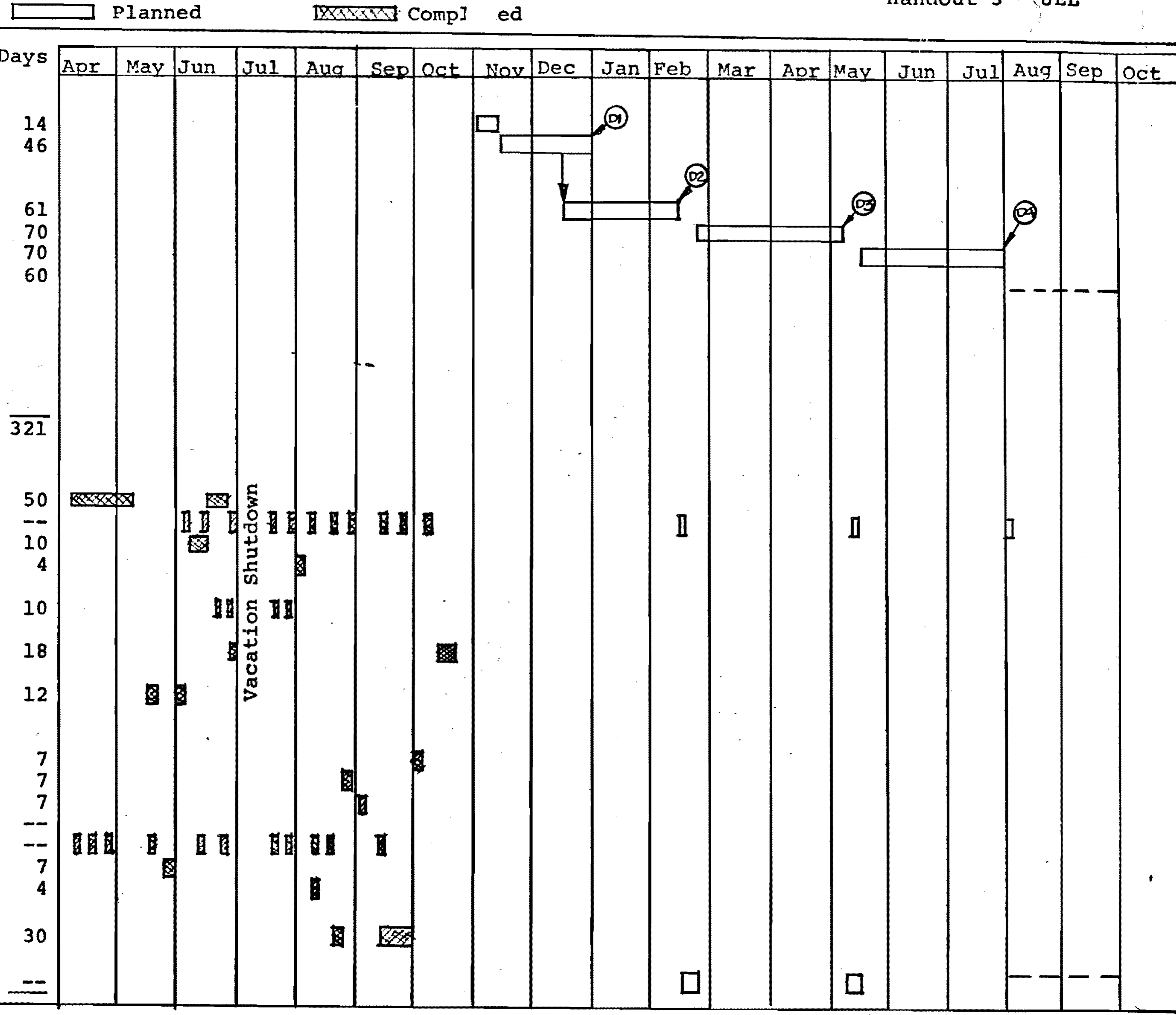
OPERABILITY FACTORS AFFECTING RETORT DESIGN

	Shale Size		
Factor	**Wide Range**	**Small**	**Large**
Shale Flow	Good	Bridges	Good
Pressure Drop*	High	Low	Low
Offgas Temperature* Spread	High	Low	Low

* These factors expected to be most significant in scaleup of process.

JELawson
11/2/66

Handout 3 JEL



in estimate.
ll be utilized during prolonged Retort No. 3 downtime.

JELawson
11/3/66

	Days
A. Retort No. 3	
1. Operator Training & Pre-Operation Schedule	14
2. Shakedown, 1 to 2 1/2 Inch Shale	46
3. Optimization and Demonstration Runs(1)	
a. 1 to 2 1/2 Inch Shale	61
b. 1/4 to 1 Inch Shale	70
c. 1/4 to 2 1/2 Inch Shale	70
4. Slack Time To Be Allocated in Future	60
a. Contingencies in Basic Program, and/or	
b. Equipment Studies, and/or	
c. Process Variations and Operability Studies	
	321
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 to 1 1/2 Inch	10
3. Shale Richness - 1/4 to 2 1/2 Inch & 1/4 to 1 Inch Shale	18
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 to 1 Inch Shale	30
11. Category "C" Studies(2)	--

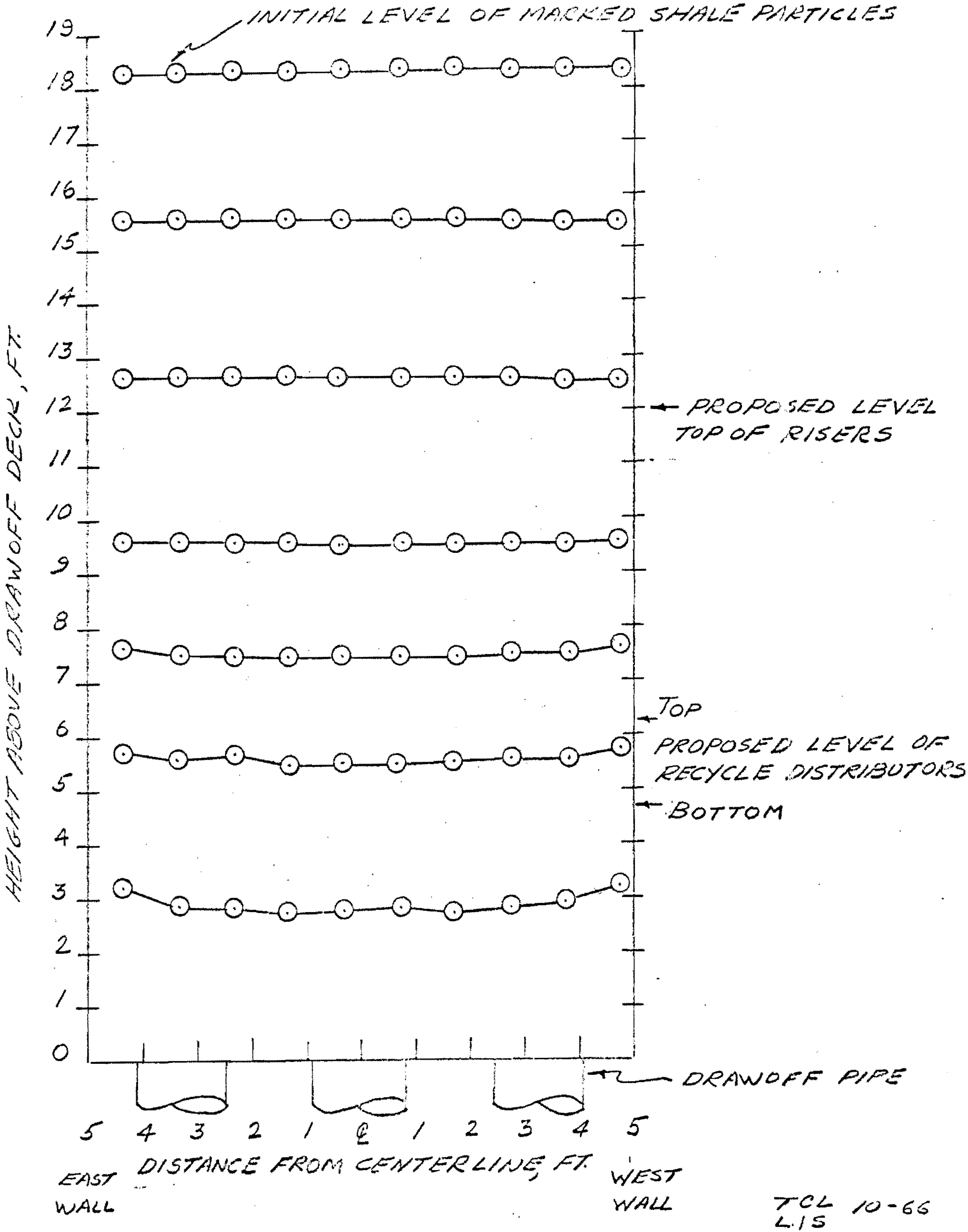
(1) Stream efficiency has not been included in

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

Handout 1 - TCL

FLOW PATTERN WITH 1 TO 2½ INCH SHALE IN 1/2 SECTION
MODEL OF RETORT NO. 3

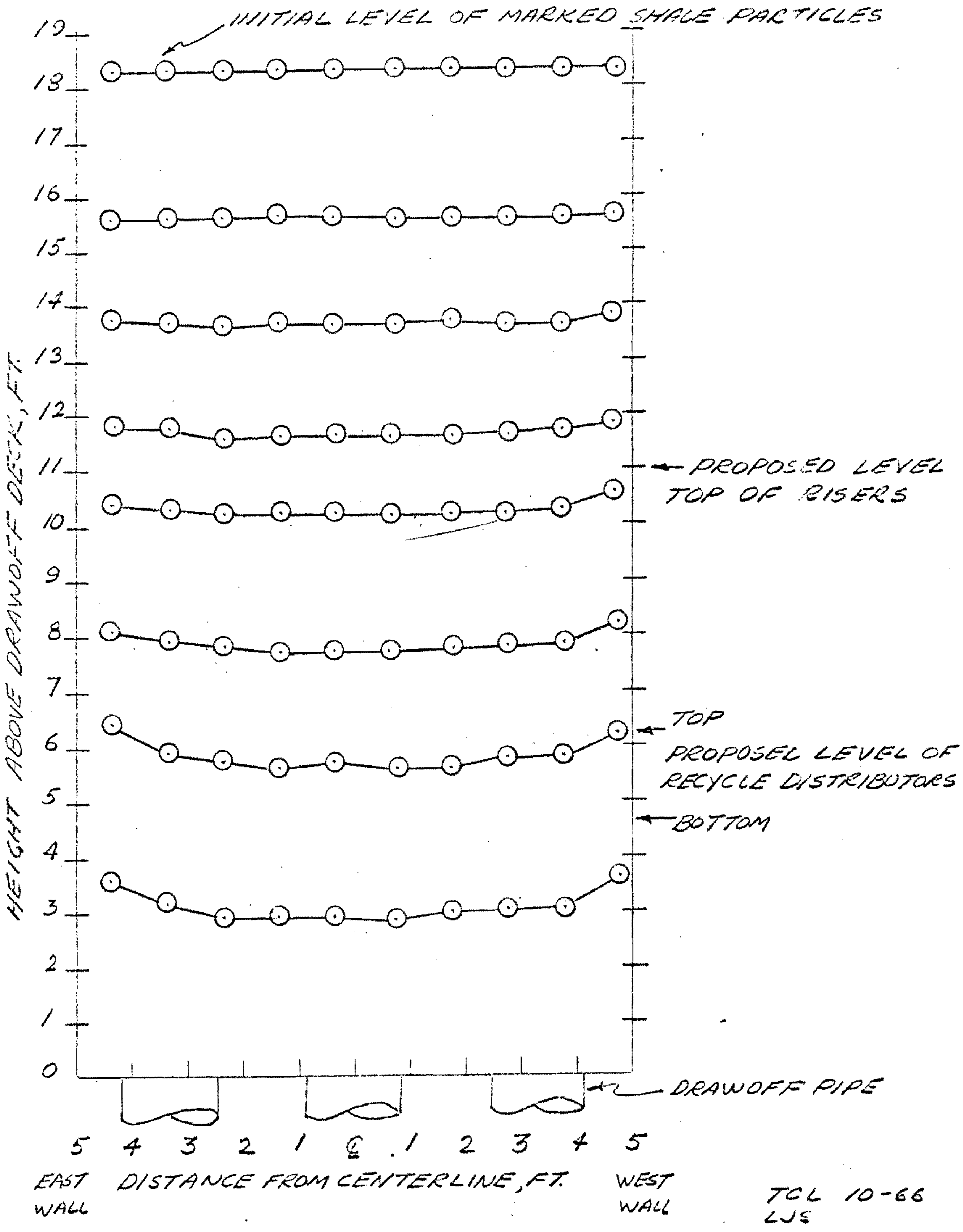
BASE CASE - NO INTERNAL HARDWARE



TCL 10-66
L.I.S

FLOW PATTERN WITH 1/4 TO 1 INCH SHALE IN 1/2 SECTION MODEL OF RETORT NO. 3

BASE CASE - NO INTERNAL HARDWARE



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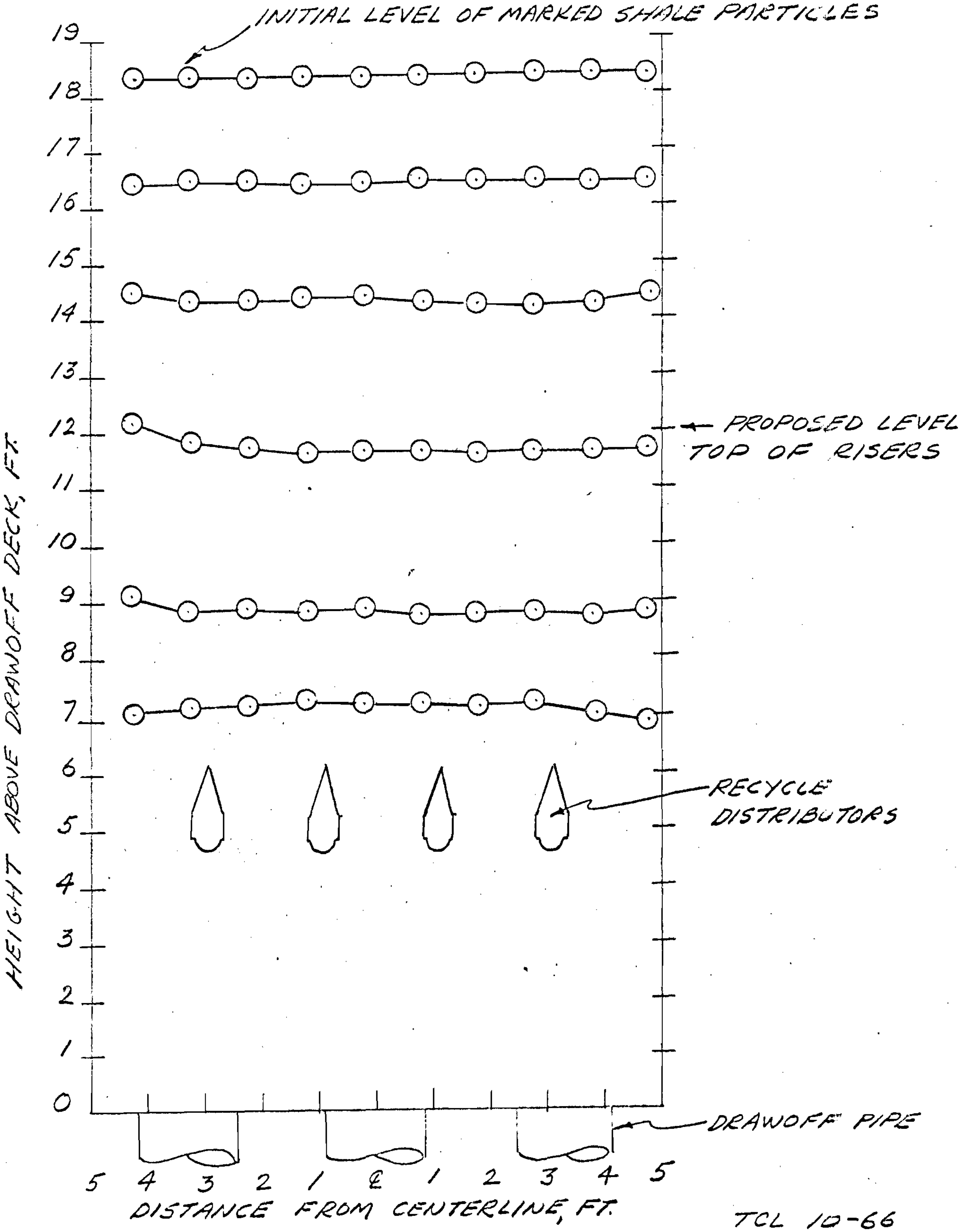
FLOW PATTERN WITH 1 TO 2 1/2 INCH SHALE IN 1/2 SECTION MODEL OF RETORT NO. 3

FLOW WITH RECYCLE DISTRIBUTORS



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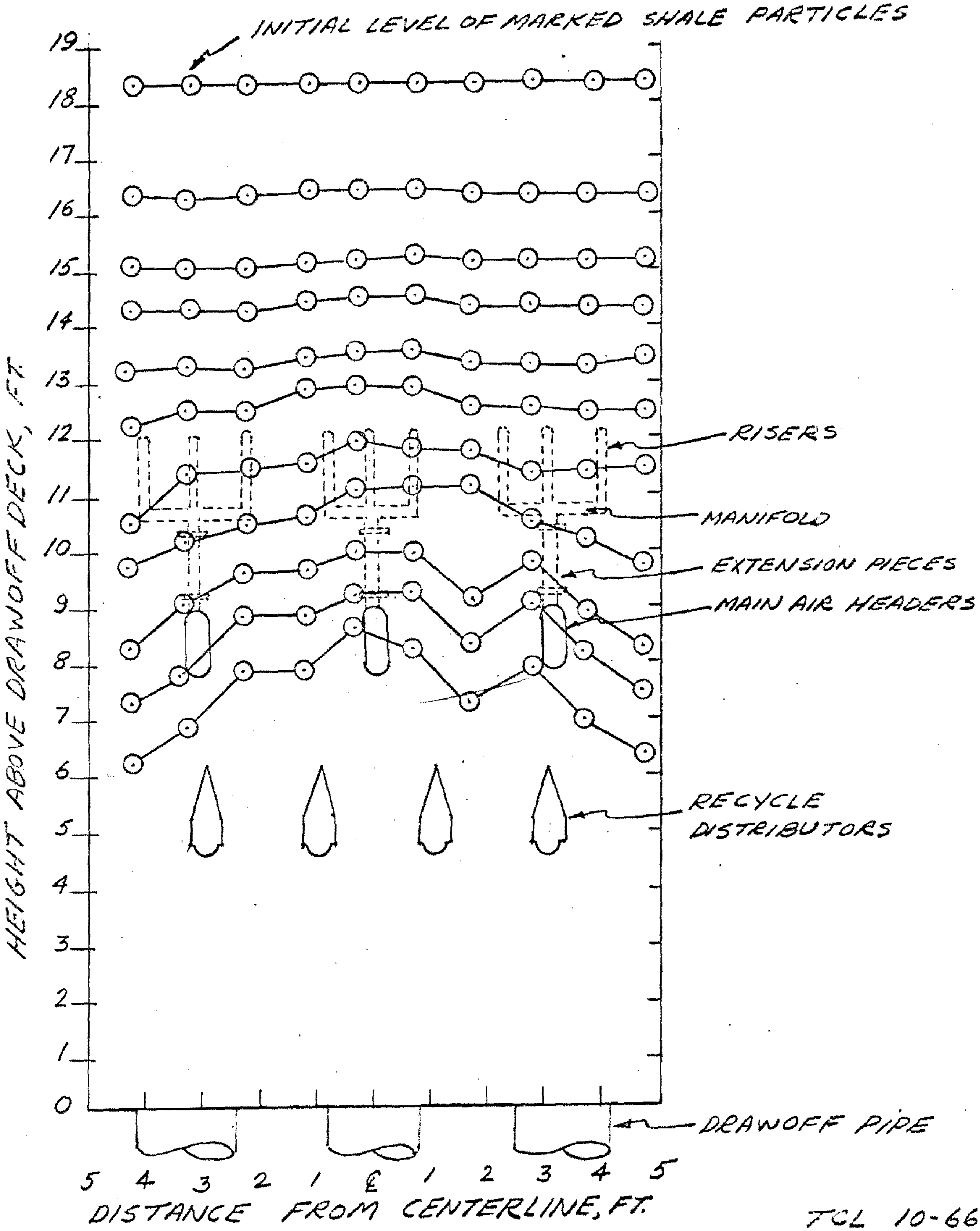
LJS

FLOW PATTERN WITH 1 TO 2 1/2 INCH SHALE IN 1/2 SECTION MODEL OF RETORT NO. 3

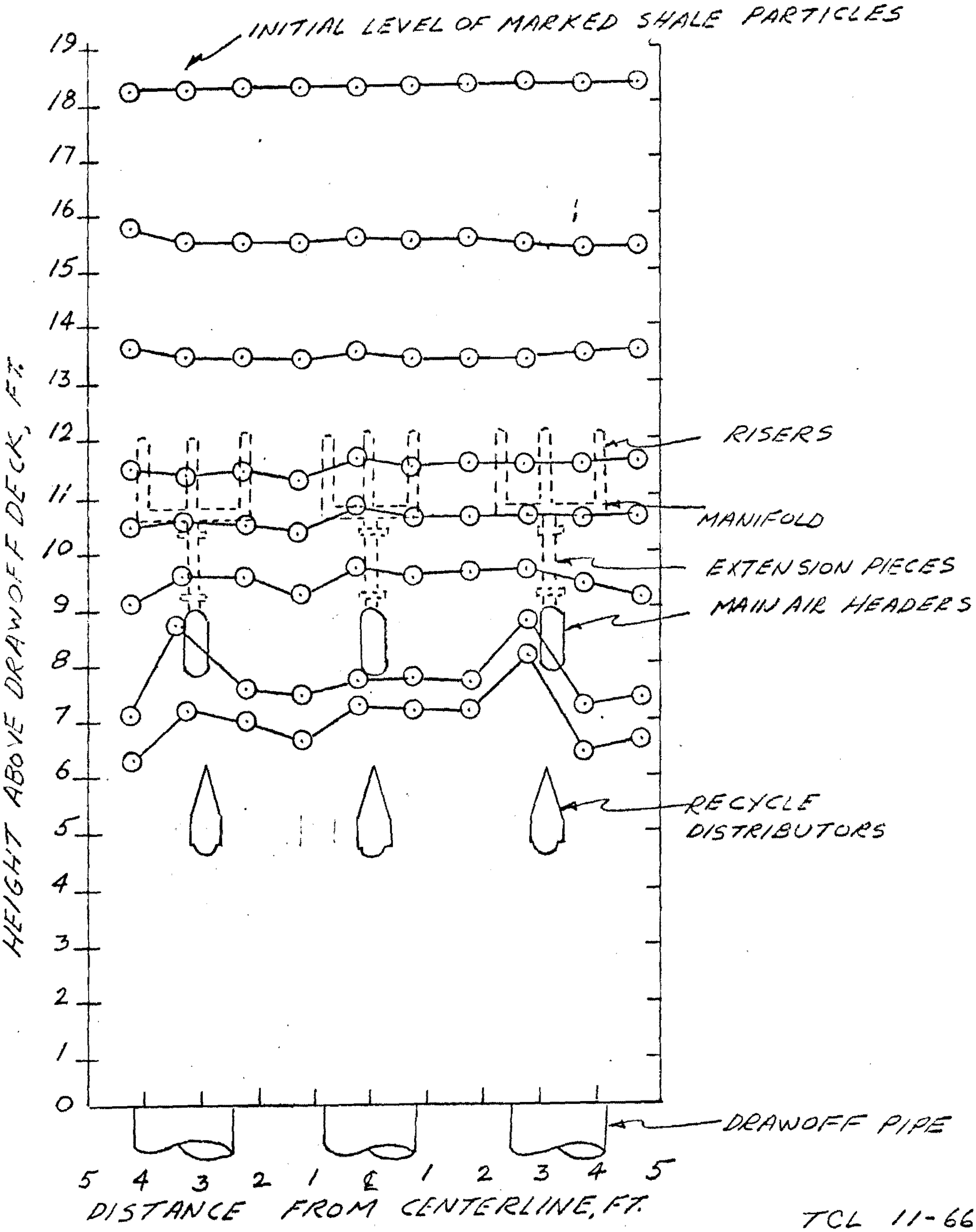
FLOW WITH AIR AND RECYCLE DISTRIBUTORS



TCL 10-66
LJS

FLOW PATTERN WITH 1 TO 2 1/2 INCH SHALE IN 1/2 SECTION MODEL OF RETORT NO. 3

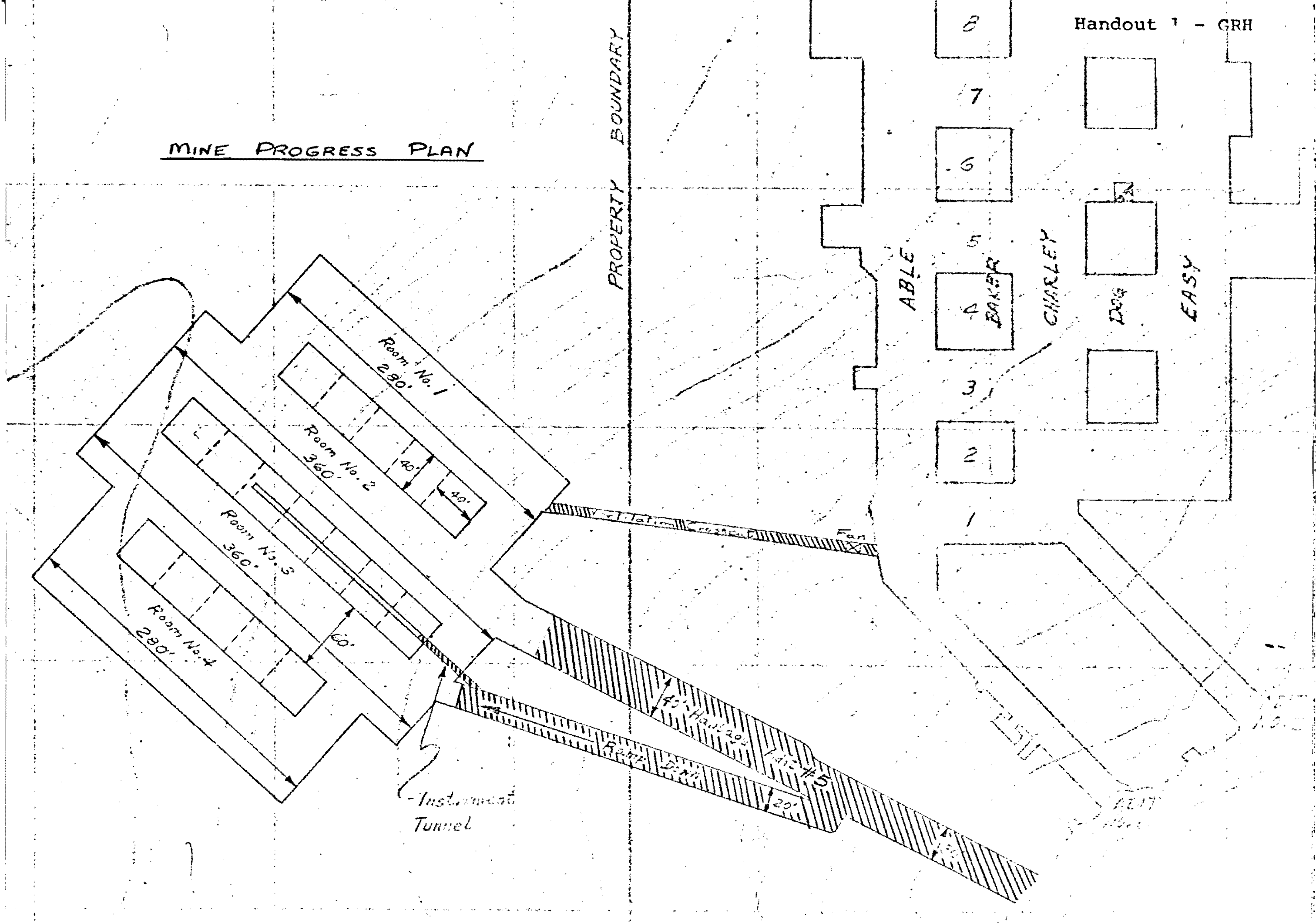
FLOW WITH MAIN AIR HEADERS LOCATED DIRECTLY ABOVE 3 RECYCLE DISTRIBUTORS



TCL 11-66
LJS

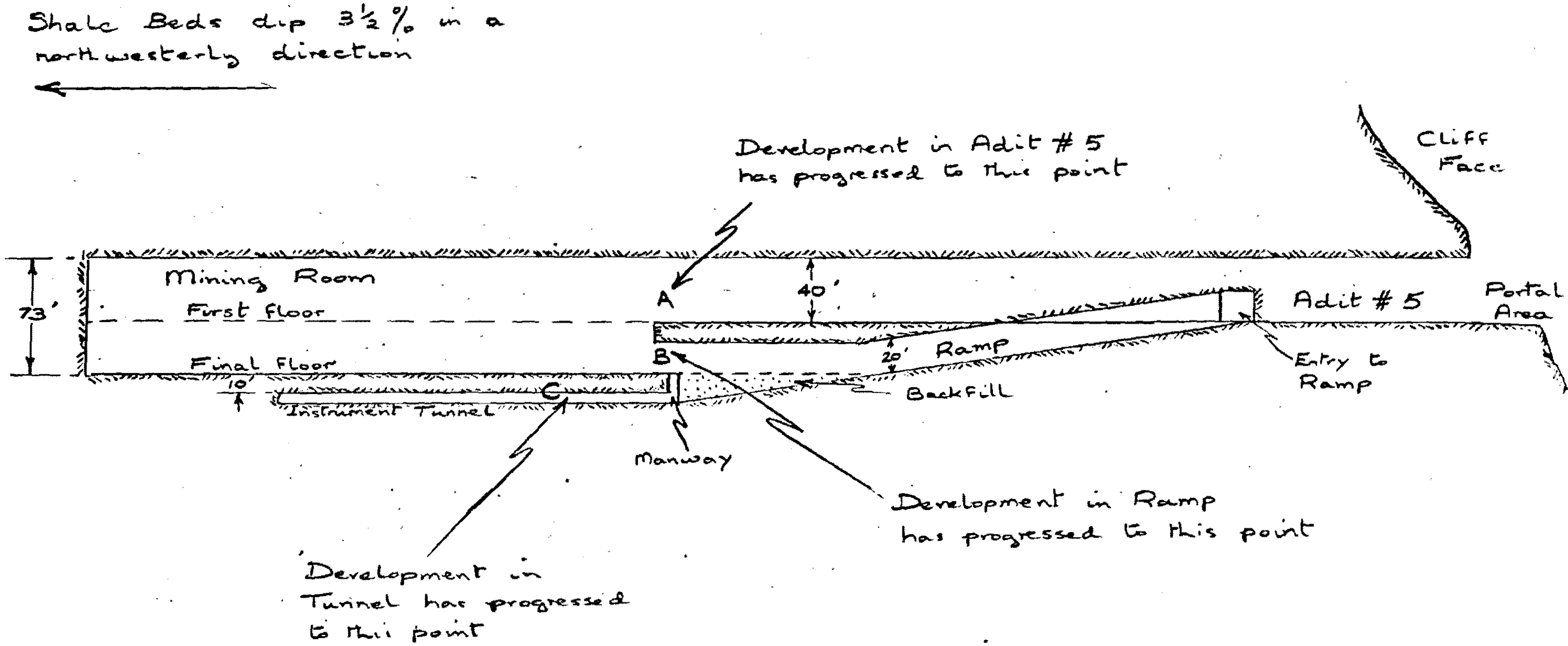
Handout 1 - GRH

MINE PROGRESS PLAN



▨ Development Work Complete to-date

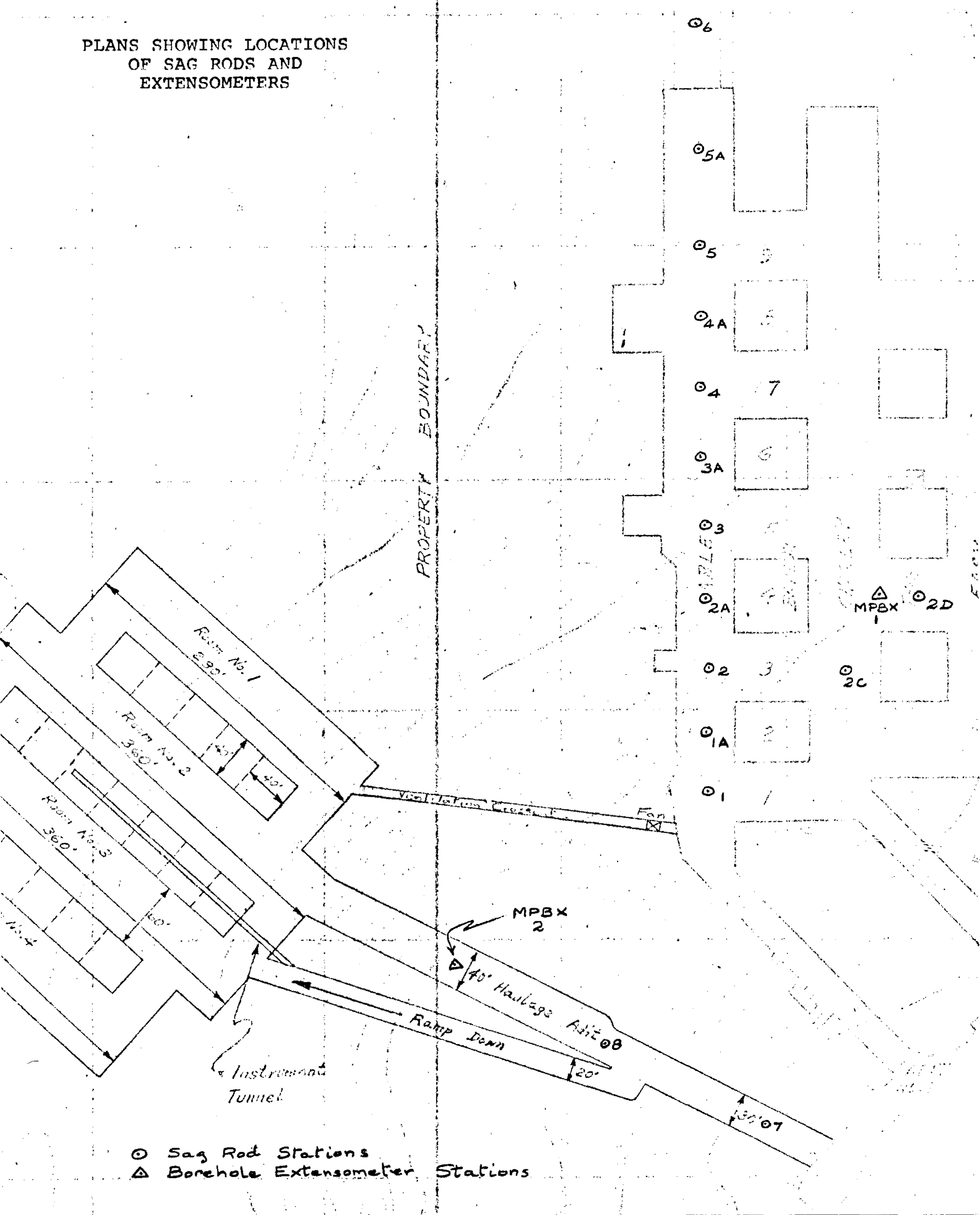
Handout 2 - GRH



SECTIONAL VIEW SHOWING MINE & DEVELOPMENT AREA

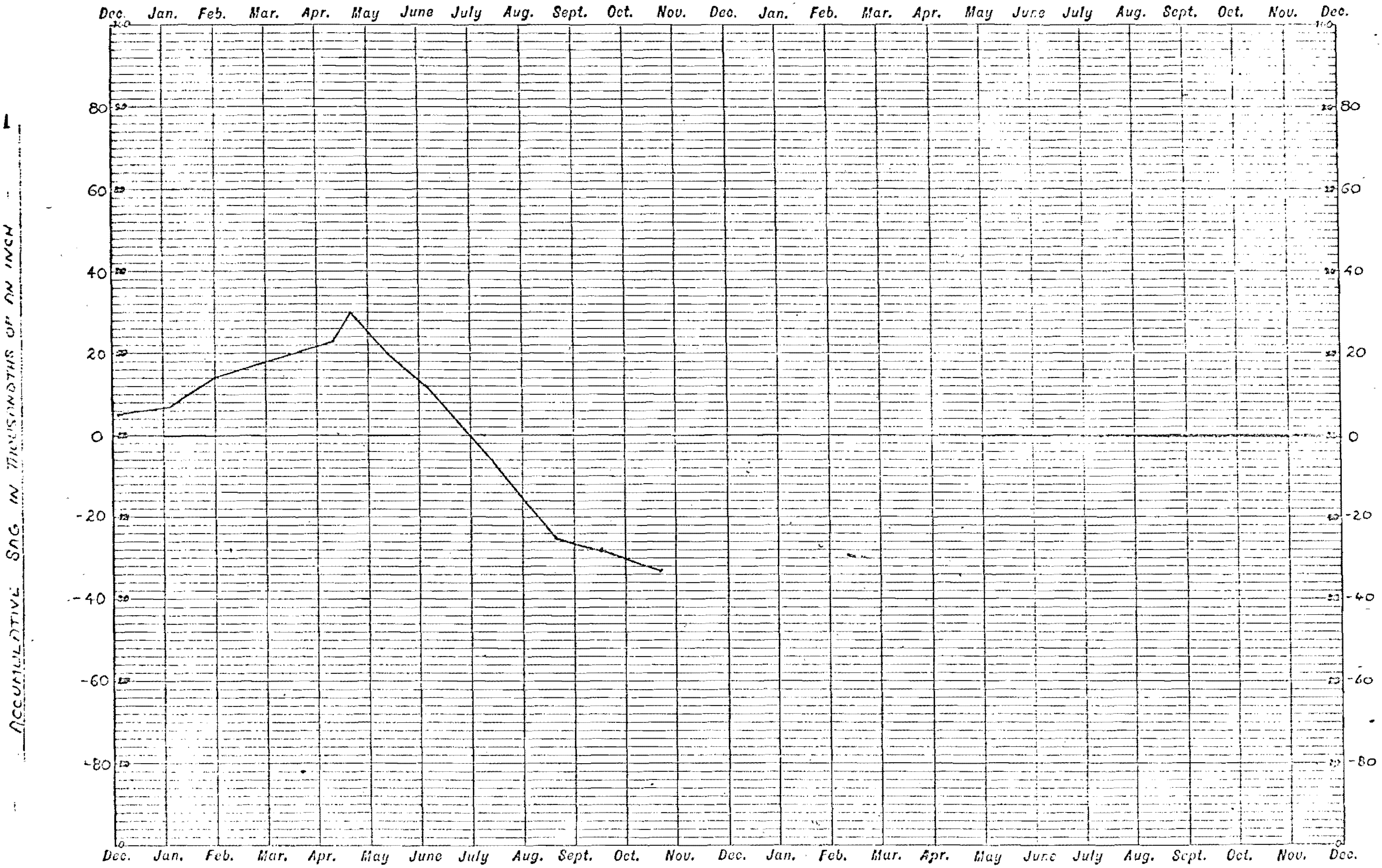
Handout 3 - GRH

PLANS SHOWING LOCATIONS OF SAG RODS AND EXTENSOMETERS



NO. 5250. TWO YEARS BY MONTHS X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS

SAG PIN STATION No 3 LENGTH 15 FT

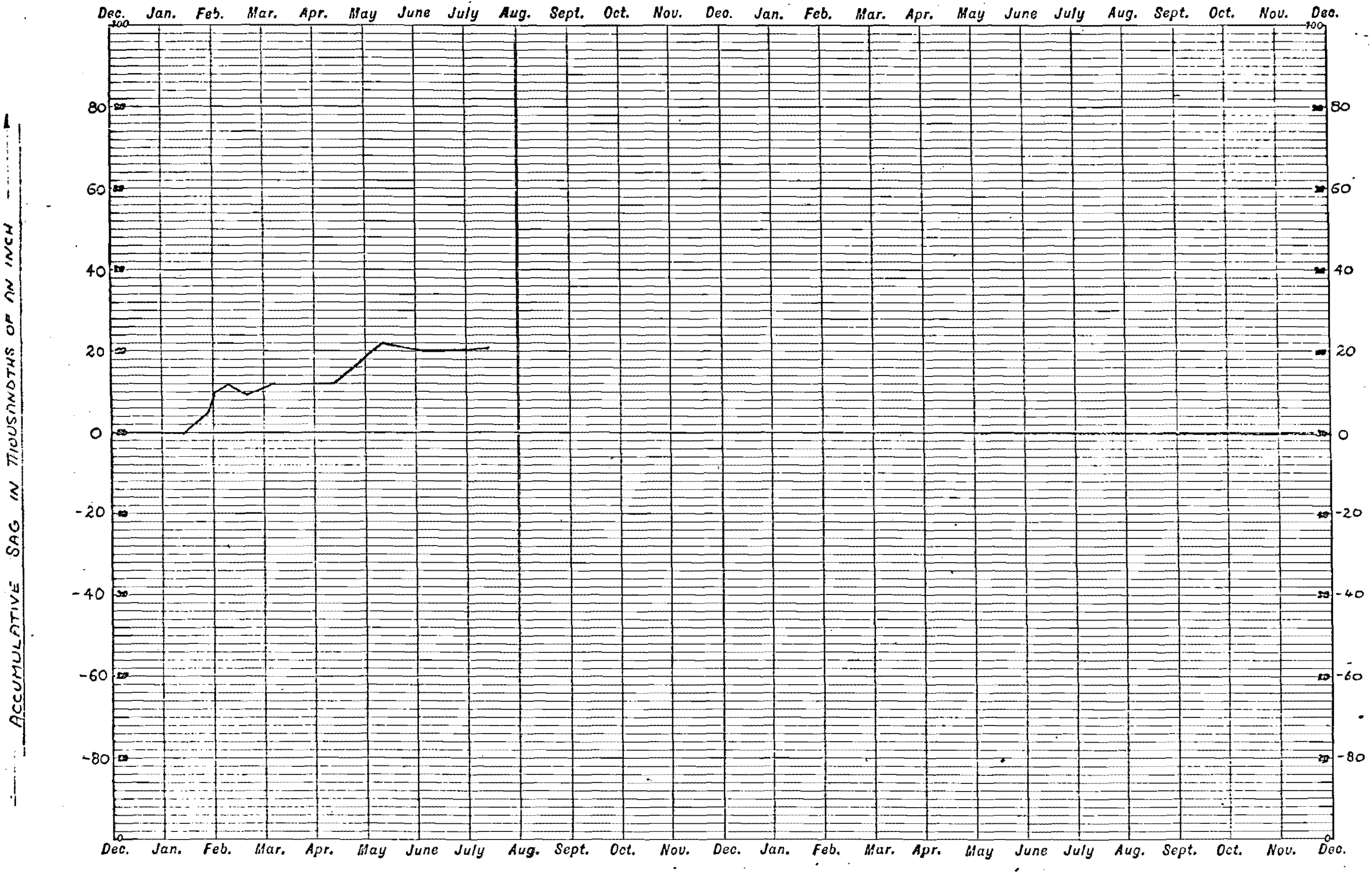


Year of 1966 Year of 1967

Handout 4A - GRII

NO. 3250. TWO YEARS BY MONTHS X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS

SAG PIN STATION No 6 LENGTH 15 FT

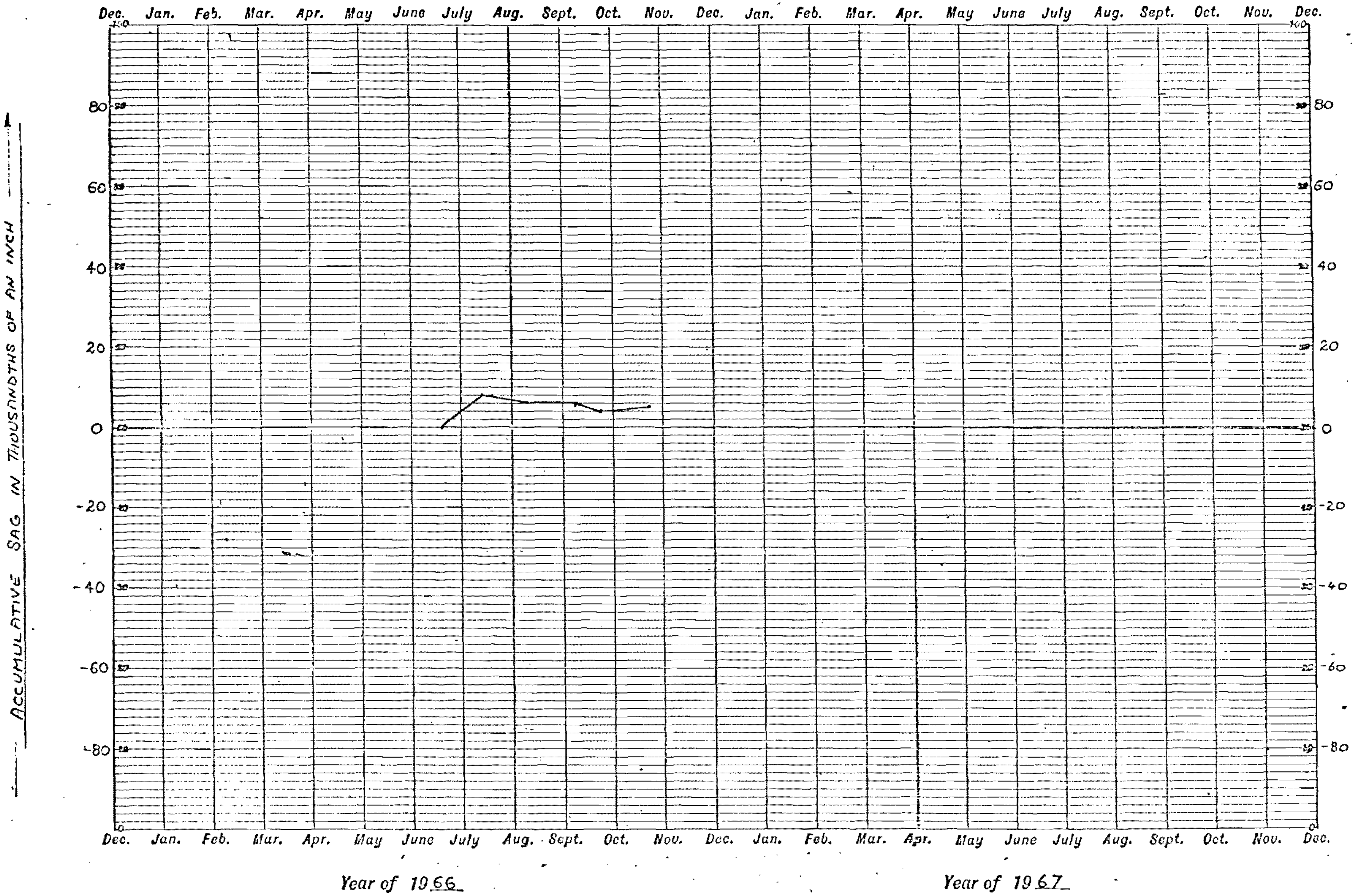


Year of 1966 Year of 1967

Handout 4D - GPH

NO. 3250. TWO YEARS BY MONTHS X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS

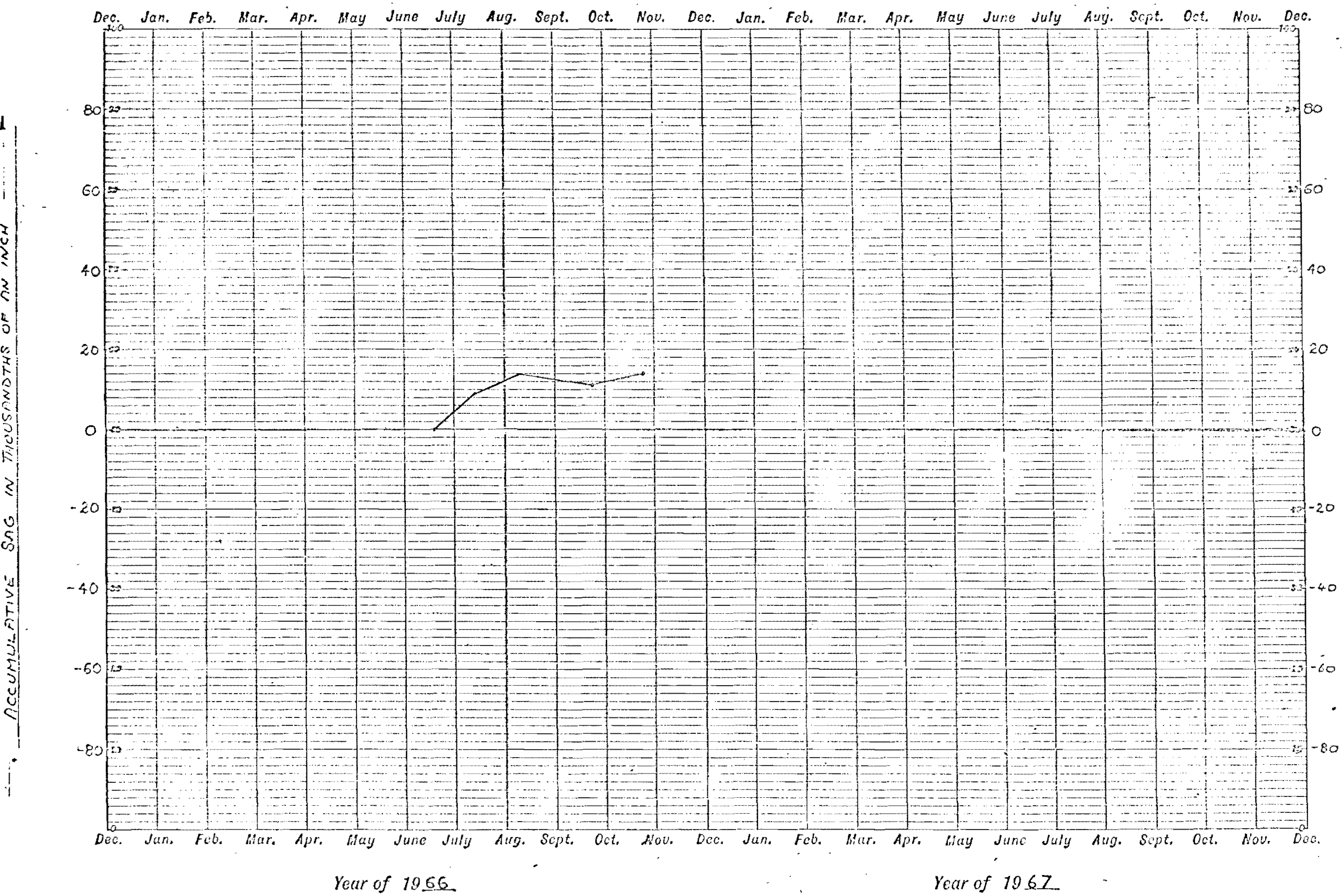
SAG PIN STATION No 7 LENGTH 15 FT.



Handout 4R - GRH

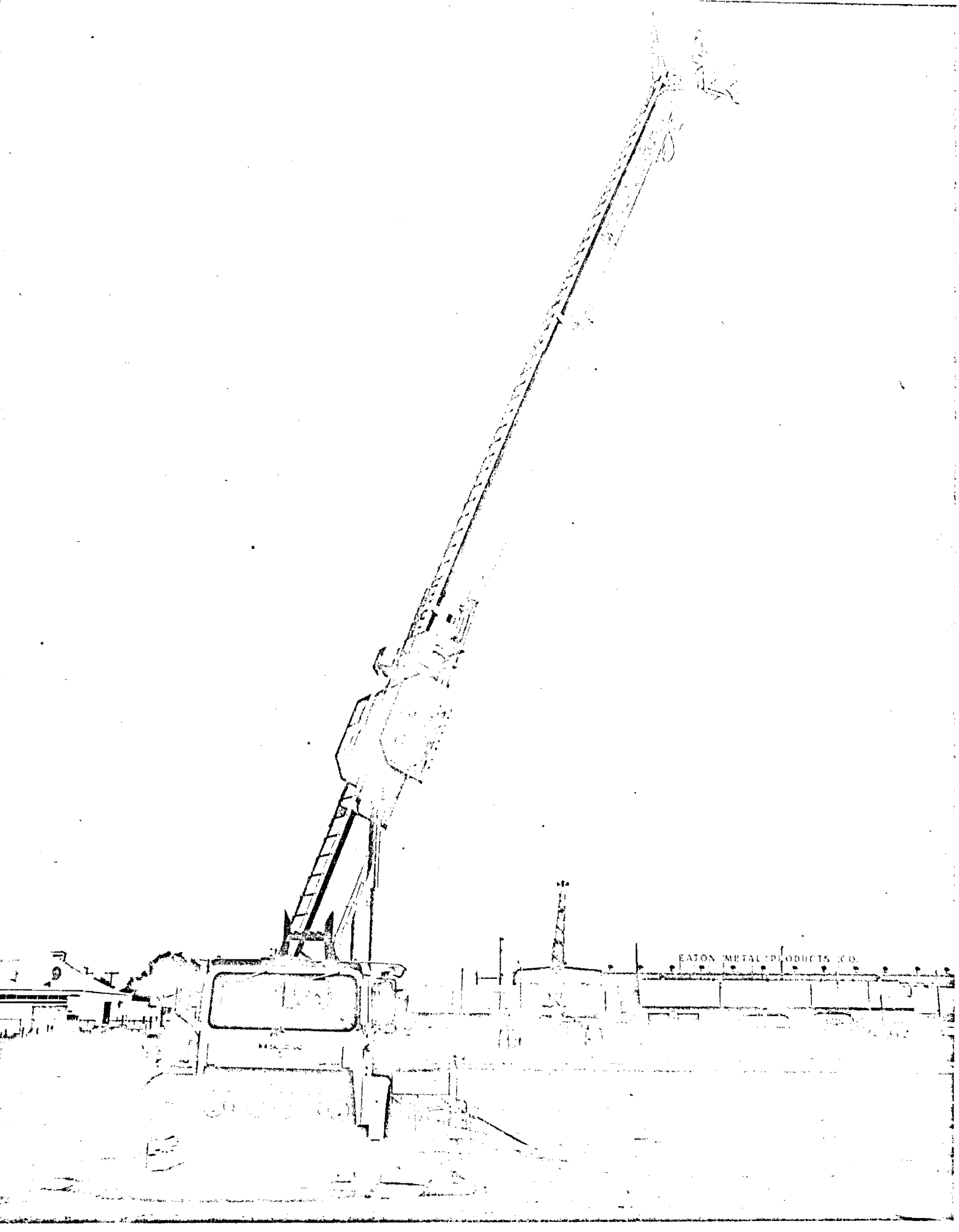
NO. 3250. TWO YEARS BY MONTHS X 100 DIVISIONS. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS

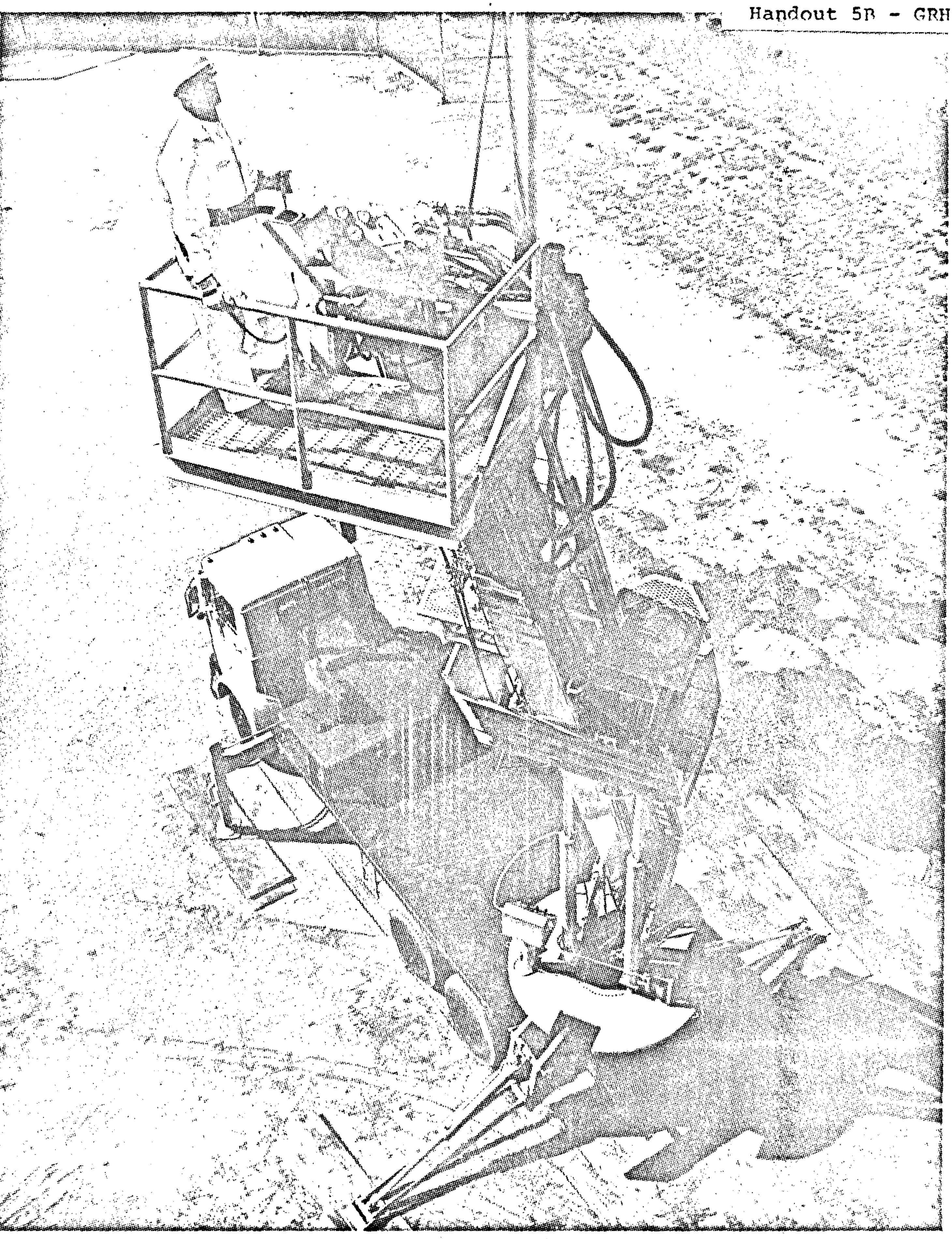
SAG PIN STATION No 8 LENGTH 15 FT



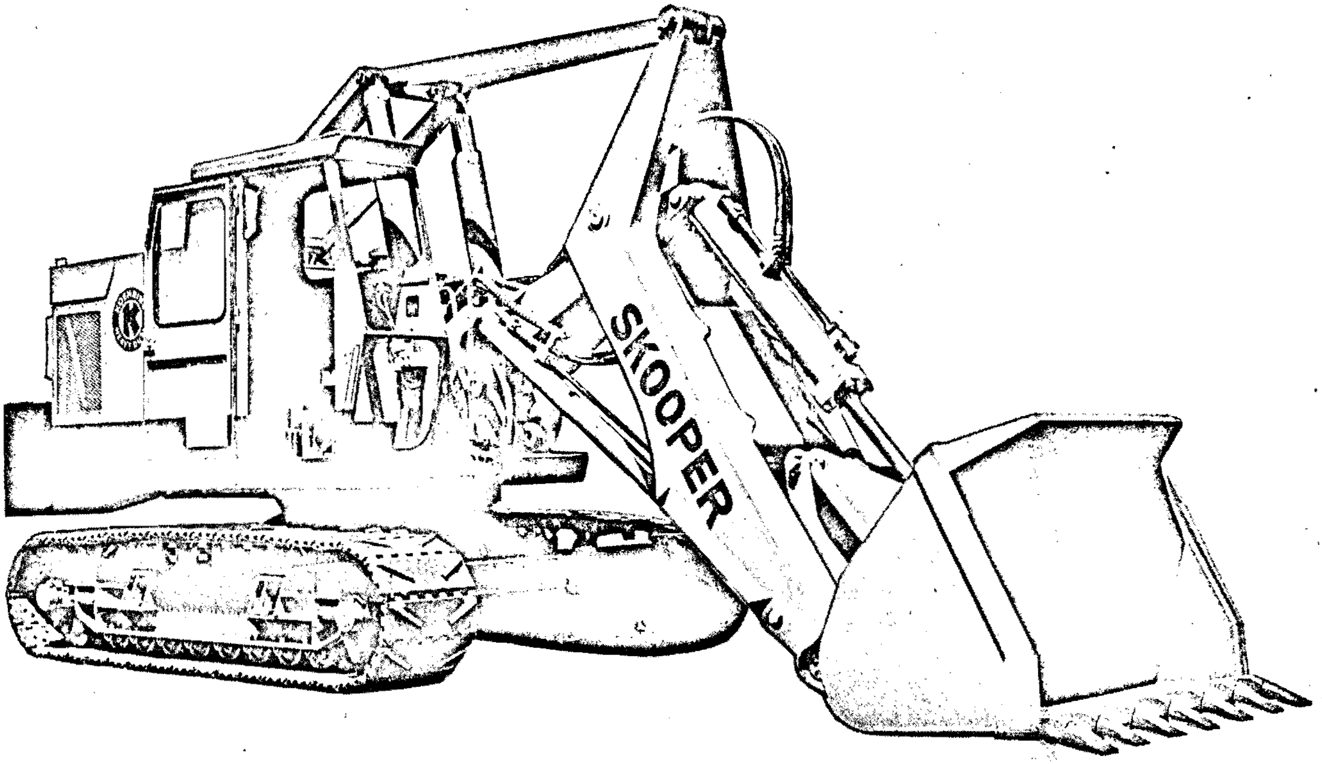
Handout 4C - GRH

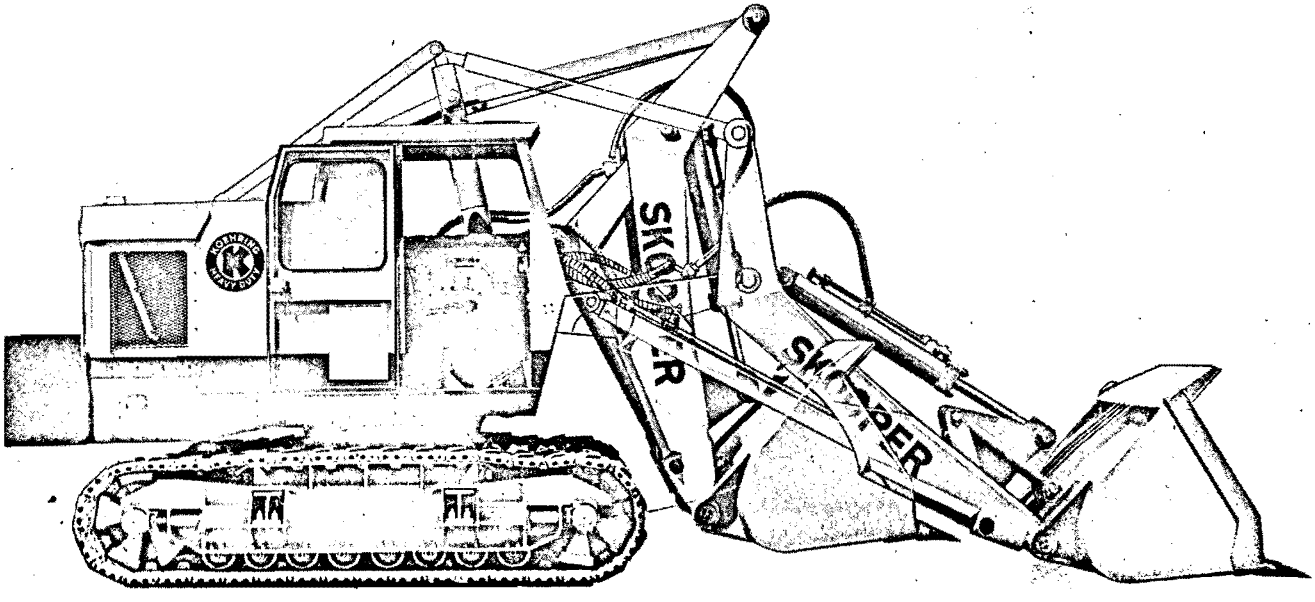
Handout 5A - GRH

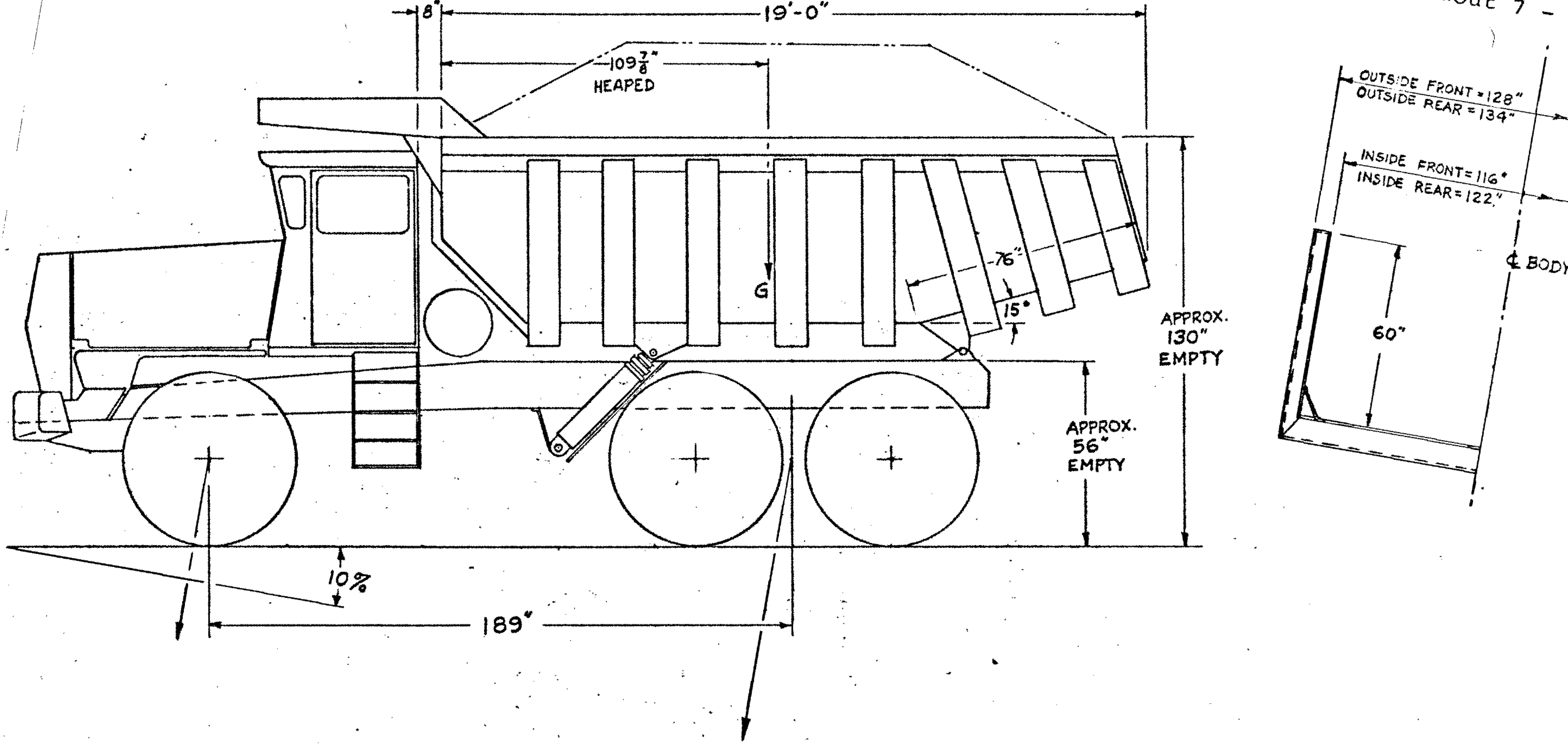




KOEHRING SKOOPER - FRONT END LOADER

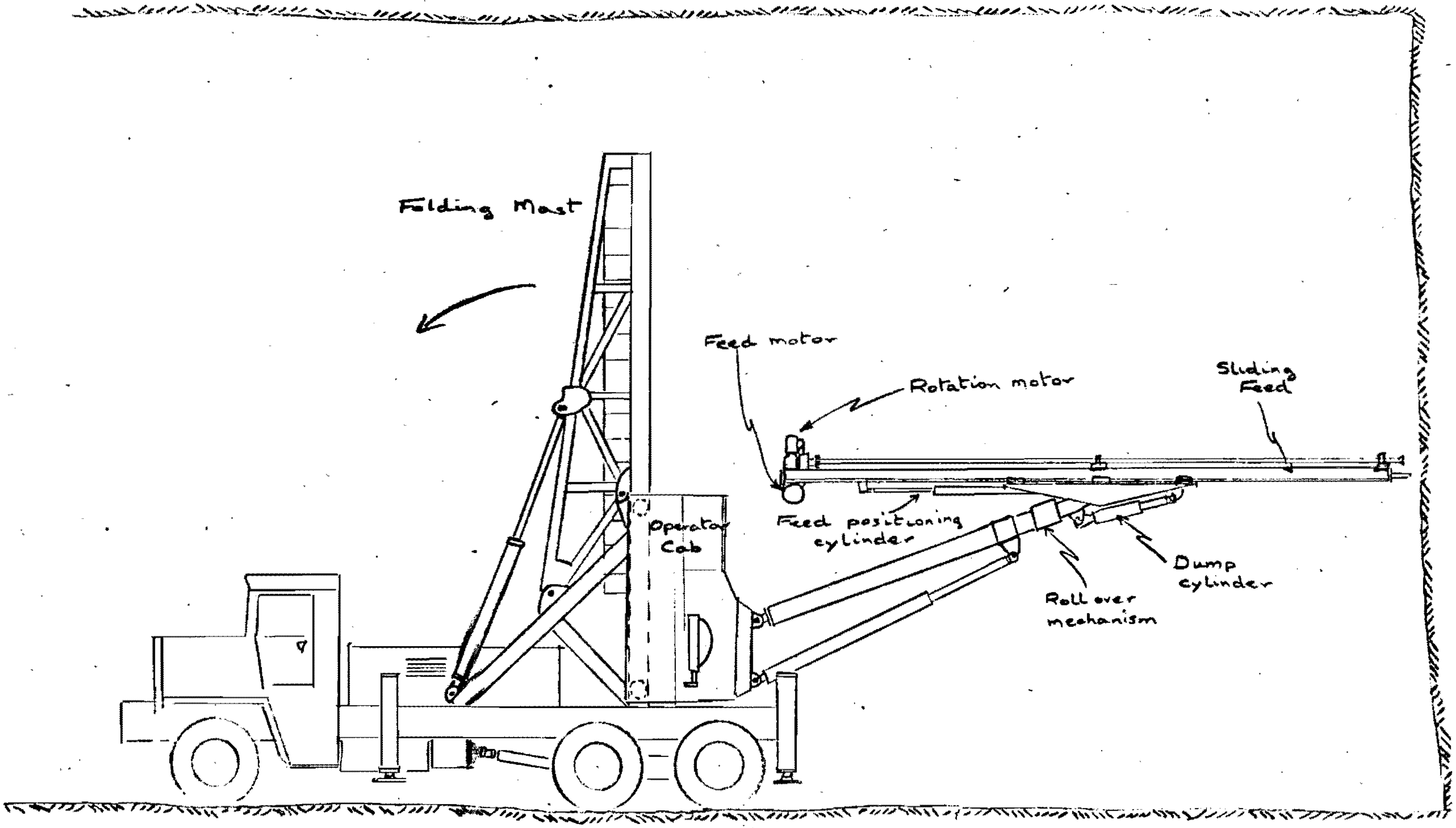




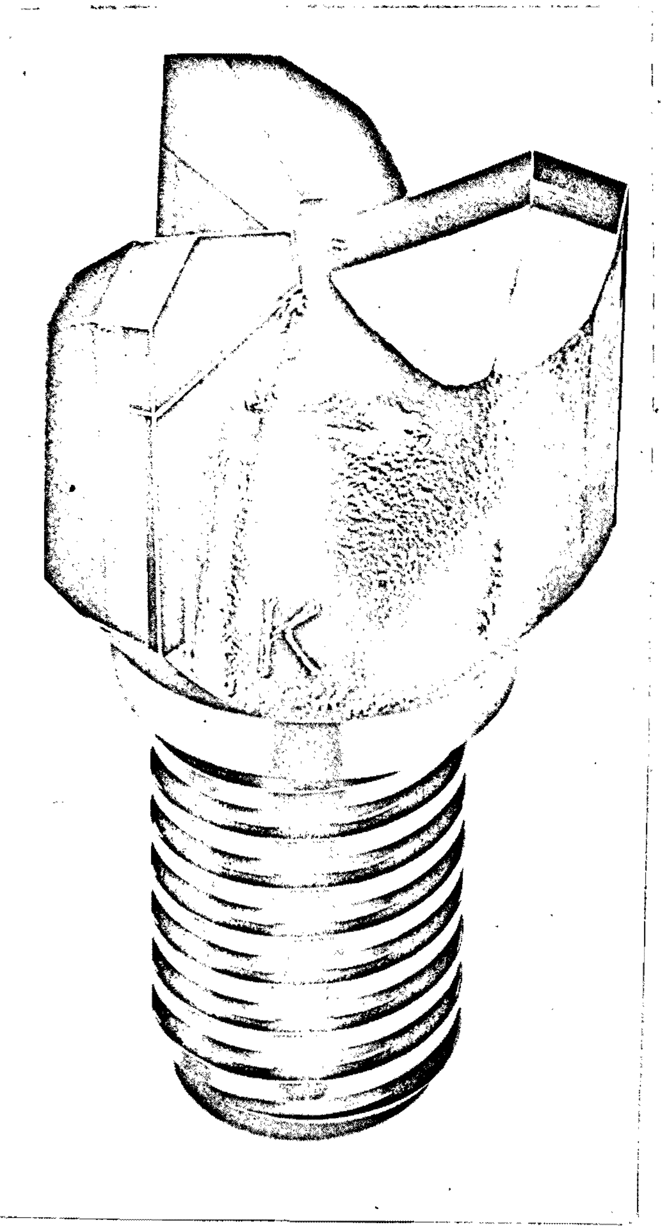


35 CU. YD. ALUMINUM ROCK BODY
TO FIT MACK M32SX
HEAPED CAPACITY S.A.E. 2:1 40 CU. YD.

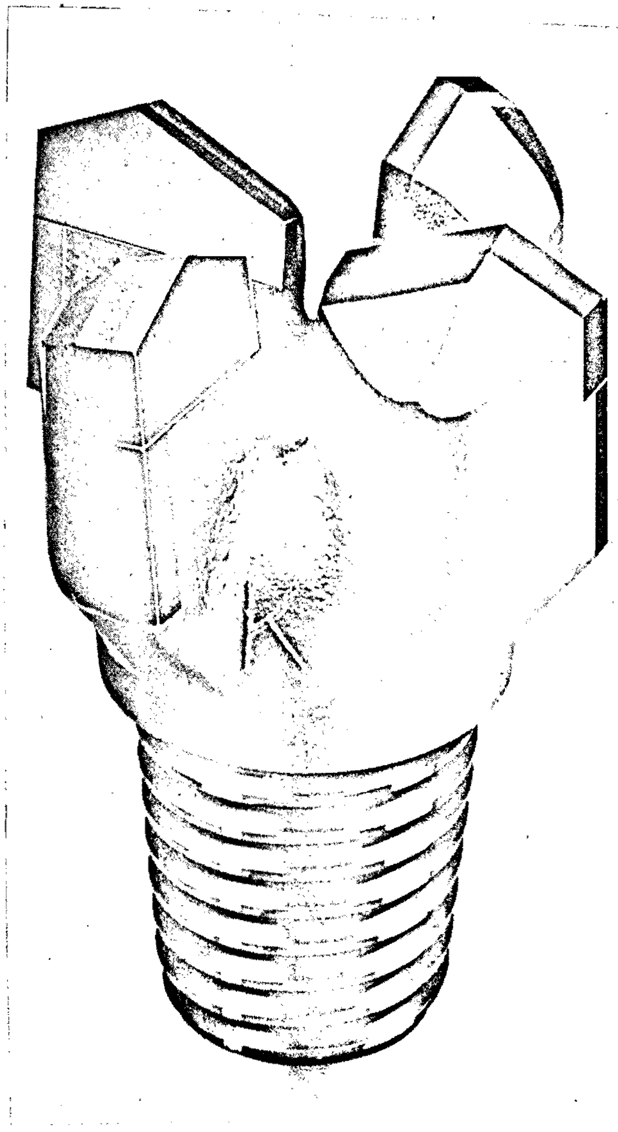
GARDNER DENVER ROTARY DRILL JUMBO



ROTARY CARBIDE ROCK BITS



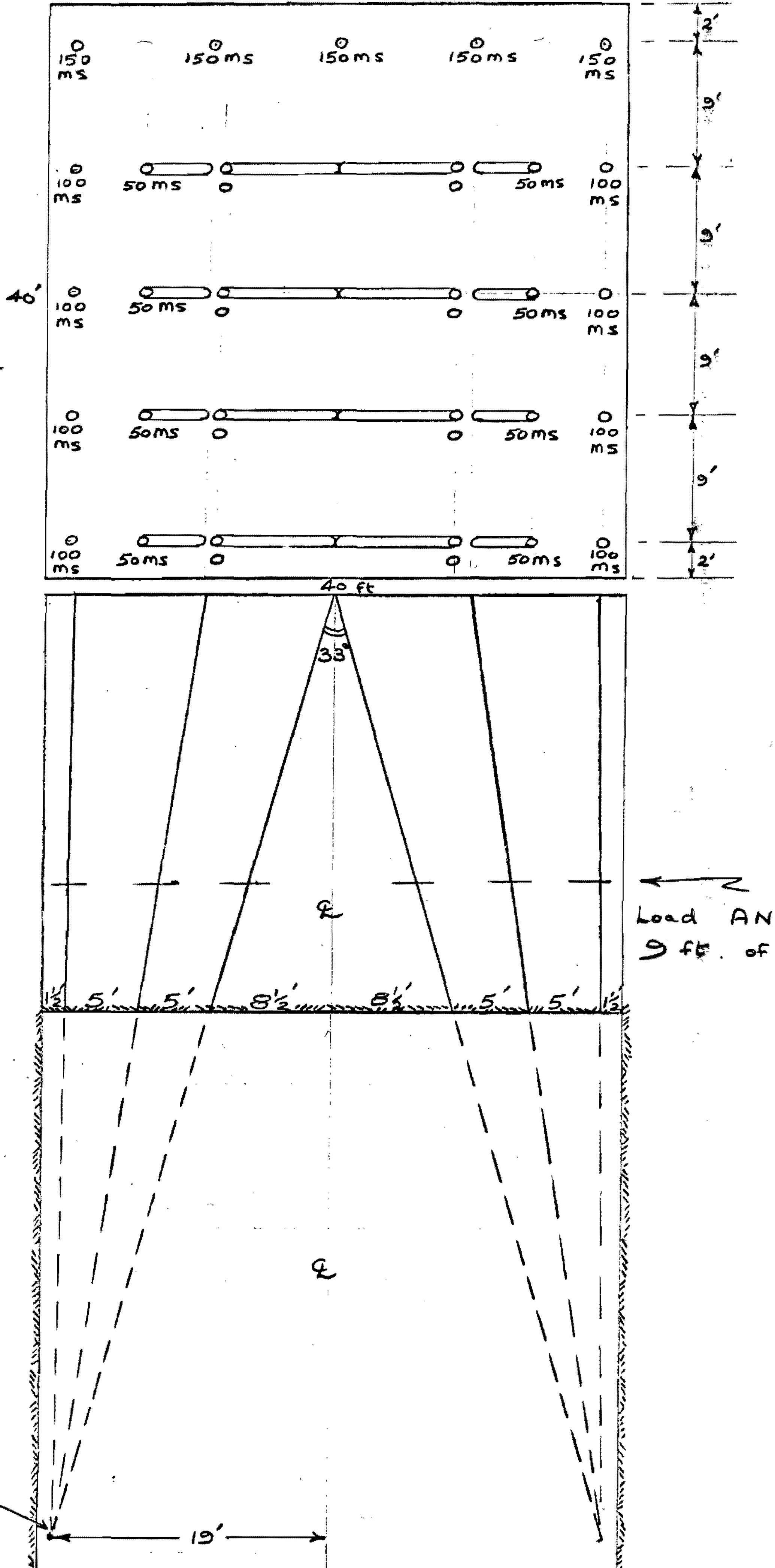
3 Inch Diameter
3 Wing



3 Inch Diameter
4 Wing

Handout 10 -
GRH

ROUND FOR
40 .. 40' FACE
HOLES 3" DIAM.
30 ft LONG.
24 AN.F.O. SACKS
MILLISECOND DELAY
EB CAPS 40' LEADS



Load ANFO to within 9 ft. of collar.

Position of Feed motor

Handout 1 - WSB

RETORT NO. 3 - COST PROJECTION

Project Construction Budget - $725,000

		Stage II Scoping Study 2/28/66 Estimate	Torkelson Company May 1966 Estimate	Projected Cost Final Cost Estimate
1.	Engineering and Construction Supervision	47,000	74,000	120,000
2.	Materials - Equipment	373,000	346,000	406,000
3.	Construction and Construction Supervision	203,000	222,000	310,000
4.	Contingency	51,000	38,000	--
5.	Fee	50,000	45,000	59,000
6.	Total	725,000	725,000	895,000

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Handout 2 - WSB

MAJOR EQUIPMENT ADDITIONS - RETORT NO. 3 RECONSTRUCTION

		Engineering Costs	Installation Costs	Material Costs
Field Decisions				
1.	Apron Feeder Ahead of Primary Crusher	$1,000	$ 5,200	$ 4,800
2.	Secondary Crusher Installation	500	4,500	--
3.	Crusher Plant Motor Control	3,500	11,500	5,300
4.	Interim Wiring Needs In Weigh House to Operate Retort No. 2	1,000	5,500	--
5.	Field Changes and Repairs to Conveyor Systems	--	7,500	--
Process Changes				
1.	Gas Flow Calibrating Equipment Extra Costs	1,000	1,500	4,000
2.	Spare Instruments	--	--	2,000
3.	Spare Rotary Feeder Rotors	--	--	1,500
4.	Test Screw Feeder	500	1,500	2,000
5.	Pressurized Gas Sampling	500	3,000	4,000
6.	New Slusher Versus Second Hand Unit	--	--	4,000
7.	Seals on Recycle Blower and Other Revisions	--	--	2,000
8.	Change Room and Electrical Store Houses	--	2,000	--
9.	Zero Speed Switches	1,000	3,000	1,500
10.	Heat Trace and Insulate Product Line to Refinery Storage. (System found Defective)	1,000	2,000	6,000
11.	100-Ton Bin Revising	--	--	5,000
12.	Rotary Feeders	--	2,000	--
	Totals	$10,000	$46,200	$40,600
	Grand Total		$96,800	

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Handout 3 - WSB

STAGE II - PERSONNEL BUILDUP

Participating Parties	Stage II Final Personnel	Stage I Personnel	Authorized Personnel 11/8/66	Remaining To Be Authorized
Administration	2	3	2	
Technical Staff	21	17	21	
Secretaries	2	1	2	
Total	25	21	25	0
Research Foundation				
Administrative Service	29	23	28	1
Shops	27	19	27	0
Mining	32	10	32	0
Crushing	12	3	12	0
Retorting	16	16	16	0
Analytical	7	6	7	0
Utilities	15	11	15	0
Total	138	88	137	1

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11/2/66