15\06\005-003

MOBIL RESEARCH AND DEVELOPMENT CORPORATION

RESEARCH DEPARTMENT

MONTHLY PROGRESS MEMORANDUM

(Covering August 16 to September 15, 1967)

ANVIL POINTS OIL SHALE RESEARCH CENTER

Rifle, Colorado

September 26, 1967

CONTRIBUTORS:

Mining Section
Mechanical Engineering
Retorting Section
Retort Operability Task Force
Engineering and Economic Analyses
Analytical Laboratory Section

Signed by:

R H Cramer

R. H. Cramer
Program Manager

C. to JCK-WRB

The primary objective of the Anvil Points Oil Shale Research Center MONTHLY PROGRESS MEMORANDUM is to advise authorized personnel employed by the Participating Parties[1] that various activities are in progress or that certain significant data have been obtained within the Research Center.

These MONTHLY PROGRESS MEMORANDA 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. The PROGRESS MEMORANDA have not been edited in detail.

[1] Mobil Research and Development Corporation

Continental Oil Company
Humble Oil and Refining Company
Pan American Petroleum Corporation
Phillips Petroleum Company
Sinclair Research, Inc.

MONTHLY PROGRESS MEMORANDUM

(Covering August 16 to September 15, 1967)

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CONFIDENTIAL

MONTHLY PROGRESS MEMORANDUM
(Covering August 16 to September 15, 1967)

I. ADMINISTRATION

Stage II of the Initial Program was not extended; this decision was announced August 25, 1967. Retort operation was terminated on August 31, when manpower shortages became too severe to continue until the scheduled date of September 6. Stage II mine experimentation was concluded on September 15. Mining is continuing under a separate agreement.

The staff has been sharply reduced. The remaining Participating Parties' personnel are preparing Technical Memoranda and reports. The remaining Research Foundation staff charged to Stage II are engaged in winterizing the plant level facility.

A decision will be made on or before October 1, 1967 as to whether the facility will be retained on a standby basis during a joint engineering appraisal of retorting, or restored and returned to the U. S. Department of Interior.

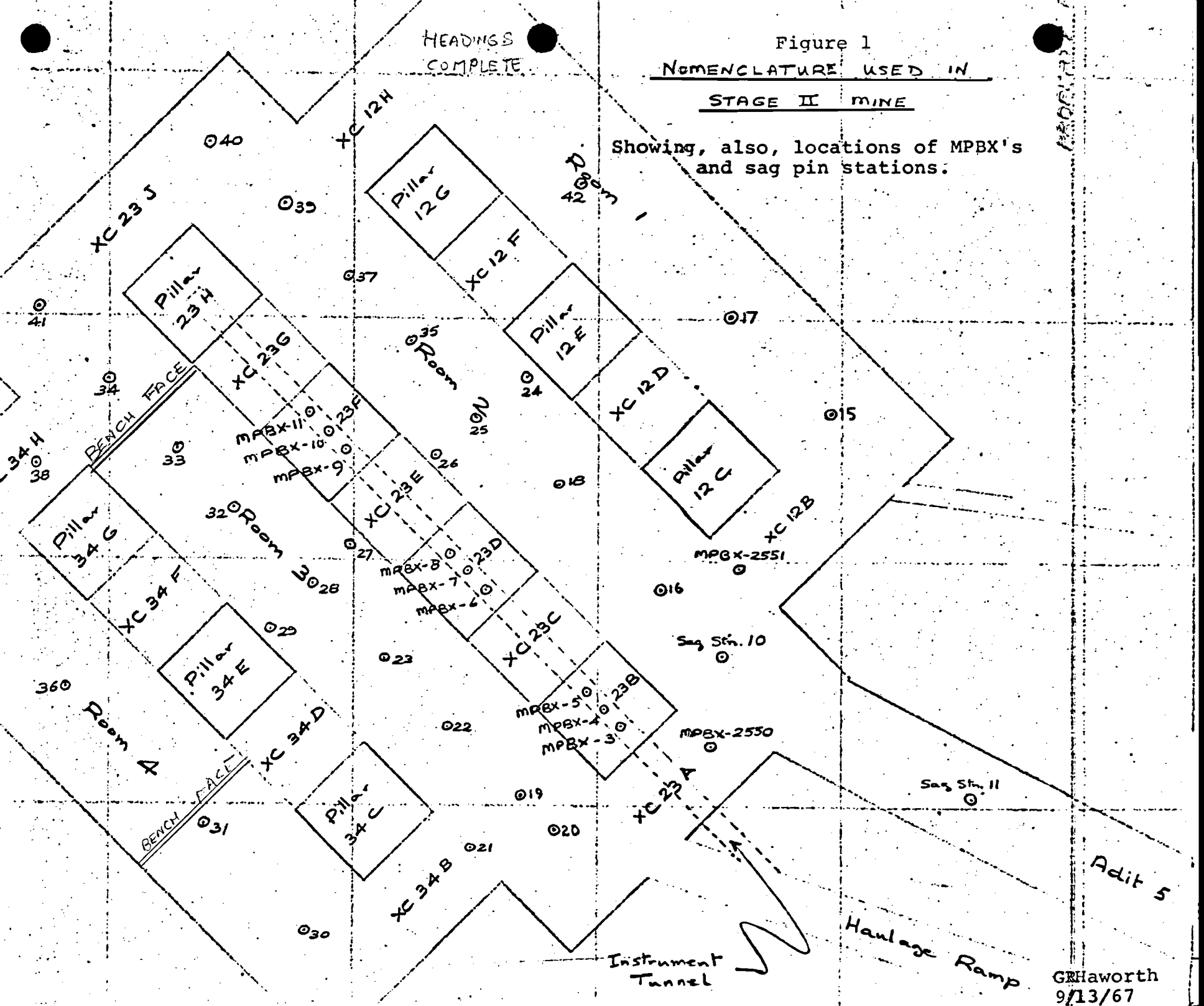
This is the final Monthly Progress Memorandum. It covers the last of the experimentation under current Stage II funding.

Figure 1

NOMENCLATURE USED IN

STAGE II MINE

Showing, also, locations of MPBX's and sag pin stations.



GRHaworth
9/13/67

II. MINING SECTION (G. R. Haworth, J. B. Sellers and F. W. Brackebusch)

A. Mining Production (J. B. Sellers)

1. Progress

During the period, two more heading rounds were taken from Room 1 and Crosscut 12H was blasted. The headings are now 100% completed. Two blasts in Room 4 have advanced the bench another 50 feet. (See Figure 1).

The mining has been held up for a period of three weeks while the pillar walls in the mining area have been scaled. Also the southeast face of Pillar 34C, the northwest face of Pillar 12H and the southwest corner of Pillar 23B have been bolted and strapped together to prevent further spalling. Six foot bolts and eight foot bolts were used for this purpose, and light steel straps. The bolts were placed on approximately 8 foot centers. The steel straps form continuous horizontal hoops around the ends of the Pillars 23 H and 34L. The remaining overhang on the southwest corner of Pillar 23B was blasted off and the corner was then bolted and strapped. Much of this work was delayed by nonavailability of the new aerial platform from which the holes were drilled and bolts set by mounting the roof-bolt drill horizontally.

The two heading rounds in Room 1 were both designed to improve the solidity of the pillar walls. It has become apparent that much of the scaling difficulties encountered during the benching operation is caused by prior damages to the heading walls due to the heavy blasting of the 4-inch diameter holes. Therefore two experiments were conducted to investigate the effects of having more holes in the rib row of the heading rounds and the effect of loading these holes lightly. In the first round nine (instead of five) ribholes, 4 inches in diameter were loaded with 2-inch diameter stick powder. In the second round the ribholes were loaded with salt ANFO. In both cases the resulting rib while not being much smoother was considerably less shattered and required less scaling.

The Crosscut 12H was loaded from Room 1 side only. The idea was to create the crosscut in two blasts so as to reduce the damage to the pillar corners. Furthermore, the ribholes were loaded with salt ANFO. Despite these measures, the crosscut blew out in its entirety. The calculated powder factor was a mere 0.33. Several large boulders were formed which required secondary blasting. The damage to the pillar corners was quite light but as in previous cases, the corners were controlled by north-south and east-west oriented joint planes.

The bench blasting was delayed by the scaling and pillar bolting previously described. It has also been delayed by a program which has been commenced to measure the shock wave intensity at various locations around the bench blasts. Special emphasis is being placed on the effect of bench blasts in Room 4 on the pillar wall in Room 3. A series of experiments are planned to determine the least damaging blast configuration on this pillar wall.

The first bench blast in Room 4 was designed primarily to protect the southwest corner of Pillar 34C and to test out the equipment for measuring the blasting intensity.

Two rows of holes were shot, but the ribhole and the hole next to it on the Room 3 side were not shot. The ribholes were shot later after the preceding round had been mucked out. This ensured that there was plenty of relief on the ribholes and that the blast would be directed sideways into Room 4 rather than in the opposite direction into Pillar 34C.

The blasting was successful and the pillar damage was slight. These first two blasts established a clean face in Room 4 which was sufficiently far from the pillar corner to permit a full row of holes to be blasted and for the blasting experiments to begin in earnest.

2. Equipment Availability

Most items of equipment have performed satisfactorily during the period. The exception is the new aerial platform. While pulling out of the ramp, the engine stalled and then the truck ran backwards, turning the engine in the reverse direction. This resulted in several bent connecting rods. The truck was out of commission for one week although it was run intermittently on electric power after being towed into place.

3. Condition of the Roof in the Mining Area

Figure 1 shows the locations of the various sag rod stations. Roof conditions during the period are summarized in Figures 2 and 3 which show the movements at the two horizons of concern.

a. 0 to 5 Foot Horizon

In general, there has been little or no movement in this zone during the period. Only two areas have shown abnormally large movements. One is at Station 42 in Room 1. This station has been affected to some degree by mining in Room 1. The second area is around Station 32 in Room 3.

Showing sagging in 0 to 5 foot zone above roof in mining area.
First number is absolute sag in thousandths of an inch
Number in parenthesis is movement during period August 15 to September 15, 1967.

\+ Indicates parting opening.
\- Indicates parting closing.

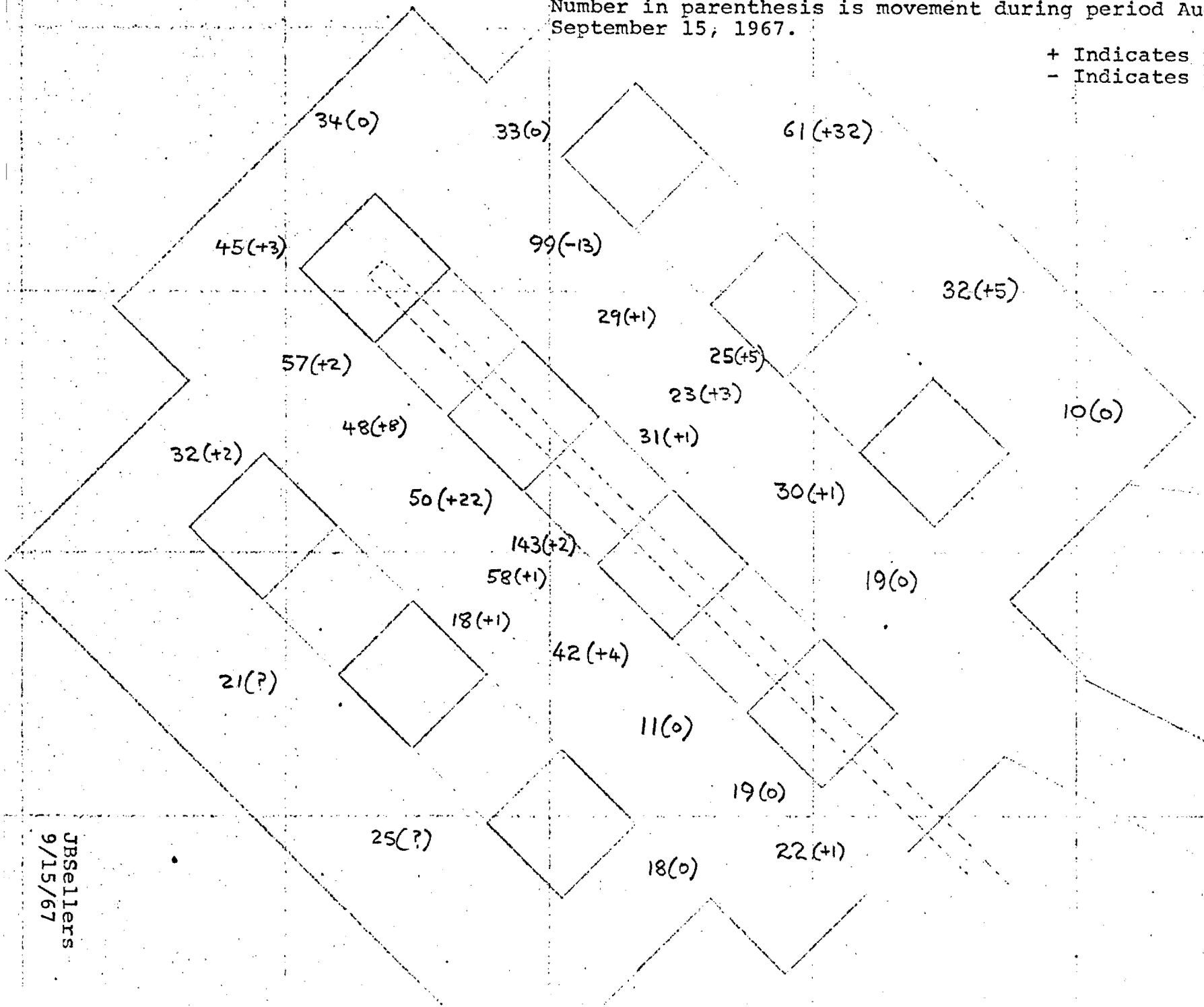


FIGURE 2

JBSellers
9/15/67

Showing sagging in 5 to 15 foot zone above roof in mining area.
First number is absolute sag in thousandths of an inch.
Number in parenthesis is movement during period August 15 to September 15.

\+ Indicates partings opening.
\- Indicates partings closing.

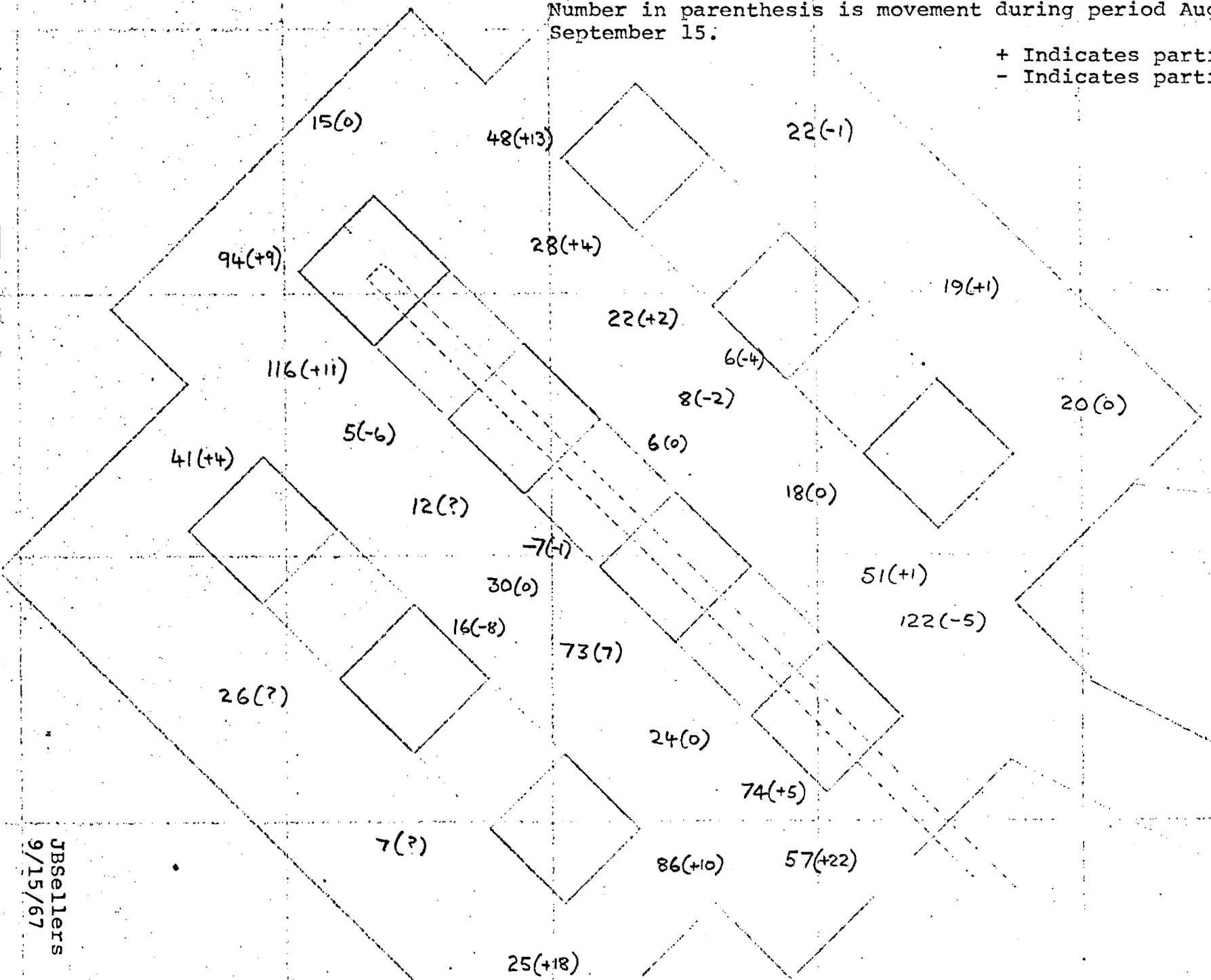


FIGURE 3

JBSellers
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At Station 37 in Room 2 the partings in the roof continue to close under the influence of the extra short bolts installed during early August.

b. 5 to 15 Foot Horizon

Movements in this zone have generally been small. When Crosscut 12H was created, a sag of 0.013 inch occurred at Station 39. Some sagging was also noted at Station 30 in Room 4 which has been affected by benching in Room 4 and by the removal of the southwest corner of Pillar 34C. Areas of concern are at Station 20 where the ramp enters Room 3 and at the northwest end of Room 3 at Station 34 and 41 where sagging continues at a steady rate of about 0.0003 inch per day.

B. Drilling and Blasting Research (F. W. Brackebusch)

1. Measurements of Blasting Vibrations

Rib pillar spalling depends upon several factors. The extent of the fracture system on the surface of a wall is a function of joint planes (number and orientation), bedding planes, and the distribution of explosive in the ribholes when the opening was created. Subsequent to the formation of the fracture system on the surface of a wall, blasting vibrations from adjacent rooms or stress increases in the pillar may cause material to be loosened on the surface of the pillar. This loosening of rocks then poses a tremendous scaling problem in order to maintain safety to personnel.

Perhaps the best way to approach the scaling problem is to control the extent of a fracture system formed on the wall of an opening when the opening is created. It is known that if the same explosive is detonated in boreholes of differing diameters, the larger borehole will have the more extensive fracture system around it. Also the fracture system formed by a large borehole may be equal in extent to the fracture system formed by a small borehole, if the detonation pressures in the former are kept lower than the pressures in the latter. Therefore, considering the above facts, two methods are available for controlling the fracture system in the ribs. The first method is to use more, smaller diameter ribholes, and the second method is to use the standard number (5) of 4-inch ribholes with a lower strength explosive such as salt formula ANFO.

The first method was employed in driving the last 40 feet of the Room 1 heading. It was deemed impractical to drill

the smaller holes with the heading drill, therefore nine 4-inch ribholes were drilled on each rib. For Round A-85 the ribholes were string loaded with 2 X 8 inch dynamite. For Round A-86 the ribholes were loaded with salt formula ANFO plus one 16-foot 1 5/8 X 1 5/8 inch wood stick per hole. (See Figure 4). The attempt for Rounds A-85 and A-86 was to obtain the effect of a larger number of smaller ribholes. The ribholes were detonated near last in the ignition sequence, thus defining the method as smoothwall blasting. While not improving the general appearance of the ribs, scaling time and effort was reduced for both rounds, an indication that the rib fracture system was less extensive than normal.

Because the headings had already been driven at the Anvil Points Mine when the scaling problem was recognized, it was decided to study the effect of blast vibrations on the rib surface fracture system that already existed. A consulting firm, Wiss, Janney and Elstner, was hired to study vibrations on the southwest rib of Room 3 caused by benching blasts in Room 4. In preliminary tests it was determined that velocity transducers would measure the frequency and amplitude of vibrations likely to be produced by bench blasts. Because the vibration energy is highest opposite the blast, one transducer is located there, and other transducers are located at various heights along the rib pillar in Room 3. The distance between the transducers and the bench holes blasted is surveyed accurately.

Initial results emphasize the importance of the distance between the blast holes of Room 4 and the southwest rib surface of Room 3. The energy of the vibrations falls off rapidly with distance. The mass of the explosive charge detonated at one time also is important to the energy of vibration. The maximum velocity of particle vibrations on the southwest rib of Room 3 has been 2 to 3 feet per second. A program has been formed in which hole diameter, burden, detonation sequence and explosive type are varied and resulting vibrations measured. It is hoped that a certain combination of these variables will produce the least vibration but still maintain good blasting results.

The connection of Rooms 1 and 2 through Crosscut 12H was completed during this period. A 20-foot round was drilled from both the Room 1 and Room 2 side of the crosscut as was done when removing Crosscut 23J. In order to limit the rounding of corners of Pillar 12G the ribholes were loaded with salt formula ANFO. Only the 20-foot round from Room 1 was loaded and blasted. The surprising result was that the entire crosscut was removed by the blast. The corners of Pillar 12G were rounded because of the presence of east-west and north-south joints in the pillar,

but the pillar rock was neither shattered nor cracked. Apparently, the reasons the entire crosscut was removed by the blast were:

1. In driving the last 40 feet of Room 1 the left rib was permitted to widen out to the left consuming part of the Crosscut 12H. Thus the northwest side of the crosscut was only 30 feet thick.

2. Six boreholes from the round on the Room 1 side intersected boreholes from the round on the Room 2 side. These six boreholes were loaded to a depth of 30 to 35 feet. Probably nearly two-thirds of the rock in the crosscut was intimate to explosives; therefore with the free face existing on the Room 2 side the breakthrough is understandable.

C. Pillar Research (J. B. Sellers)

1. Pillar Convergence

Readings from the MPBX's in the instrument tunnel have been taken at frequent intervals during the period. No movement of the pillars have been detected. This is because the pillars are remote from what little mining has been done during the period. It may be concluded that the pillars are stable, that they are not deforming plastically and that the spalling of the pillars is purely a surface feature.

2. Overcoring Tests

An overcoring test was performed in Pillar 23F to measure inherent ground stresses. Photoelastic gauges were used, and the following results were obtained.

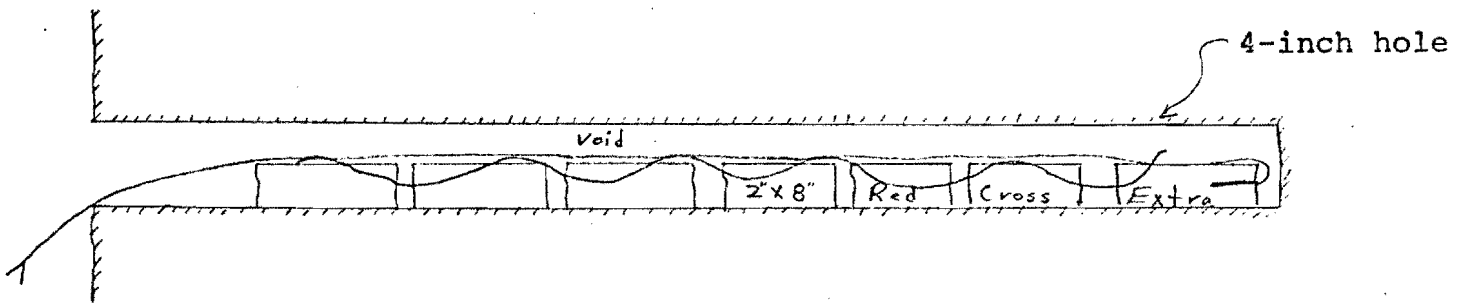
Distance From Pillar Wall	Measured Fringe Order	Calculated Stress psi
4 feet	2.36	950
6 feet	2.66	1070
8 feet 9 inches	2.85	1150
10 feet 9 inches	2.30	930
13 feet	3.00	1210
14 feet	2.54 (poor bond)	1020
15 feet 4 inches	3.00	1210
18 feet	2.64 (poor bond)	1060

Stresses are calculated from the observed fringe order by the formula.

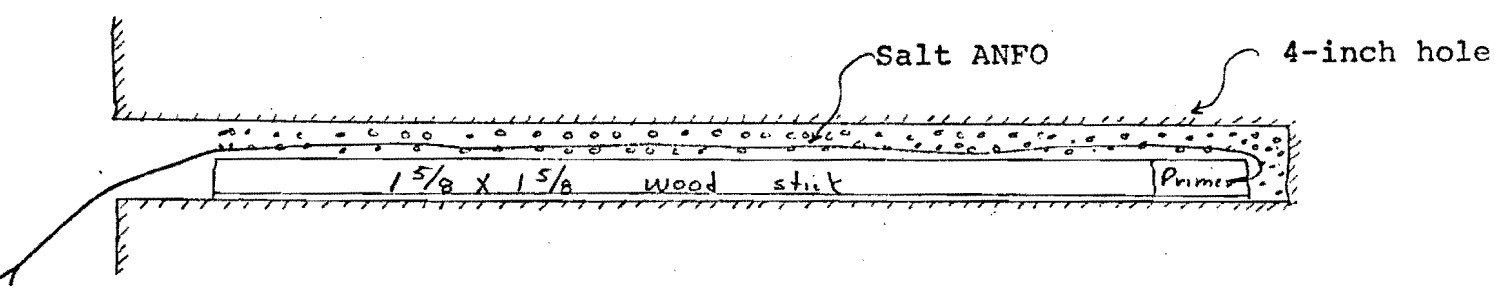
FIGURE 4

LOADING METHODS - SMOOTHWALL BLASTING

Round A-85



Round A-86



FWBrackebusch
9/15/67

$$P = \frac{E}{(1-\mu^2)} \times \frac{S}{K} \times \text{fringe order}$$

Where: E = Youngs Modulus = 1.25×10^6
μ = Poisson's Ratio = 0.30
S = Sensitivity of photoelastic gauge = 440 microstrains per fringe
K = Stress concentration at the back of the borehole = 1.5
P = Rock stress in psi
i.e. = P = 403 X fringe order

The Youngs Modulus was calculated from charts of Youngs Modulus versus specific gravity. The specific gravity of the core was measured and found to be equal to 2.1.

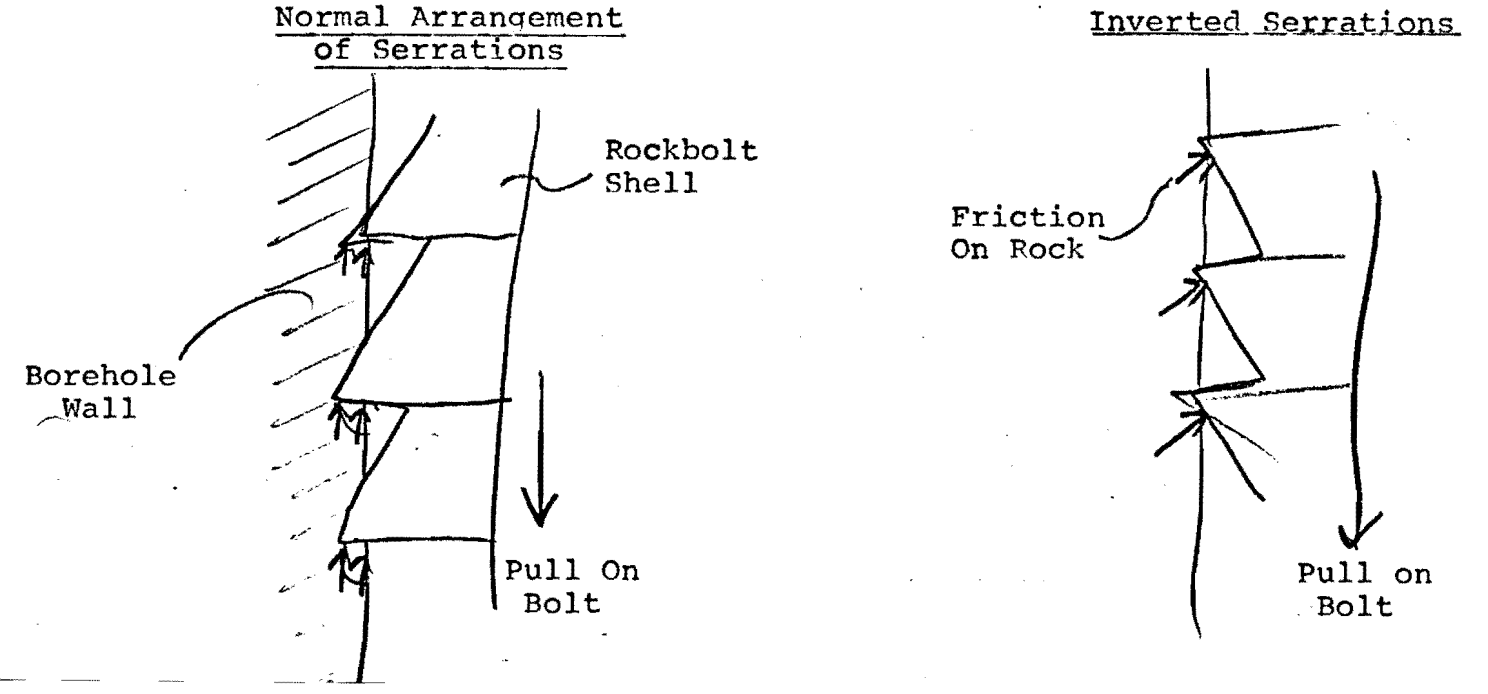
The stresses in the pillar measured in this way were somewhat lower than expected.

D. Physical Property Tests

The oil content of the test specimens has been checked by Fischer Assay. The relationship between Youngs Modulus and Fischer Assay is shown graphically in Figure 5, 6, and 7. Points on the curve are taken from elastic property tests and compressive strength tests. Those points from tests designed specifically to measure Youngs Modulus are shown as crosses. A very good correlation has been obtained with little scatter.

E. Rockbolt Pull Tests

A new type of expanding rockbolt shell was tested during the period. In all normal rockbolt shells serrations are present which are designed to bite into the walls of the borehole when the shell is tightened up. Normally, the teeth of the serration point downwards. The teeth on the rockbolt shell tested recently pointed upwards. The sketch below shows the different holding action of the shells.



It can be seen that the normal arrangement could impose high stresses at the tips of the teeth and cause the rock to fail in shear. With inverted serrations there is a wedging action and the pull on the bolt is resisted by compressive stresses in the rock, with less tendency for the rock to fail in shear around the tips of the teeth.

The results of the test are shown in Table 3[1]. Figure 8 shows the results plotted. Comparison with the results taken from tests on the normally serrated bolts (see Monthly Progress Memorandum, June 1966) shows that once again an excellent anchor was obtained. There is no significant difference in anchorage obtained with the type of serration tested here as compared with the anchorage obtained with a normal type shell.

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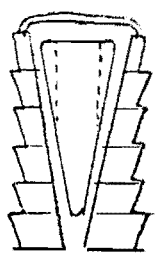
[1] Tables 1 and 2 have been deleted from this memorandum.

TABLE 3

ROCKBOLT PULL TEST, SEPTEMBER 8, 1967. PATTIN ROCKBOLT SHELL INVERTED SERRATIONS
72 X 3/4 Inch Diameter CF & I Expansion Shell Type Rockbolts Anchored in 1 3/8 Inch Diameter Holes

TYPE SHELL	INSTALLATION TORQUE FT LBS	Dial Gage Reading in inches at Indicated Bolt Load (Tons)														TOTAL MOVEMENT in 18,000 lbs inches.	REMARKS
		0	1	2	2½	3	4	5	6	7	8	9	10	11	12		
PATTIN	200	0.063			0.069		0.074	0.080	0.088	0.104	0.166	0.226	0.303		½"	0.163	
INVERTED	200	0.076			0.077		0.084	0.090	0.097	0.104	0.131	0.175	0.218	¼"	5/16"	0.099	pulling at 12 tons
SERRATIONS	150	0.068			0.076		0.087	0.094	0.101	0.121	0.175	0.238	0.325	7/16"	12/16"	0.170	
	170	0.085			0.090		0.099	0.106	0.113	0.130	0.179	0.249	0.319			0.164	
		0.264	0.289		0.320		0.333	0.348	0.363		←		0.419			0.264	Load Held for 5 minutes at 10 tons then slackened off slowly
	200	0.034	0.035	0.042		0.056	0.071	0.088	0.102	0.132	0.193	0.306				0.272	bolt slackened off to 20ft lbs before pulling
		0.187	0.205	0.218		0.237	0.249	0.262	0.280	0.296	0.304	←					Load released slowly all readings taken at 30 second intervals.
	170	0.013	0.018	0.030		0.049	0.060	0.075	0.095	0.156	0.259	0.356				0.343	pause 30 seconds between readings
		0.234	0.255	0.267		0.284	0.297	0.312	0.331	0.347	0.356	←					bolt slackened off to 20ft lbs prior to pull test
	150	0.039	0.045	0.058		0.073	0.087	0.114	0.160	0.213	0.266	0.346				0.307	bolt slackened off to 20ft lbs prior to testing
		0.224	0.24	0.254		0.272	0.285	0.298	0.318	0.335	0.346	←					pause 30 seconds between readings.

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9/15/67

FIGURE 5

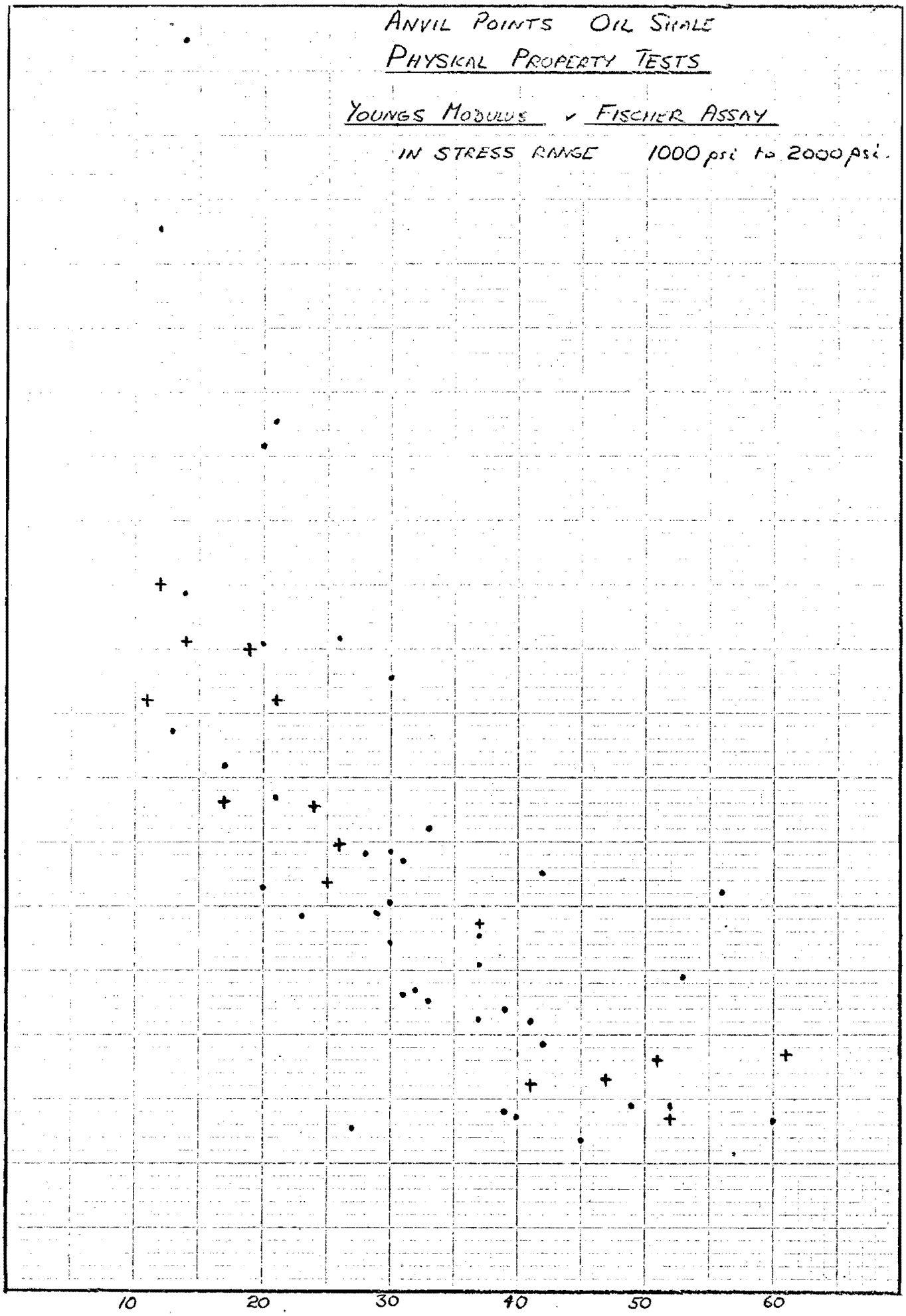
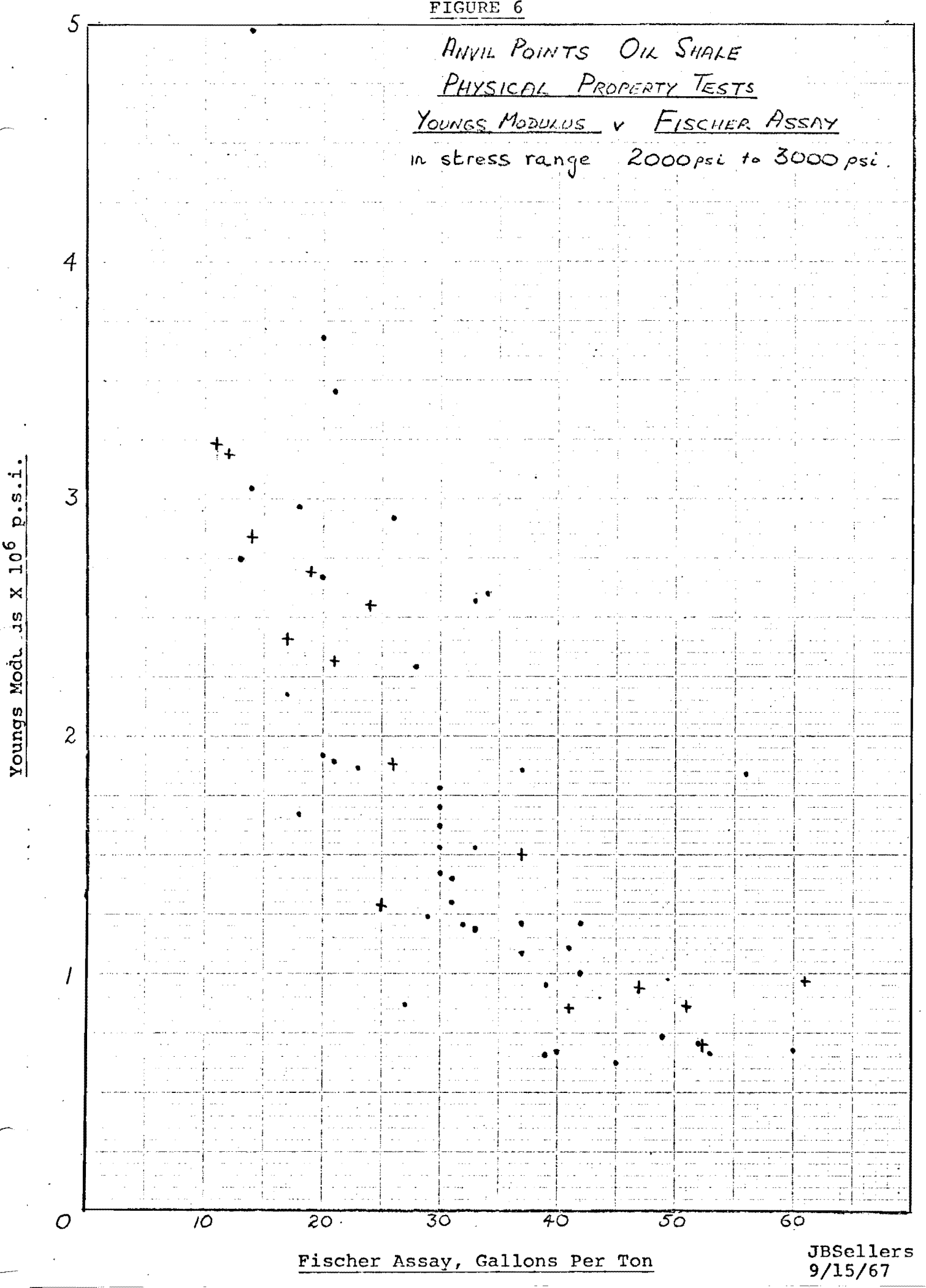

ANVIL POINTS OIL SHALE
PHYSICAL PROPERTY TESTS
YOUNGS MODULUS v FISCHER ASSAY
IN STRESS RANGE 1000 psi to 2000 psi.
Youngs Mod as x 10⁶ p.s.i.
4
3
2
1
0
10
20
30
40
50
60
Fischer Assay, Gallons Per Ton
JBSellers
9/15/67

FIGURE 6



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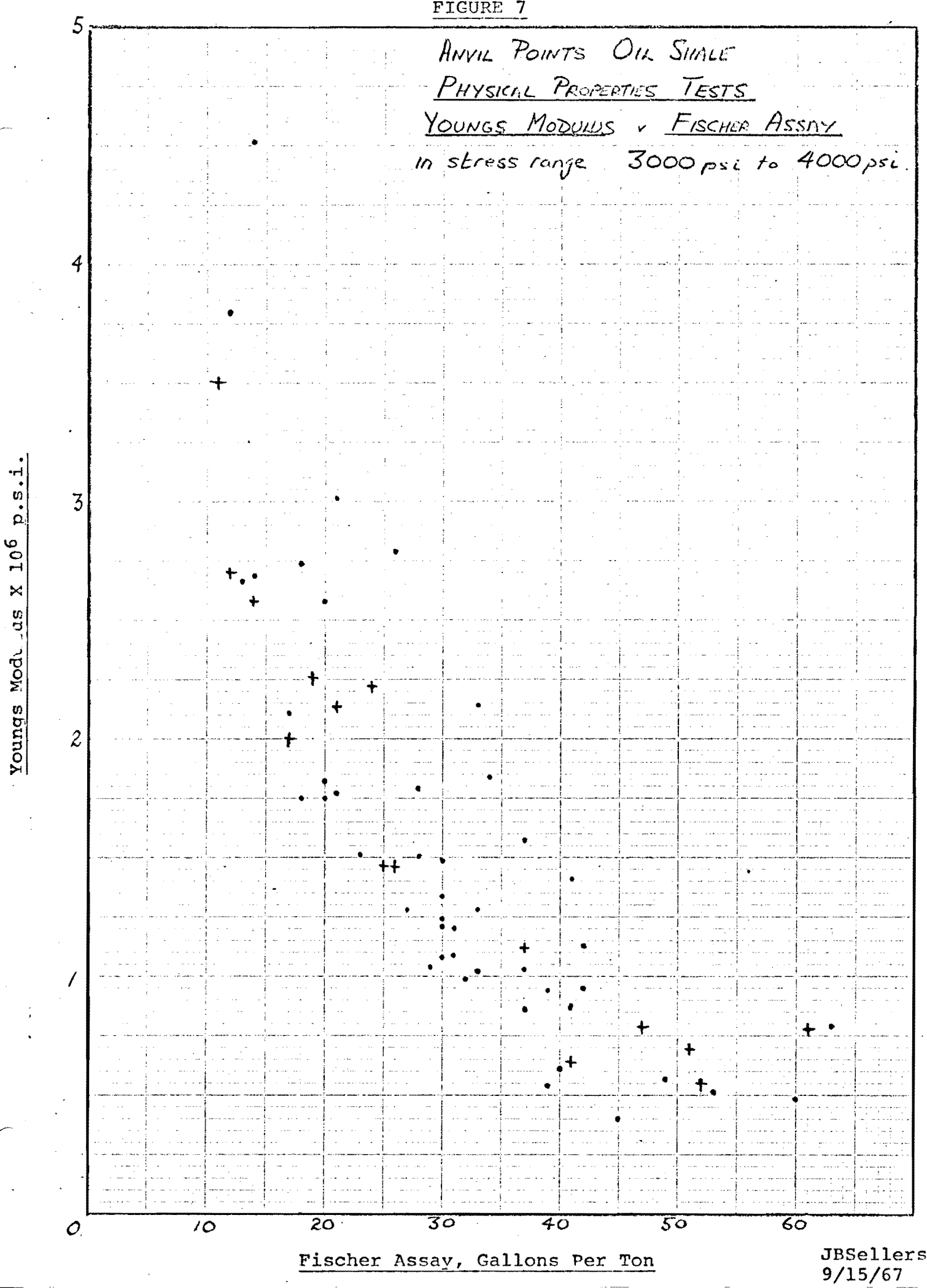
9/15/67

FIGURE 7



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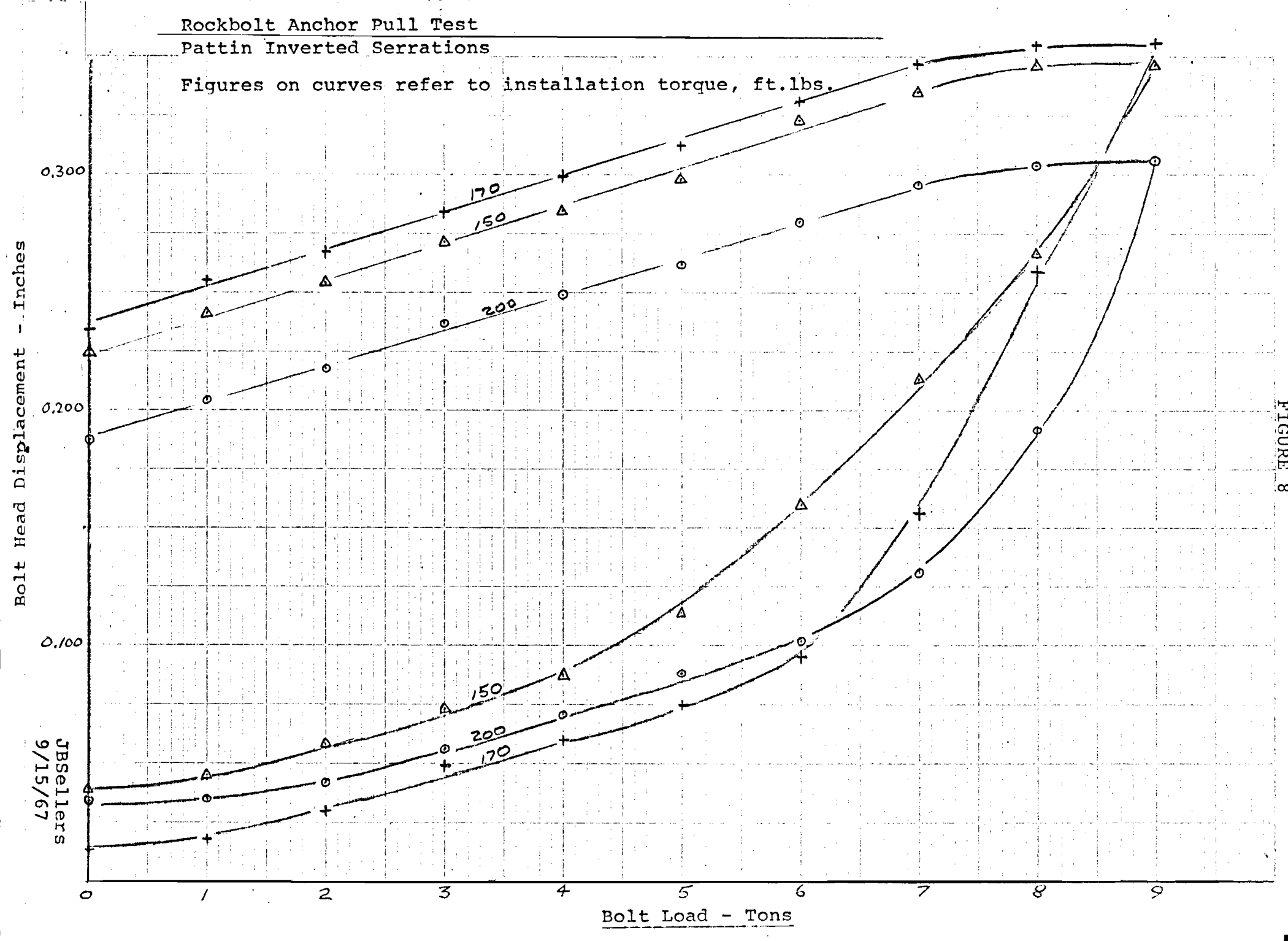

Rockbolt Anchor Pull Test
Pattin Inverted Serrations
Figures on curves refer to installation torque, ft.lbs.
Bolt Head Displacement - Inches
0.300
0.200
0.100
170
150
200
150
200
170
0
1
2
3
4
5
6
7
8
9
Bolt Load - Tons
JBSellers
9/15/67

FIGURE 8

III. MECHANICAL ENGINEERING (W. S. Bergen, R. E. Smith, and J. J. McAleer)

Three liquid disengaging configurations were tested in Retort No. 3 operations with 1/4 to 1 inch shale. Following these tests, the retort was shut down, August 31, deactivated, and put into standby condition for future experimentors.

Major modifications incorporated in the liquid disengaging system were:

1. C1056 - Installation of gas re-engagers in the shale bed above the deck. Bed depth below the deck was 38 inches. See Figure 9.

2. C1057 - Removed cyclones and increased retort bed below deck to 44 inches. Installed two valved gas bypasses through deck to be used to control gas flow through the shale chutes. See Figure 10.

3. C1058 - Increased retort bed below deck to 72 inches. Installed 50° pitched hats on shale outlets below deck. Installed two valved gas bypasses through deck to be used as noted above. See Figure 11.

Other modifications included revisions and additions to the liquid drain piping from the deck and cyclones to facilitate their cleaning.

An extensive program is underway to place all retorting, supporting, and plant level facilities in a standby condition. This program will be completed early in October.

Two members of the Mechanical Engineering staff have transferred from Anvil Points: J. J. McAleer on August 25 and R. E. Smith on September 15. Their efforts in behalf of the Program have been appreciated.

A. Discussion

1. Retort No. 3

A series of changes were made to the oil disengaging system in an effort to both better understand the occurrence of liquid in the bed and how to effect its removal.

All tests made in Retort No. 3 were with 1/4 to 1 inch shale and a 54 riser type air distributor configuration.

a. C1056 (Figure 9) - In order to insure effective utilization of the shale bed above the deck by better gas distribution, a gas re-engager system was installed. The outlets from each of the six cyclones

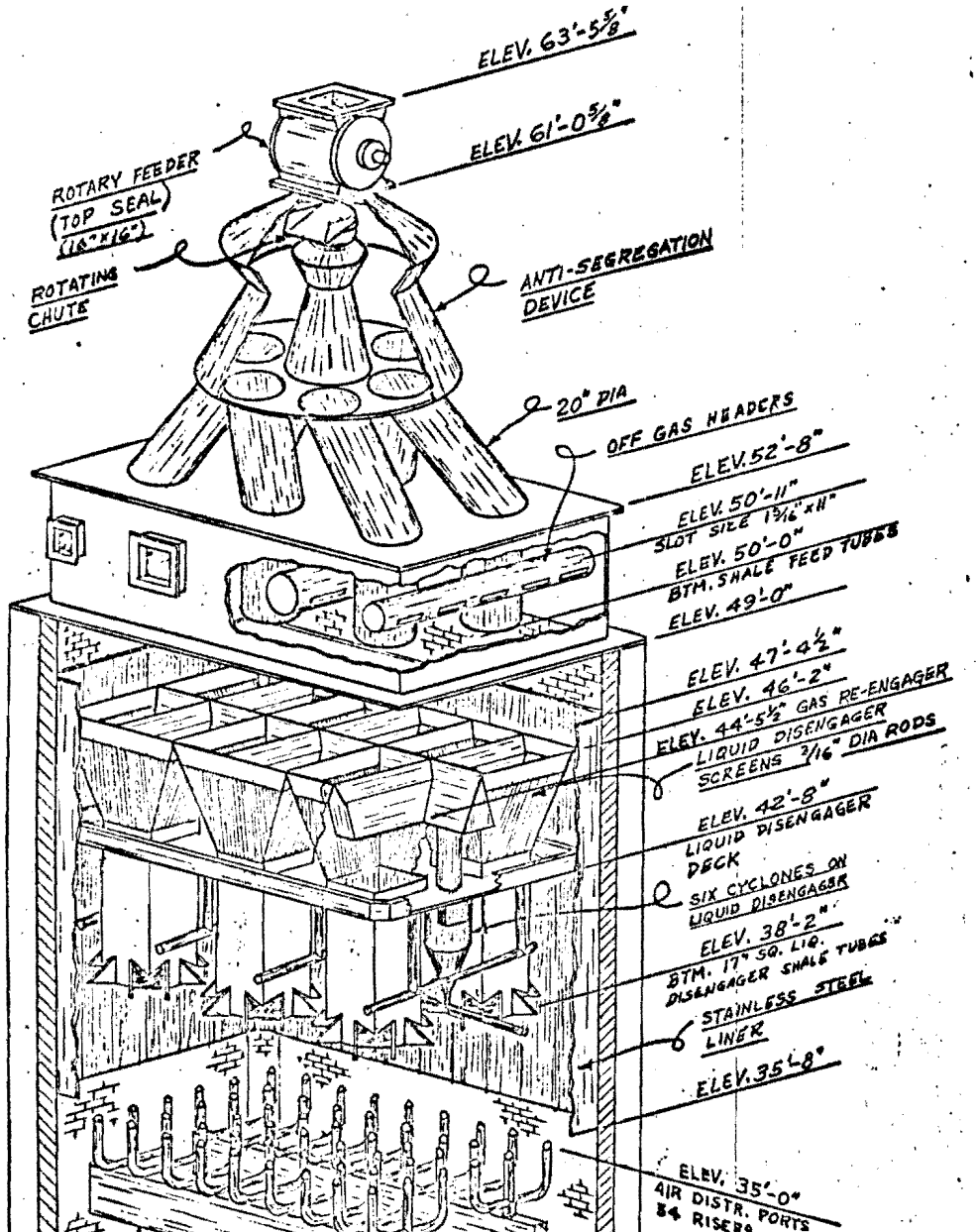
FIGURE 9

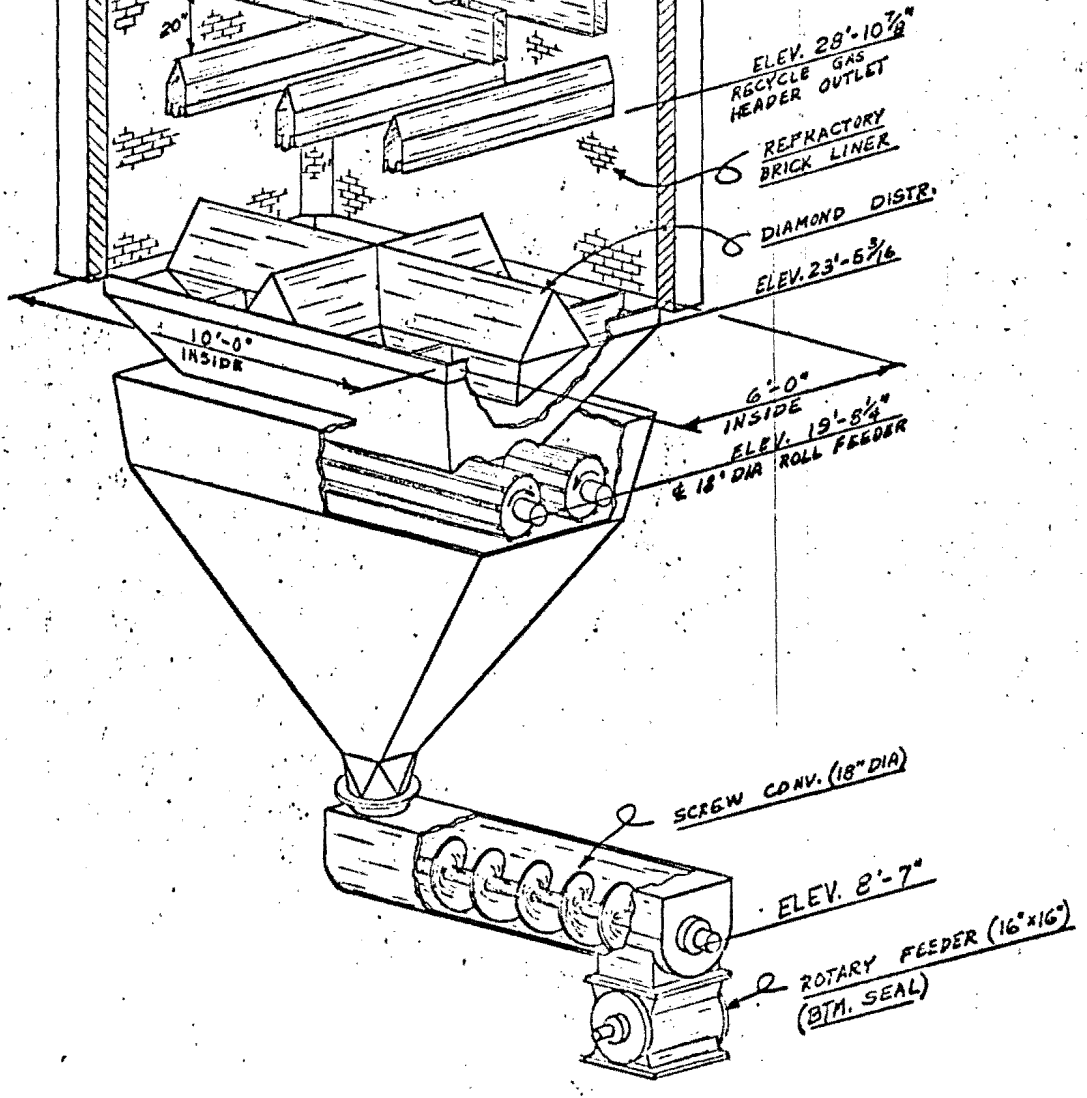
RETORT NO. 3

HARDWARE CONFIGURATION

(AUG. 14, 1967)

C-1056




20"
ELEV. 28'-10 7/8"
RECYCLE GAS HEADER OUTLET
REFRACTORY BRICK LINER
DIAMOND DISTR.
ELEV. 23'-6 3/16
10'-0" INSIDE
6'-0" INSIDE
ELEV. 19'-8 1/4"
@ 18" DIA ROLL FEEDER
SCREW CONV. (18" DIA)
ELEV. 8'-7"
ROTARY FEEDER (16"x16") (BTM. SEAL)

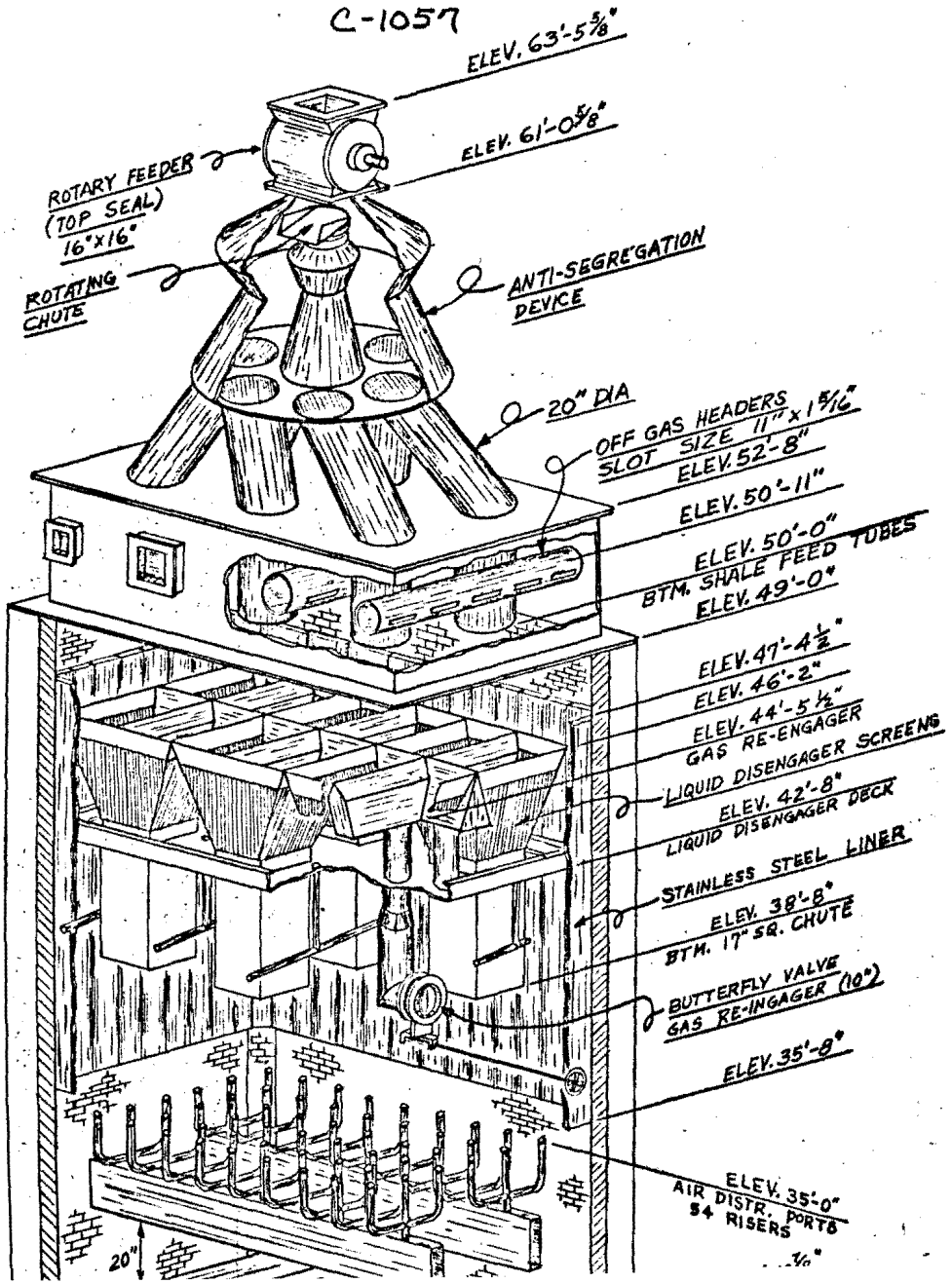
JRH 6/21/67

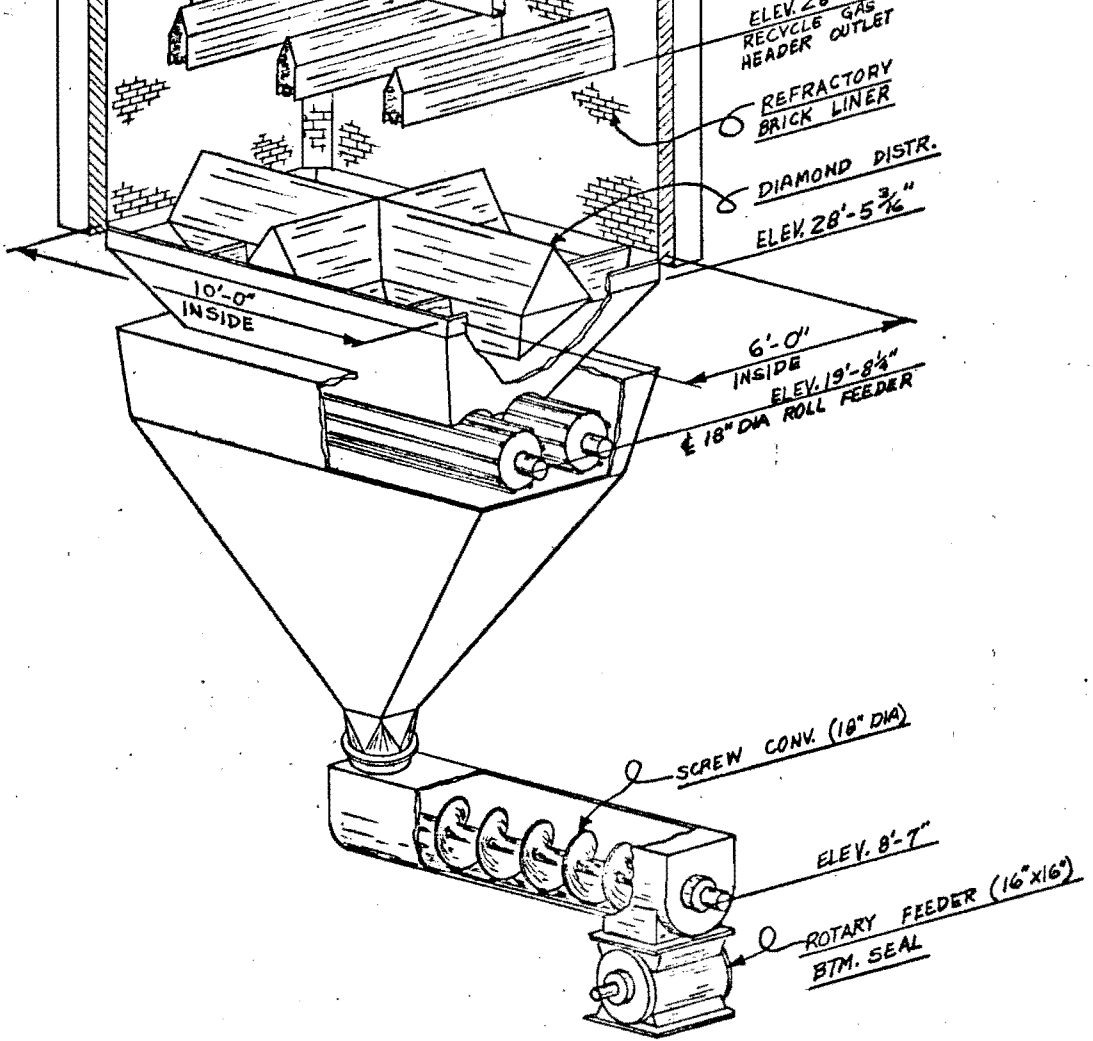
FIGURE 10

RETORT NO. 3
HARDWARE CONFIGURATION

AUGUST 22, 1967

C-1057




ELEV. 28'-
RECYCLE GAS
HEADER OUTLET
REFRACTORY
BRICK LINER
DIAMOND DISTR.
ELEV. 28'-5 3/16"
10'-0"
INSIDE
6'-0"
INSIDE
ELEV. 19'-8¼"
℄ 18" DIA ROLL FEEDER
SCREW CONV. (18" DIA)
ELEV. 8'-7"
ROTARY FEEDER (16"x16")
BTM. SEAL

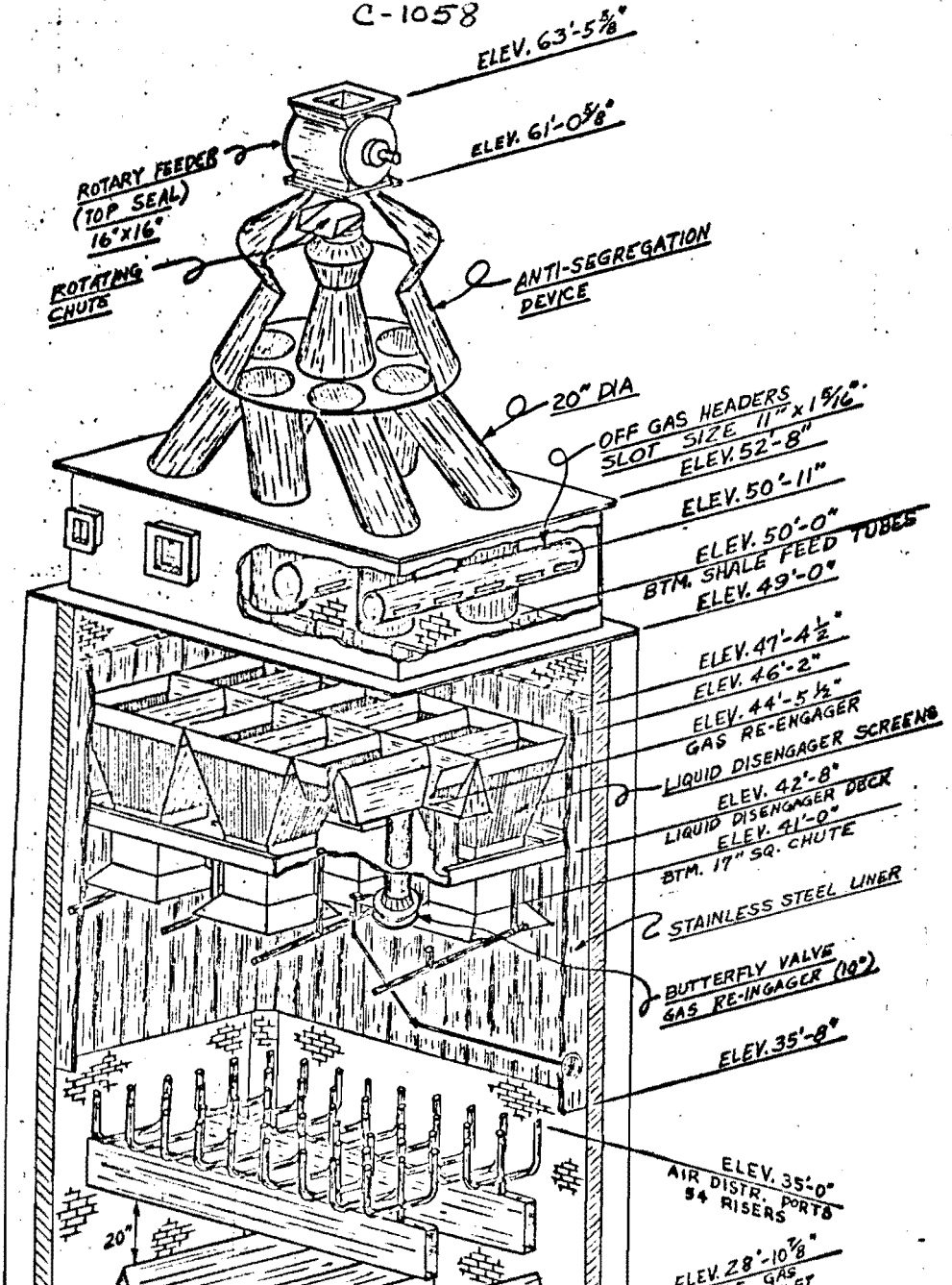
JRH 8/23/67

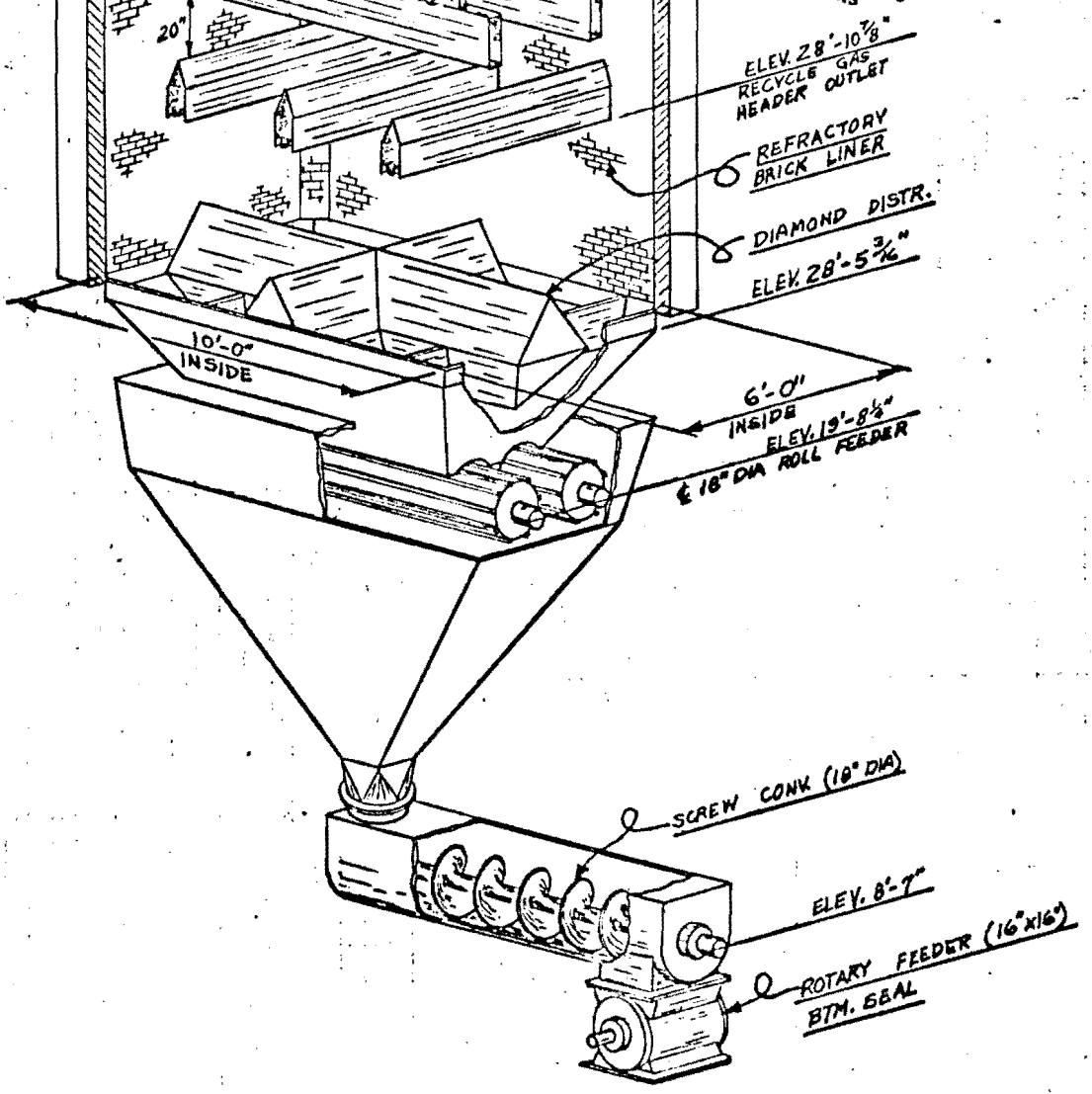
FIGURE 11

RETORT NO. 3
HARDWARE CONFIGURATION

AUGUST 29, 1967

C-1058




20"
ELEV. 28'-10 7/8"
RECYCLE GAS
HEADER OUTLET
REFRACTORY
BRICK LINER
DIAMOND DISTR.
ELEV. 28'-5 3/16"
10'-0"
INSIDE
6'-0"
INSIDE
ELEV. 19'-8 1/2"
℄ 18" DIA ROLL FEEDER
SCREW CONV. (18" DIA)
ELEV. 8'-7"
ROTARY FEEDER (16"X16")
BTM. SEAL

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were welded into a common plenum chamber. Six inverted U channels, one above each of the shale chutes, were opened to the plenum to act as re-engagers. The crows feet installed on the shale chute outlets for test C1055 remained in tact.

b. C1057 (Figure 10) - Revisions to the deck were minimal. The crows feet were cut off the shale chute to prevent shale flow blockages and to bring the retorting zone back to C1053 bed height conditions (44 inches).

All cyclones were cut out from under the deck. Blanks were installed in four and valves, operated from outside of the retort, installed on the other two.

No attempt was made to clean the deck of fines between runs. Drain pipes were cleaned.

c. C1058 (Figure 11) - Shale chutes were cut back to the equivalent of a 72 inch bed height. Confining hat type cones were welded to the bottom of each chute effectively blanking off 66% of the top of the bed. The cone sides were pitched 50° from the horizontal. The reasoning for this "hat" addition at the top of the bed was to insure the flow of any liquid formed in the bed up into the shale chutes and finally into the screens above the deck. Operating gas flows, maintained higher than flooding velocities, were to enforce these conditions.

Valves were relocated on the two active 9 inch deck bypass gas lines for control purposes. They were operated external to the retort.

Deck drain lines had been cleared of shale but the deck was not cleaned between tests C1057 and C1058. Visual inspection and liquid flow tests deemed cleaning as unnecessary.

2. Fouling Problems

Fouling of equipment occurred in several places.

a. Deck - When the deck was operated at temperatures 400 F and higher any residual oil tended to coke. This, combined with shale dust and chips, formed very hard agglomerates. Removal from the deck required chiseling and hammering.

b. Drains - Drains plugged with a deposit described above.

c. Surge Drains - Surge drains accumulated deposits of chips and fines carried to this point. These deposits were not cohesive.

d. Filter Tanks - A 10 mesh screen was used in the filter tanks. These plugged on 8 to 12 hour intervals with chips and fines. This material was not cohesive.

3. Roll Feeder

Slight shifts of the rolls occurred. Steelwork was installed to retain the rolls in a fixed position.

4. Vertical Thermowells

Thermowells were relocated to suit tests' specifications. Drawings exist for thermocouple locations for each test.

5. Recycle Blower

A slight unbalance was noted in the recycle blower. Inspection developed that the main drain was plugged and liquid had remained in several stages. The motor and blower were also realigned. No problems were experienced after these two changes.

6. Turnaround Schedules

Turnaround schedules were longer than anticipated during this period. Workmen were scheduled on 12-hour shifts around the clock. The nature of deposits made their removal very time consuming. Revisions were made in areas both highly constricted and congested with piping and other steelwork.

7. Electrostatic Precipitator

The precipitator was tested using the "tar camera" technique. Precipitator efficiency was better than 99%.

After shutting down the retort, the precipitator was inspected. Deposits on the two lower decks (below the electrodes) were measured. Layers were between 1/8 and 1 inch thick. Electrodes and collecting surfaces were coated with a thin layer of residue. The shell, top redistributor plate, cover plate, and outlet pipe were clean of oil deposits.

B. Deactivation of Facilities

A detailed listing of work to place plant level facilities in standby condition has been formulated. This program went

into effect September 1, 1967. Much of the work was accomplished prior to the reduction in manpower September 8, 1967.

Essentially, all Retort No. 1, 2, and 3 equipment and supporting facilities will be cleaned, oil and greased, and left in operable condition.

All utilities will be deactivated, and water and steam lines drained to a point protected from freezing.

All drawing prints have been gathered and burned.

All equipment external to the retort will be gathered and stored.

Retort No. 1 has been desensitized.

All small plastic models will be stored in the quonset at Retort No. 3.

All broken windows in the crusher, storage bin area, and Retort No. 1, 2, and 3 areas will be repaired.

Finally, buildings not in use will be locked and the grounds cleaned of debris.

C. Mine

Work is currently in progress repairing the shale spillway by Adit No. 4 of the mine. Shale and drain water have under cut the concrete for barrier protecting trucks dumping shale over the cliff. This work was completed September 15, 1967.

IV. RETORTING SECTION (J. E. Lawson)

A. Retort Group (T. C. Lyons, W. M. Broman, R. L. Clampitt, D. P. Cotrupe, J. W. Hasz, R. L. McGalliard and B. L. Reymond

1. Retort No. 3 Operations Summary - Runs C1056 Through C1058 (R. L. Clampitt)

Retort No. 3 was shut down and placed on a standby status the evening of August 31, 1967. On this date retort experimental work was concluded with Run C1058-2. Technical presentations covering the final work in Retort No. 3 have been included in this report.

Since the August Progress Memorandum, three unsuccessful attempts were made to operate Retort No. 3 utilizing variations of the liquid oil removal system. The first attempt, Run C1056 was started up on August 18, charging 1/4 to 1 inch shale at 300 lbs/(hr)(ft^2), gas rates were 5,000 SCF/T air and 12,000 SCF/T recycle. The unit ran, in a ragged fashion, until the morning of August 10 when it was shut down with a clinker on the west side. The primary changes over the previous run were lower gas temperatures leaving the retorting zone and rerouting gas to be engaged in the upper bed through a special distributor rather than through the deck grid.

The first run with the liquid removal system (Run C1053) was also the run, during which the most liquid oil was removed - about 8% of the product. During this run the temperature of the gas leaving the retorting zone below the deck was lower than desired (ca 400 F versus 600 F). It was postulated that during Run C1053 most of the liquid oil was recovered from the cyclone, having been removed from the low temperature gas in droplet form. During Run C1056, gas rates were adjusted to obtain the retorting zone gas exit temperatures achieved in Run C1053. No oil was recovered from either the cyclone or the deck drain system, indicating that this hypothesis was incorrect. Further, operability was adversely affected; therefore, low retorting zone gas exit temperatures do not appear desirable.

The deck grid system was relatively clean, indicating that rerouting the gas to bypass the grids had been beneficial. However, shale chips which had fallen through the grid did accumulate on the deck.

Run C1057 (the second attempt) was started up on August 23, charging 1/4 to 1 inch shale at 300 lbs/(hr)(ft^2). Initial gas rates were 5,000 SCF/T air and 15,000 SCF/T recycle. The internal cyclones were removed prior to this run in

order to maximize gas rates up through the shale chutes. The pressure drop across the deck was held at 14 inches of H_2O and higher in order to insure that no liquid would drain down the shale chutes and into the retorting zone.

During the course of the operation, the recycle rate was increased from 15,000 SCF/T to 18,100 SCF/T. (Air rates were reduced from 5,000 to 4,300 SCF/T.) This was effective in increasing the liquid disengaging temperature from 350 F to 530 F and reducing the oil content of the spent shale from 6 gallons per ton to 2 gallons per ton. However, the rate of total liquid product and the percentage of the liquid product removed from the disengager did not change materially during this period. The amount of liquid removed averaged 8 1/2% during the pretest period and held at this level in the next balance period. After 36 hours of operation, high temperatures were observed in the combustion zone and the unit was shut down shortly thereafter with a large clinker. There was a similar temperature peak early in the startup and there is evidence that a small clinker may have been formed at this time.

A somewhat different approach was used in Run C1058, the final operational effort, to test the liquid oil removal system in Retort No. 3. This technique was to prevent liquid accumulation at the top of the shale bed. (Heretofore, our efforts were directed toward disengaging liquid from intermediate levels in the condensing zone.) This attempt was unsuccessful and the unit was shut down after two days of operation. A very small portion of the total liquid product (roughly 2%) was recovered in the disengaging system.

Run C1058 was started up on August 29 charging 1/4 to 1 inch shale. This run was based on observations made in plastic model studies which indicated that liquid may accumulate in the top of the bed at mass rates in excess of 400 lbs/(hr)(ft^2) and total gas rates of 20,000 SCF/T. Therefore, the retort was modified to obtain a conventional 6 feet of bed above the air distributors. Pyramidal hats were installed at the top of the shale bed to facilitate liquid entrainment into the disengaging system. In addition, the startup was carried out at 400 lbs/(hr)(ft^2) while holding gas rates at a high level (4,500 SCF/T air and 15,700 SCF/T recycle) and an early transition to 500 lbs/(hr)(ft^2) was made. A shale bridge occurred early in the startup and there is evidence that some clinkering resulted at this time. From the outset, the temperatures at the top of the bed ran considerably higher than expected (300 to 400 F compared to the normal 130 to 150 F). Thus, severe gas channeling is indicated which may explain the fact that the oil content of the spent shale ranged from 4 to

Two changes, one process and one mechanical, were made before Run C1056 to improve the performance of the liquid disengagement system. The process change was to start the unit up at 300 mass rate conditions and operate at a low recycle rate (12,000 SCF/T) in order to determine the effect on liquid recovery by lowering the disengagement deck temperature. This would lower the gas temperatures to the 200 to 300 F level where oil was previously recovered in the early stages of Run C1053. Two attempts (Runs C1054 and C1055) to recover oil at higher deck temperatures (400 to 600 F) failed. The mechanical change was to install gas re-distributors at the top of the deck system to insure uniform gas distribution and to bypass the gas around the grids. These changes along with drawings are covered in this report in the Mechanical Engineering section.

Startup process conditions for Run C1056 were:

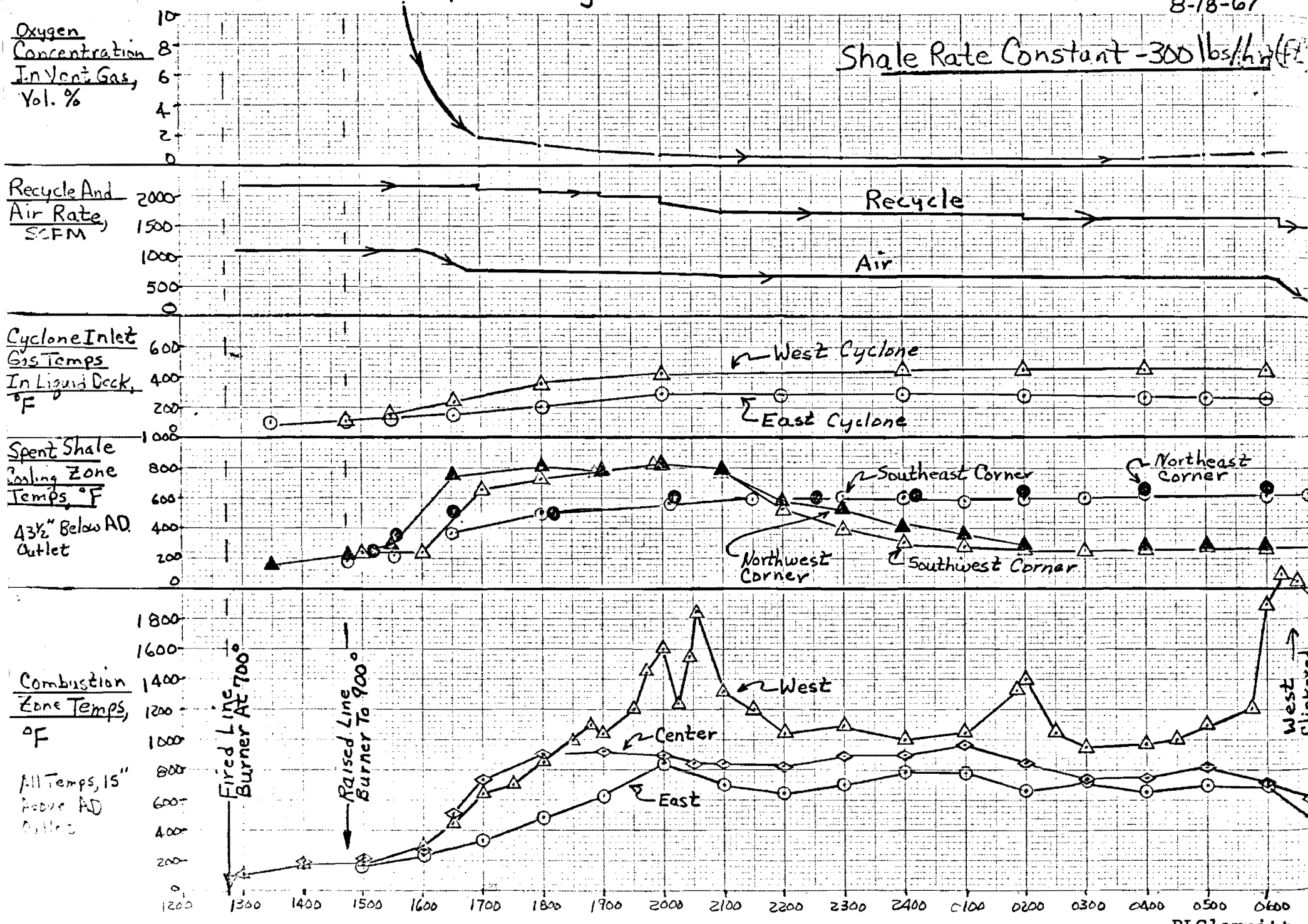
Shale Rate - 300 lbs/(hr)(ft^2)
Air Rate - 7,000 SCF/T - Air equivalent constant oxygen consumption rate used was 5,000 to 5,200 SCF/T.
Recycle Rate - 14,700 SCF/T - Begin lowering recycle rate in steps when O_2 reaches 2.0% in vent gas. Target recycle rate was 12,000 SCF/T.
Total Wash Oil Circulation - 110 gallons per minute
Rate to Cyclones and Disengagement Deck - 25 gallons per minute to Cyclones, 85 gallons per minute to Deck.
Line Burner Outlet Gas Temperature - 700 F First 2 hours 900 F thereafter.

The run began with firing of the line burner at 1245 hours on August 18, 1967. A startup history of pertinent information is shown in Figure 12. The startup was slow but similar to previous runs. At 1930 hours, a shale bridge was experienced on the west side of the retort just above the air distributor. The west combustion zone temperature peaked at 1,850 F before the bridge appeared to break and pass through. However, in reviewing the spent shale cooling zone temperatures at the four corners of the retort (shown in Figure 12), it appears that the retort clinkered between 2100 and 2200 hours. The spent shale temperatures at the northwest and southwest corner cooled off abnormally and remained cold until the unit was shut down. This indicates a static shale zone on the west side of the retort with a high cooling recycle gas to shale ratio. Probably the agglomerate slumped down into the air distributor as indicated by the temperature on the west side, which fell to a normal level at 2100 hours.

FIGURE 12

Startup History - Run C-1056 With ¼ to 1" Shale

8-18-67



RLClampitt
9/15/67

Gas temperatures at the deck cyclones remained skewed (east - cold at 280 F, west - hot at 470 F) throughout the startup.

At 0600 hours on August 19, 1967, 16 hours after firing the line burner, there was a positive indication that the unit was clinkered on the west side. The west combustion zone temperature began to climb rapidly and peaked at 2,100 F. Reductions of air and recycle gas were not effective in lowering the temperatures. The unit was shut down at 0700 hours.

The clinker was on the west end of the retort as was indicated by the temperatures. A diagram of its location is shown in Figure 13. The south center raw shale chute in the disengagement deck was completely full of oily shale. This shale was well packed as a result of a large amount of heavy oil present.

Throughout the startup, efforts were made to evaluate the reason for lack of oil production from the disengagement system. Observations made during the run indicated there might have been some oil being pumped out of the wash system and into the shale bed. At one point during the run (0200 hours) temperatures in the west side of the retort began to rise and an isothermal zone was created. When this happened, the total wash flow (110 gallons per minute) was cut down and the cyclone wash system was cut off. The isothermal zone on the west side immediately developed the normal temperature gradient.

After shutdown, observations also indicated that large amounts of liquid may have been present in the upper sections of the retort. As was mentioned earlier, the south center deck chute was completely plugged with shale because of the large amount of oil present in the chute. The consistency of this mixture was similar to a heavy molasses-shale mixture which tends to flow as one large mass instead of individual particles.

Pertinent laboratory analysis of the raw shale, and the oil flowing through the disengagement deck system are shown in Table 4.

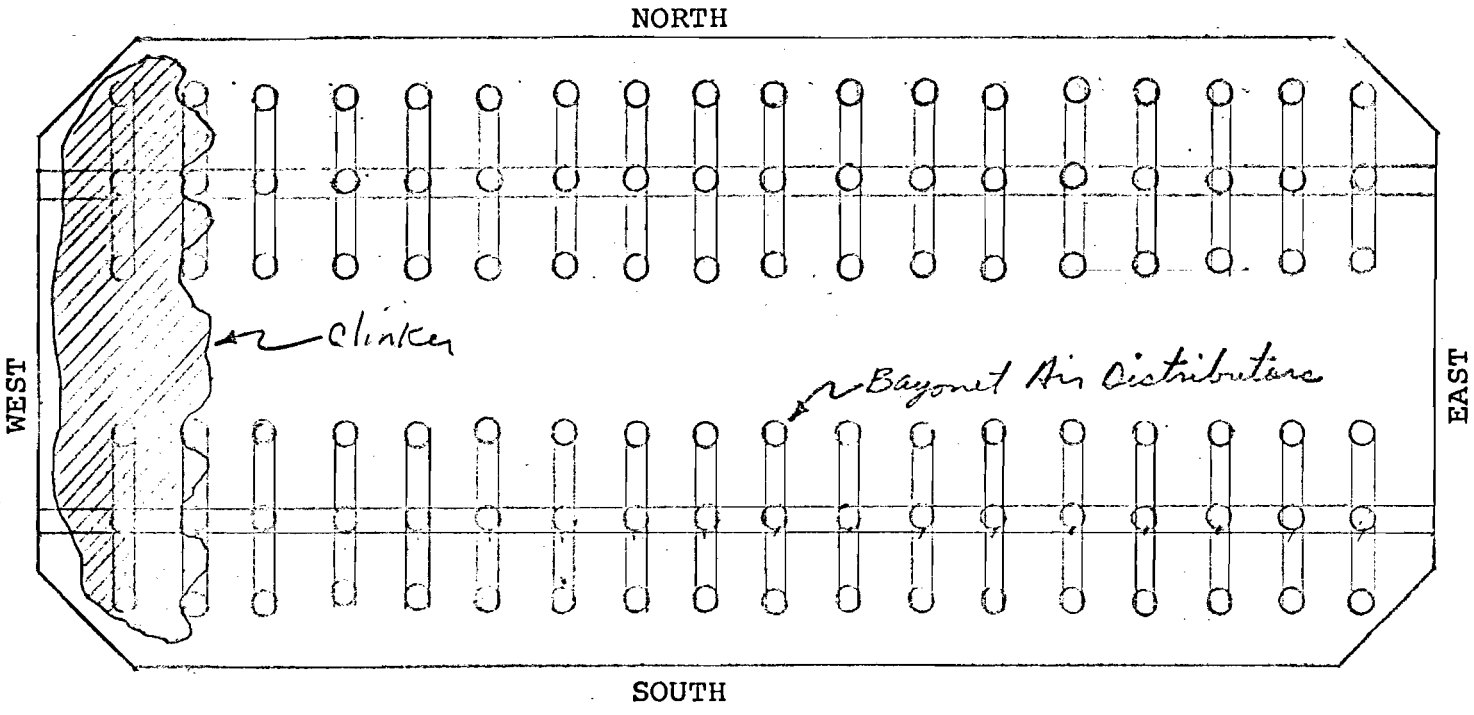
The shale size distribution for the 1/4 to 1 inch shale used in C1056 startup is shown in Figure 14.

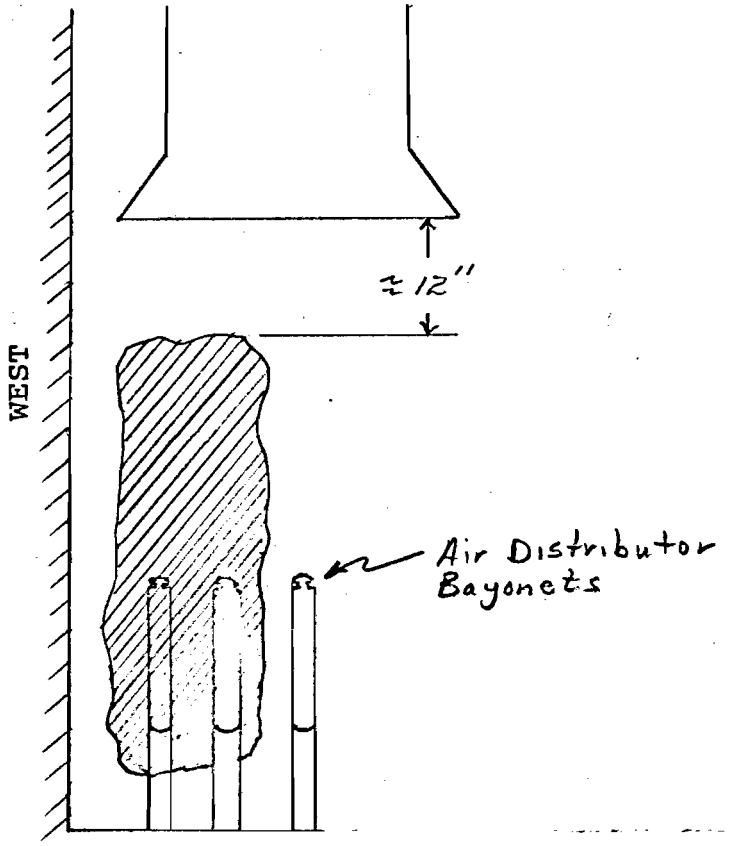
3. Operations History - Run C1057 With 1/4 to 1 Inch Shale

Following Run C1056 with 1/4 to 1 inch shale, several changes were made in the retort hardware configuration. These were:

FIGURE 13

CLINKER LOCATION - RUN C1056 - August 18, 1967





WMBroman
8/20/67

TABLE 4

SIGNIFICANT DATA FROM RUN C1056 - August 18, 1967

Raw Shale Fischer Assay	-	28.2 gallons per ton (SUC1056)
Oil Recovered In Filter Tank		
August 18, 1967 - 2400 hours	-	Gravity - 16.7 °API Ash - 0.40% (Wt)
August 19, 1967 - 0600 hours	-	Gravity - 17.1 °API
Composite Oil Sample from LACT System	-	Gravity - 19.9 °API Water - 8% (Wt)

C1056PT RAW AND SPENT SHALE ANALYSIS

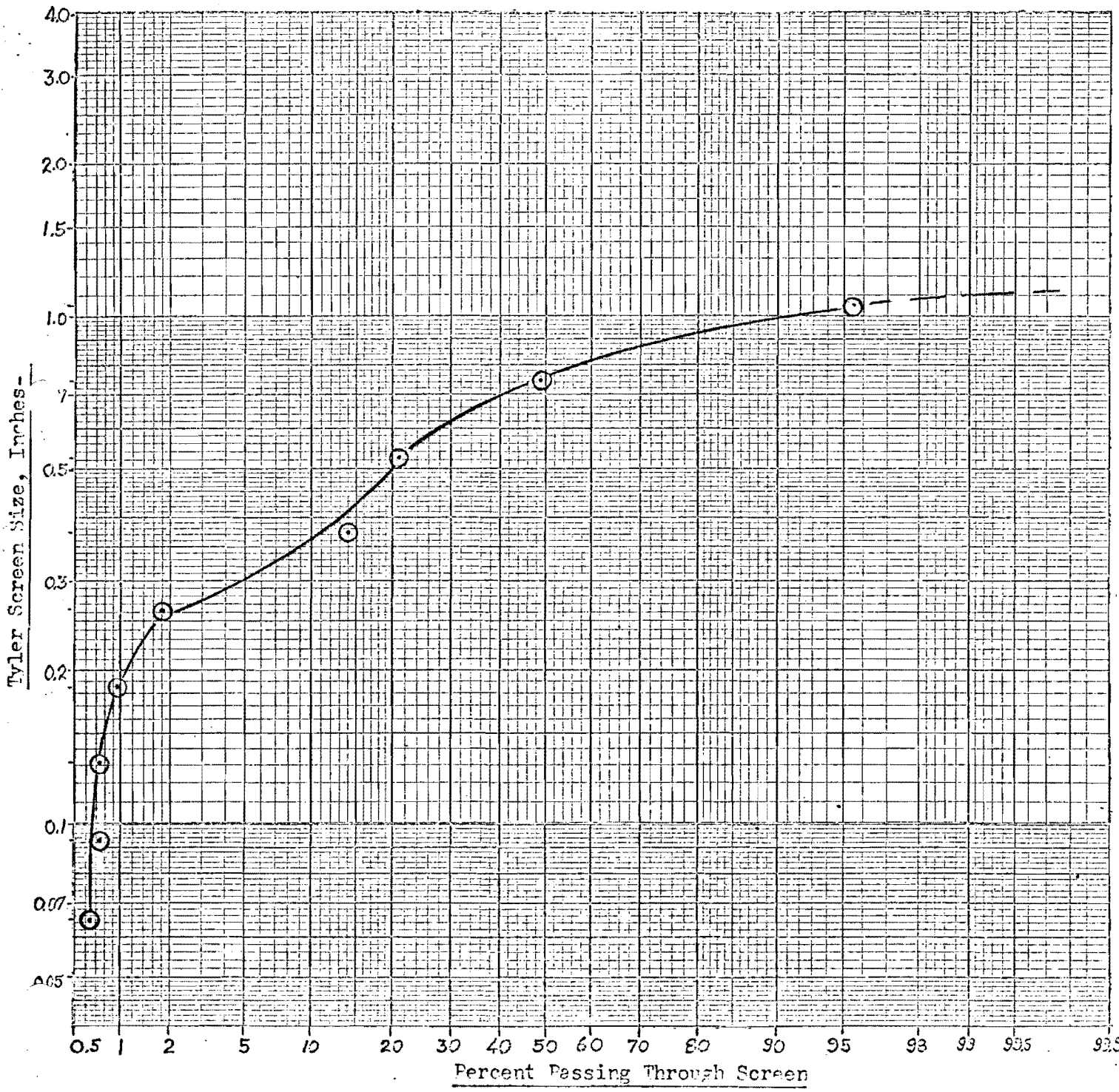
Raw Shale - 27.5 gallons per ton

Spent Shale - 3.9 gallons per ton

FIGURE 14

SHALE SIZE DISTRIBUTION

Startup - Run C1056 With 1/4 to 1 Inch Shale
Sample Wt. - 94.3 lbs.



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9/15/67

1. The cyclone system was removed and gas inlets plugged. This was done because it was the intention during the next run to flow most of the gas through the shale chutes.

2. The "crows feet" were removed from the bottom of the deck chutes to facilitate better shale movement through the chutes.

3. Butterfly valves were installed on two of the lines previously used as cyclone inlets so that pressure drops across the deck could be controlled by bypassing gas. Target ΔP across the deck and feed chutes was 12 inches of water.

The retort was started up for Run C1057 on August 23, 1967 at 0500 hours. The startup was smooth and very similar to the previous startups with the liquid disengager system. The startup procedure was identical to that used in C1056. As can be seen in Figure 15, the combustion zone temperatures on the west side of the retort fired off first with the center and east lagging behind.

At about 1300 hours, the west combustion zone temperature climbed rapidly to around 1,700 F. A small clinker was probably formed at this time. Evidence of the existence of this clinker is shown by the plot of the spent shale cooling zone corner grid temperatures, also on Figure 15. The northwest and southwest temperatures fell rapidly to an abnormally low level of 200 to 300 F one hour after the high west side combustion zone temperature.

The clinkered condition probably existed until the unit was shut down on August 29, 1967.

Even though a clinker was believed to be present in the retort, it was decided that several things about liquid removal could be studied. The recycle rate was increased in increments of 500 SCF/T to study its effect on ΔP across the deck, liquid removal rates, and deck temperatures. Figure 16 shows a plot of recycle rate versus deck temperature. This curve suggests there is an upper limit of deck temperature of 600 F with the existing bed depth above the air inlets. This 600 F limit would require 2,900 SCFM of recycle gas.

Final process conditions tested before shutdown were:

Shale Rate - 300 lbs/(hr)(ft^2)
Air Rate - 4,300 SCF/T
Recycle Rate - 18,000 SCF/T

Table 5 lists preliminary results for the C1057 series of runs.

FIGURE 15

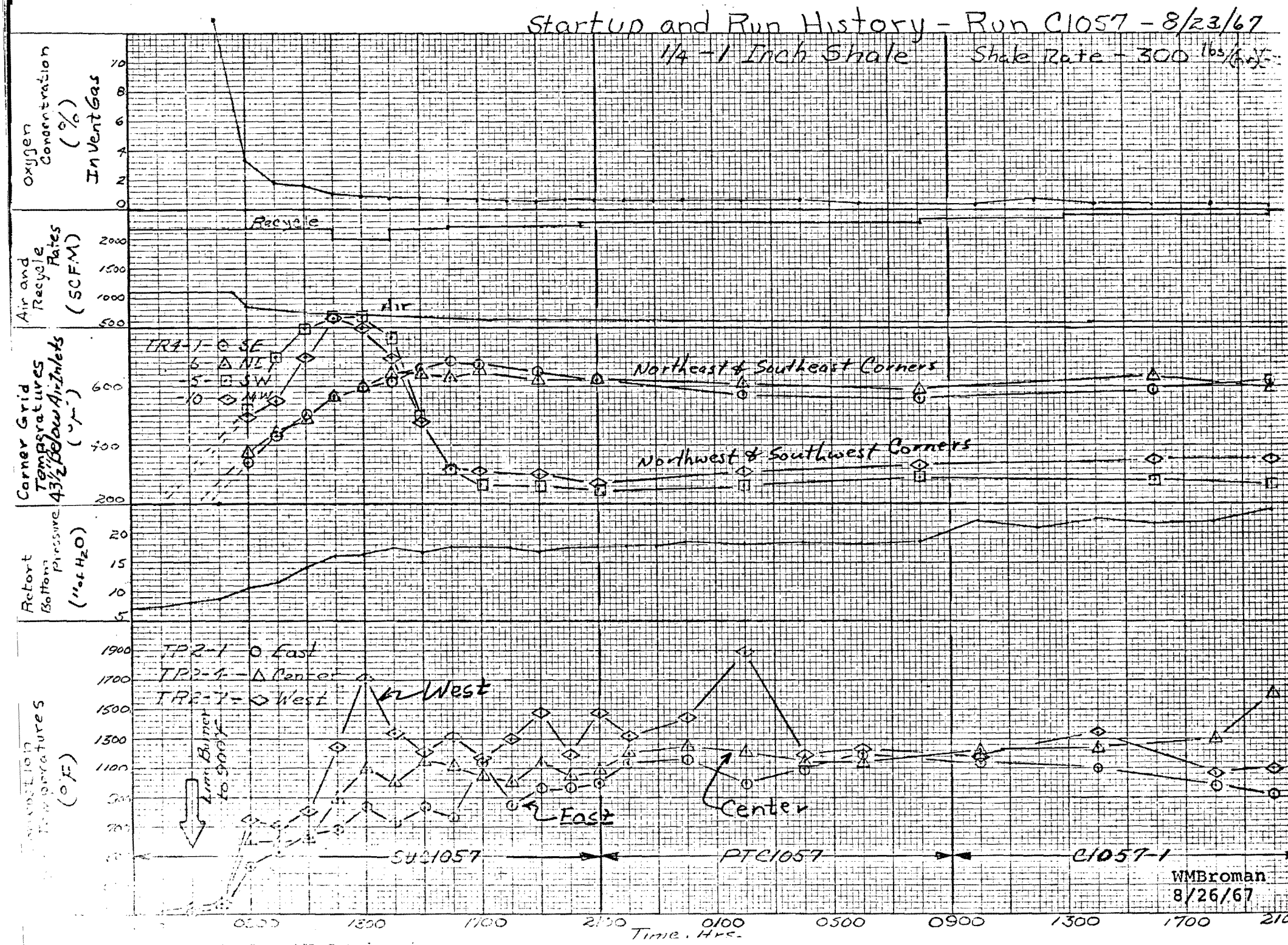
Startup and Run History - Run C1057 - 8/23/67
1/4 - 1 Inch Shale
Shale Rate - 300 lbs/hr
Oxygen Concentration (%) In Vent Gas
Air and Recycle Rates (SCFM)
Recycle
Air
Corner Grid Temperatures 4½" Below Air Inlets (°F)
TR4-1 SE
NE
SW
NW
Northeast & Southeast Corners
Northwest & Southwest Corners
Retort Bottom Pressure ("of H2O)
TP2-1 East
TP2-4 Center
TP2-7 West
Temperatures (°F)
Turn Burner to Start
West
East
Center
SU1057
PTC1057
C1057-1
WMBroman
8/26/67
Time, Hrs.

FIGURE 16

RECYCLE RATE VERSUS DECK TEMPERATURE
Run C1057, September 23, 1967

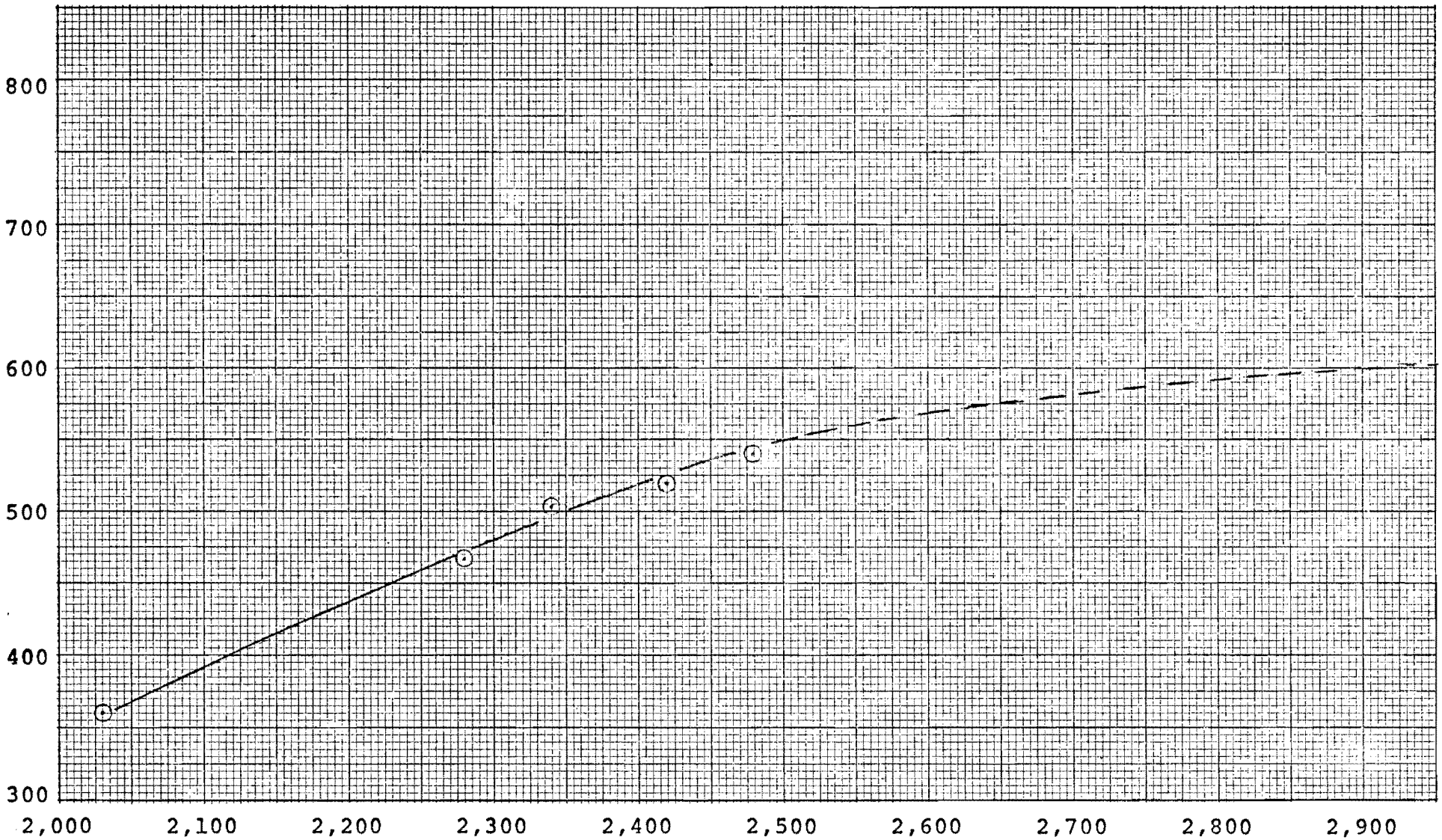

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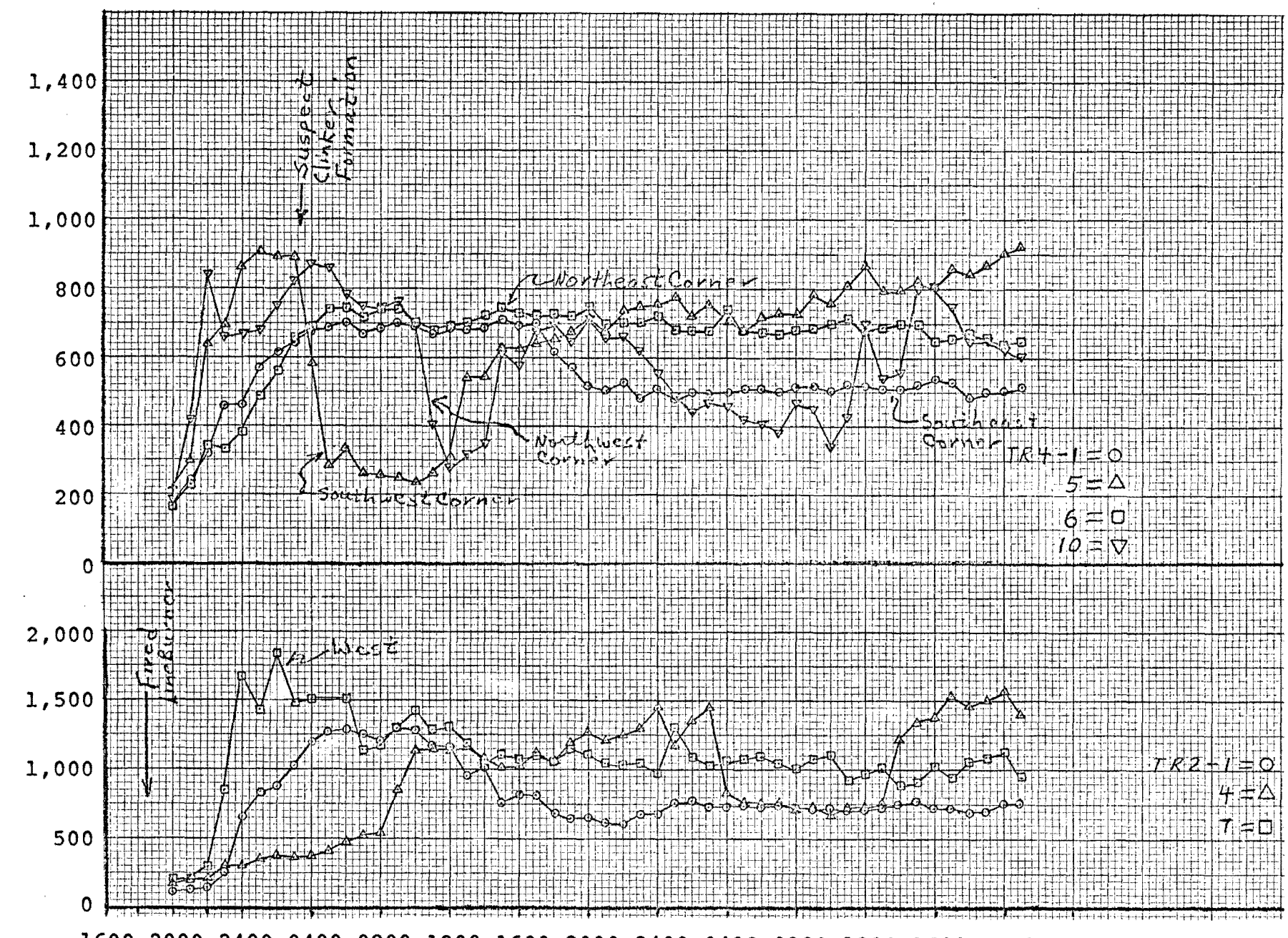
FIGURE 17

STARTUP HISTORY RUN C1058, 1/4 TO 1 INCH SHALE



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9/15/67

TABLE 5

PRELIMINARY RESULTS
Run C1057 - August 23, 1967

	SUC1057	PTC1057	C1057-1
Shale Rate, lbs/(hr)(ft^2)	299	296	294
Air Rate, SCF/T	5,330	4,910	4,500
Recycle Rate, SCF/T	15,950	16,900	18,200
Yield, % RSFA	53.3	76.8	79.5
Raw Shale FA, gal/ton	27.6	26.7	26.5
Spent Shale FA, gal/ton	6.2	2.9	2.1
Deck ΔP, Inches of H_2O	13.4	15.4	16.4
Bottom Pressure, inches of H_2O	18.2	20.4	22.1

BLReymond
8/31/67

During the C1057 series of runs, oil recovery from the disengager deck was measured continuously after 1230 hours on August 23, 1967.

Table 6 shows the total liquid product and disengaged oil as both run period production in barrels, and hourly rate in barrels per hour. The volumetric ratio of oil disengaged to total liquid product is shown as a percentage in the last column.

Table 7 is a digest of the run conditions that were thought to influence the rate of oil disengagement. Recycle rate, pressure drop across deck, deck temperatures are either averaged or shown as minimum to maximum range.

From Table 7, the run condition trends can be easily seen. The recycle rate was increased throughout the three periods in an effort to raise the deck temperature to the ideal value of 600 F. Figure 16 suggests that the recycle rate lost its effectiveness to increase deck temperatures as it was raised, thereby limiting the maximum deck temperature. The deck pressure drop, caused by the high gas velocity in the shale chutes, is shown to increase with recycle rate as would be expected. However, it fluctuated quite widely even at a constant recycle gas rate, as a more detailed look within each run period would reveal.

Two conclusions can be drawn from data in Tables 6 and 7.

1. The amount of oil disengaged in all run periods fell short of expectations, as it had in all previous runs with the disengaging deck.

2. The large increase in recycle rate and deck temperature did not cause any significant trend in disengaged oil production.

4. Operations History Run C1058 With 1/4 to 1 Inch Shale

Data from previous runs, along with recent mechanical model studies, suggested that free oil in the shale bed probably would be present near the top of the shale bed at mass rates in excess of 400 lbs/(hr)(ft^2) and total gas of 20,000 SCF/T. The data also suggested that any free oil could probably be more readily collected from this low temperature (130 to 150 F) region.

A way to test the above theory would be to lower the offgas headers so they would be immersed 1 to 2 inches into the top of the shale bed. This would require removing the liquid disengagement deck and lowering the four offgas headers. The mechanical changes were not possible because

TABLE 6

OIL PRODUCTION: RUN C1057

Run period C1057	Duration (hr)	Total liquid product		Oil disengaged		Percentage of Oil Disengaged
		Run total (bbl)	Rate (bbl/hr)	Run total (bbl)	Rate (bbl/hr)	
Startup	8.5	31.18	3.67	3.16	0.372	10.1
Pretest	12.0	49.60	4.13	4.18	0.348	8.4
1	12.0	48.95	4.08	4.20	0.350	8.6

TABLE 7

C1057 RUN CONDITIONS INFLUENCING RATE OF OIL DISENGAGED
(Average Over Run Periods)

Run period C1057	Duration (hr)	Recycle rate Average (SCF/Ton RS)	Deck pressure drop - range (inch H_2O)	Deck temperature - range (^oF)
Startup	8.5	15,590	13 to 14	360 to 450
Pretest	12.0	16,540	14 to 18	450 to 500
1	12.0	17,380	15.6 to 18	500 to 540

BLReymond
8/31/67

of insufficient program time in Stage II. Therefore, it was decided that an alternate mechanical modification requiring less time should be tried. This change required the shortening of the shale chutes below the liquid removal deck so that gas temperature would be low (140 F) at the top of the shale bed. The change provided 72 inches of bed height above the air outlet level. If the hypothesis were correct, liquid which collected in the low temperature zone at the top of the shale bed would be blown up through the deck shale chutes at high velocities and collected as it passed over the deck grids. It was also reasoned from mechanical model studies that high total gas rates should be maintained throughout the startup to minimize liquid buildup concentrations below the deck. Startup process conditions were changed to a 400 mass rate followed by a quick transition to a 500 mass rate. Previous runs used 300 mass rate conditions which were probably insufficient to maintain a dry shale bed during the early stages of the startup. Target startup conditions and run conditions were:

Startup Conditions - Run C1058

Shale Rate - 400 lbs/(hr)(ft^2)
Air Rate - 5,000 to 5,200 SCF/T Air Equivalent Oxygen Consumption Rate
Recycle Rate - 15,700 SCF/T
Line Burner Temperatures - 700 F First two hours and 900 F thereafter

When oxygen concentration in the vent gas reached 0.5%, began transition to 500 mass rate conditions while phasing the line burner out in 100 F increments.

Target Run Conditions - C1058

Shale Rate - 500 lbs/(hr)(ft^2)
Air Rate - 4,500 SCF/T
Recycle Rate - 15,700 SCF/T

Run C1058, which was the final experiment in Stage II, began at 1830 hours on August 29, 1967. Although the mass rate and gas rates were higher, the startup was fast and similar to previous runs. Four hours after firing the line burner, it was noticed that a small amount (1 to 2%) of oil was being collected on the liquid disengagement deck. However, five hours after firing the line burner, a partial shale bridge was experienced in the west side of the retort as evidenced by a rapid increase from 1,200 to 1,700 F in combustion zone temperature. A substantial cut in air rate appeared to correct the situation as the temperature on the west side was lowered to the 1,400 to 1,500 F level. The improvement in the operation was

short-lived because at 0330 hours on August 30, 1967, (nine hours after firing the line burner) the first evidence was observed that the retort contained a clinker in the southwest corner. The spent shale temperature in this corner of the retort began to cool off rapidly indicating a high recycle gas to shale ratio. Refer to Figure 17 where spent shale cooling zone temperatures and combustion zone temperatures are shown. At 1000 hours on August 30, 1967, the spent shale temperature in the northwest corner of the retort experienced the same reduction as was observed in the southwest corner. Over a period of two hours, the spent shale temperature in the northwest corner dropped from 700 F to 280 F. At this point, the retort appeared to be clinkered across the west end above the air distributor. Temperature responses, indicating the clinker, were very similar to those observed in Runs C1056 and C1057.

Although the retort was clinkered early, the operation was continued with a transition being made to the 500 mass rate conditions. Two 12-hour material balances were made at the 500 mass rate to evaluate the effectiveness of the oil disengagement principle with the modified hardware configuration. During the two balance periods, only a small amount (2%) of the oil was recovered on the disengagement deck. Inability to collect substantial quantities of oil at the top of the retort bed in this experiment, suggests there are only small quantities present at this location.

Retort No. 3 was shut down after 50 hours of operation. Two small clinkers, one each in the northwest and southwest corners, were found. The clinkers were very hard and free of oil indicating they were probably present early in the operation.

Severe gas channeling was indicated at the top of the shale bed which led to inefficient retorting. Gas temperatures were observed to be 300 to 400 F rather than 130 to 150 F, the normal level. The inefficient retorting is pointed out by the excessive quantities (4 to 9 gallons per ton) of oil present in the spent shale throughout the C1058 operation. Approximately 75 to 90% of the oil in the spent shale was benzene extractable. Free oil in the spent shale could be oil that ran down from the retorting zone, or oil made by decomposing kerogen in the spent shale cooling zone.

Pertinent data from the two 12-hour material balances are:

Run Number	C1058-1	C1058-2
Raw Shale Fischer Assay, Gal/Ton	26.5	28.6
Shale Rate, lbs/(hr)(ft^2)	489	493
Air Rate, SCF/T	5,060	5,040
Recycle Rate, SCF/T	13,400	13,200
Oil Yield, Vol. % Raw Shale FA	68.7	64.9
Fischer Assay Oil in the Spent Shale, Gal/Ton	7.9	6.9
Percentage of Fischer Assay Oil In the Spent Shale Which was Benzene Extractable	90	77

B. Mechanical Models Group (L. J. Skowronek)

1. Corrosion-Erosion Program

Monitoring of retorting and mining equipment was picked up from where it was delayed by the breakdown of the Sonoray Caliper. A series of readings was taken in August and a thorough visual inspection along with measurements for metal loss was made after the shutdown of the unit on August 31, 1967. The findings of these inspections and conclusions that may be drawn will be presented in a Technical Memorandum.

2. Retort No. 3 (Half Section Model) Studies

As previously reported in Monthly Progress Memoranda of May 24 and June 23, 1967, the half section model had been modified and instrumented to develop the imposed loadings due to shale flow on retort internals and the effect the geometry of these internals.

In the aforementioned memoranda, the loading on a single contoured header was reported. This data along with the data collected in the test with wall headers is presented on Figure 18. To eliminate the influence of the wall on the determined loadings, half distributors were installed along each wall and the test was run with 1/4 to 2 1/2 inch shale. The findings of this run are reported on Figure 18. It can be seen that with an 18 inch center to center the loadings are slightly decreased. An analysis of the data and correlation to existing formulas will be made during this next month.

In addition, the imposed loadings on the simulated recycle headers was determined. The center to center spacings of these headers from the bin walls was 24"-36"-36"-24". The loading on the center and one side header was developed The findings are depicted on Figure 19 for both shale ranges 1/4 to 1 inch and 1/4 to 2 1/2 inch. It can be clearly seen that these headers although at right angles

BEAM LOADING CONTOURER 3 '2 INCH WIDE AIR DISTRIBUTOR

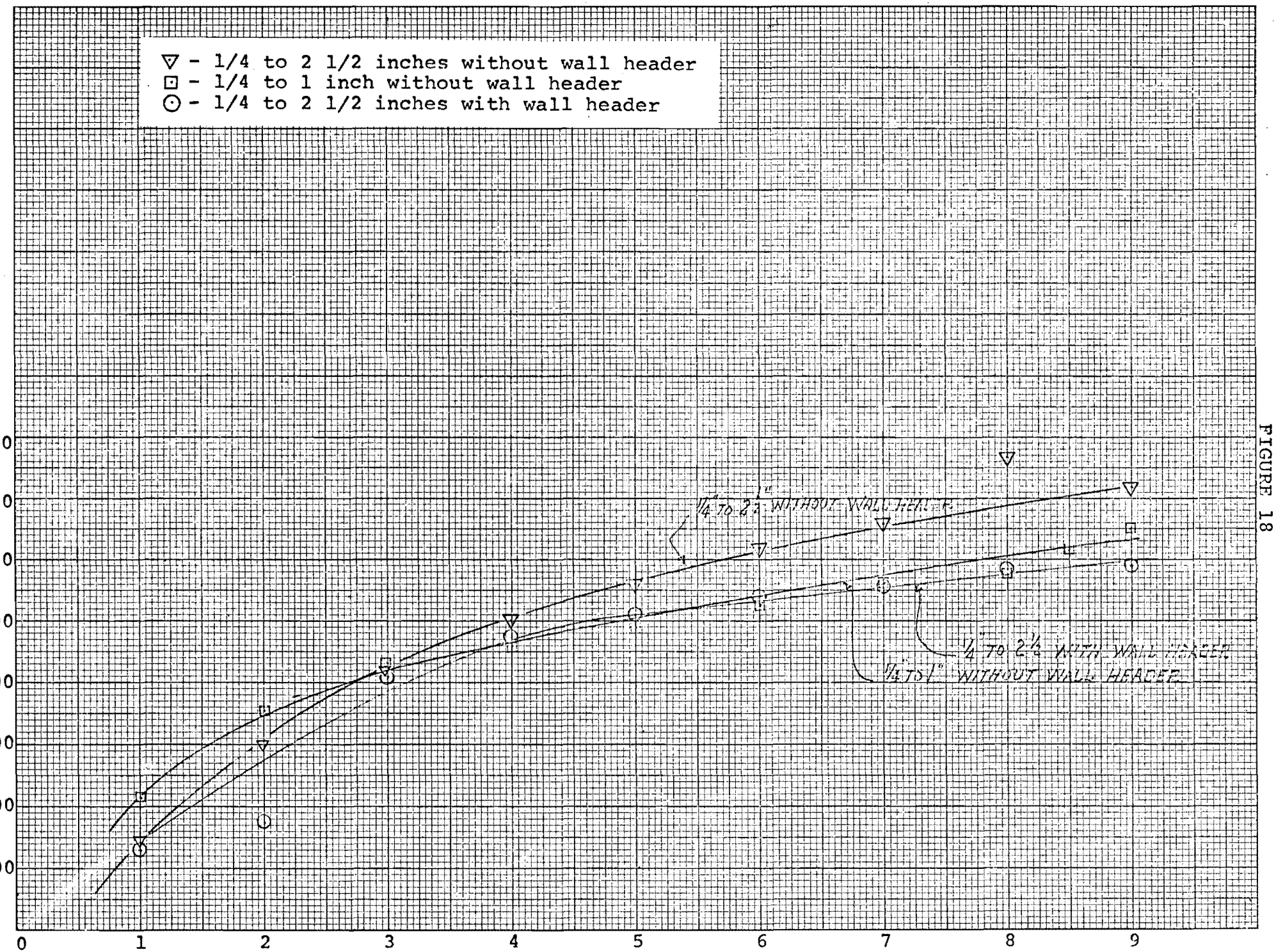

FIGURE 18

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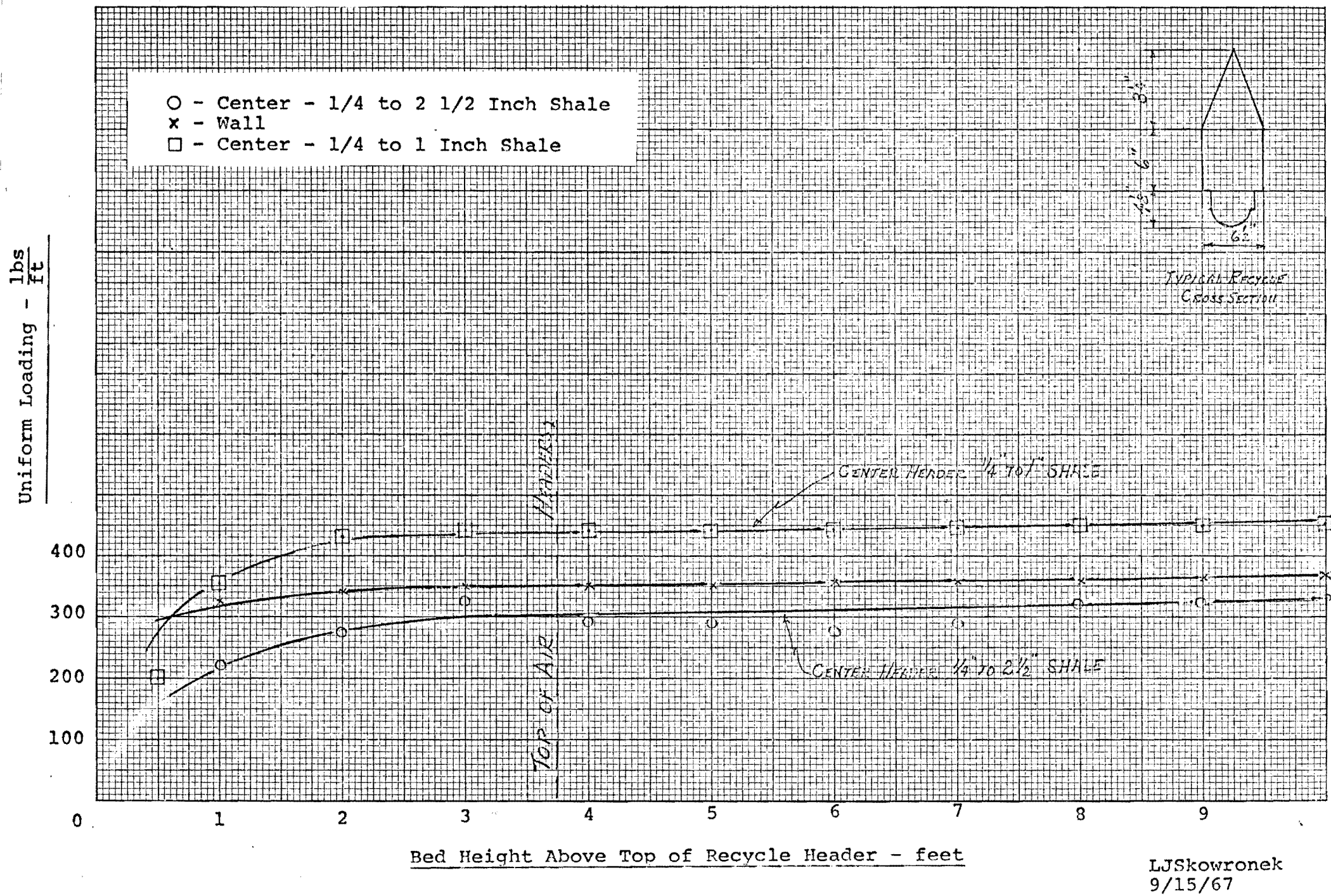
FIGUR 19

BEAM LOADING RECYCLE HEADER 70° RIDGE



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to the air header carry only the shale load between the air and recycle header systems. It should be noted that the data presented represents dynamic loading, i.e. load while shale bed was moving. Static loads were always lower, usually by 15% or more.

V. RETORT OPERABILITY TASK FORCE (K. I. Jagel, Jr., D. Liederman, and L. J. Skowronek)

A. Model Studies Dealing With Liquid Disengager Elements

Two model studies of limited scope dealing with local flooding in a retort equipped with a liquid disengager have been completed. Motion pictures of each of these studies are now being processed and it is anticipated that they will be distributed as part of a memorandum summarizing the activities of this group.

1. Gas Flow From Shale Downcomer Into Expansion Section

In the first of these studies the interaction of gas and liquid in a packed bed of 1/4 to 1/2 inch shale at the transition from the shale disengager to the expansion section of a liquid downcomer was simulated. In this simulation, air was used in place of retort gas and No. 1 fuel oil was used to simulate shale oil. The equipment used is illustrated in Figure 20. Table 8 summarizes the data obtained. At conditions simulating 300 mass rate, 20,000 SCF/T raw shale total gas rate operations in the simulated gas temperature range from 150 to 600 F, considerable flow of liquid down the shale downcomers countercurrent to the gas flow occurs. When 500 mass rate, 20,000 SCF/T raw shale total gas rate, 600 F gas temperature conditions are simulated, incipient flooding of liquid in the shale downcomers appears to occur. At simulated conditions of 1,000 mass rate and 20,000 SCF/T raw shale total gas rate in the gas temperature range from 150 to 600 F, flooding in the downcomers did occur and no apparent flow of liquid down the downcomers was observed.

2. Gas Flow From the Shale Into the Shale Downcomer

The second study that we have completed dealt with the interaction of gas and liquid in a packed bed of 1/4 to 1/2 inch shale at the transition from the full bed of shale into the shale downcomer. The same fluids were used as in the previous study. The equipment used is illustrated in Figure 21. When the model was operated near the loading point or the incipient flooding point, splashing and some local accumulation of oil occurred at the free shale surface. These conditions were observed at simulated 400 and 500 mass rate, respectively, with simulated 20,000 SCF/T raw shale total gas rate and 600 F gas temperature. The results are summarized in Table 9.

FIGURE 20

SHALE DOWNCOMER - EXPANSION SECTION TRANSITION

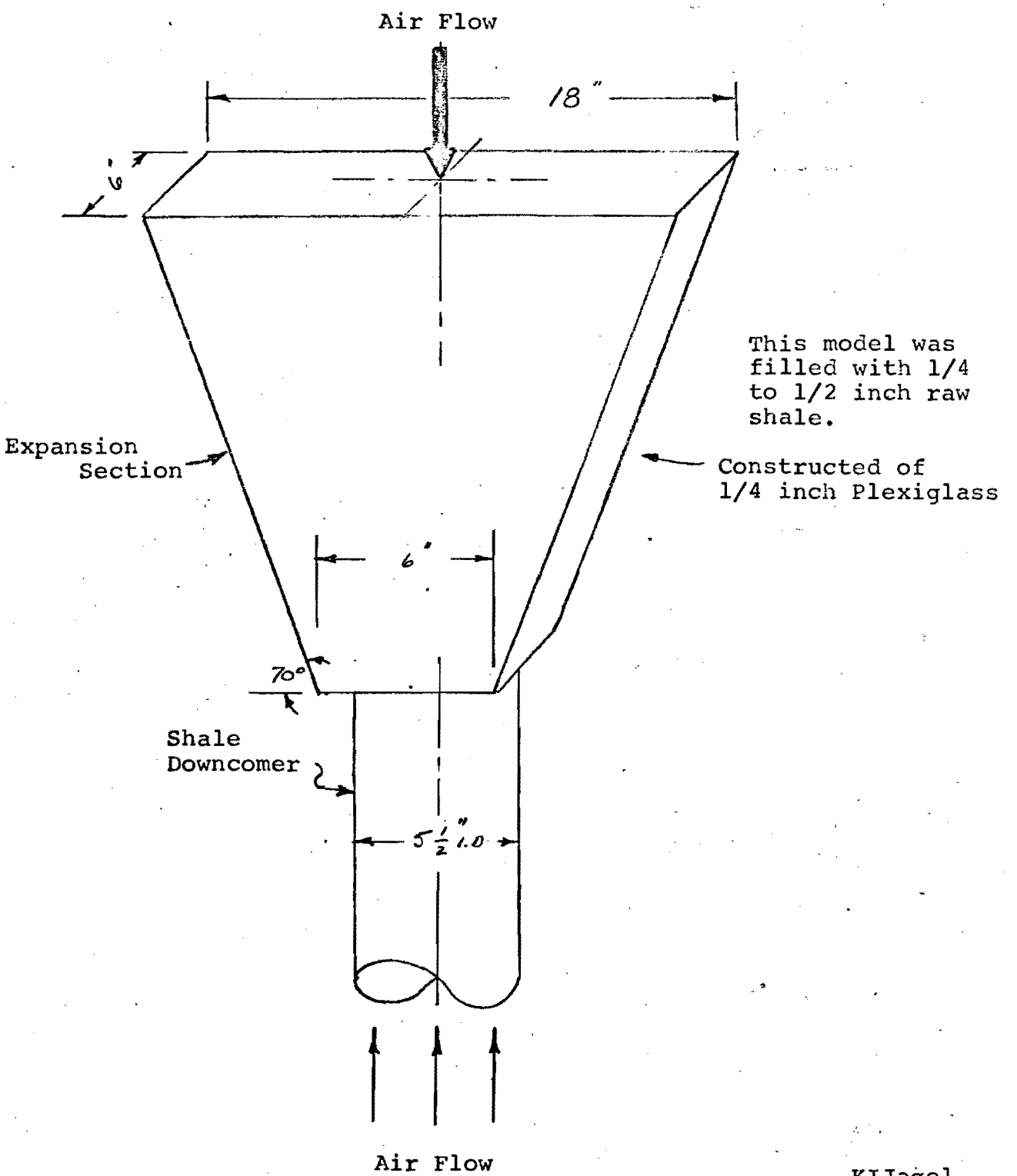

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FIGURE 21

SHALE BED - SHALE DOWNCOMER TRANSITION

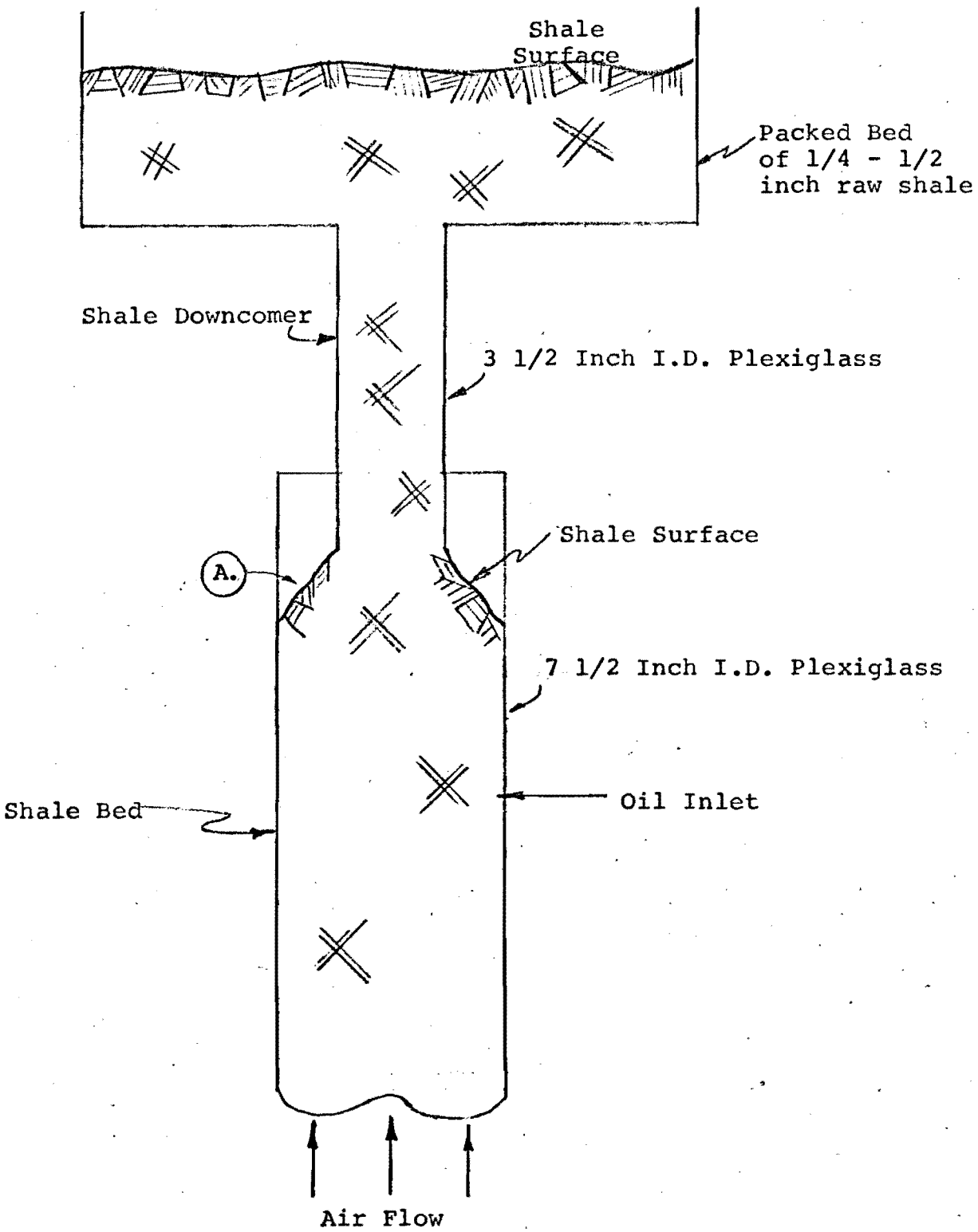

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TABLE 8

VISUAL OBSERVATION OF LOADING AND FLOODING IN A PACKED BED
OF 1/4 TO 1/2 INCH SHALE - TRANSITION FROM SHALE DOWNCOMER TO EXPANSION SECTION

Conditions Simulated						
Raw Shale, lbs/(hr)(ft^2)	300	300	400	500	1,000	1,000
Total Gas Rate, SCF/T	20,000	20,000	20,000	20,000	20,000	20,000
Gas Temperatures, ^oF	150	600	600	600	150	600

Liquid rate was chosen so that it simulated a refluxing liquid stream equal to 50% of the oil that would be recovered from 28 gal/ton shale at 90 Vol. % Fischer Assay yield.

Actual Rates						
Superficial Gas Velocity In Shale Downcomer Feet/Second	1.0	1.7	2.3	2.8	3.3	5.7
Volumetric Liquid Rate cc/min	19.6	19.6	26.2	32.7	65.4	65.4
Visual Observations	Liquid drained downward through shale downcomer. No significant liquid holdup other than surface wetting was apparent.	Some holdup at contact points of shale occurred in shale downcomer. A significant flow of liquid downward through the shale downcomer still occurred.	Increased holdup in shale downcomer occurred.	Liquid holdup in shale downcomer increased. Incipient flooding is believed to have occurred.	Flooded in shale downcomer. No apparent downward flow of liquid in downcomer. Separation of a liquid continuous bubbling zone in the expansion section occurred.	The bubbling zone in the expansion section became more agitated.

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TABLE 9

VISUAL OBSERVATION OF LOADING AND SPLASHING IN A PACKED BED OF 1/4 TO 1/2 INCH SHALE TRANSITION FROM SHALE BED TO SHALE DOWNCOMER

Conditions Simulated						
Raw Shale, lbs/(hr)(ft^2)	300	400	500	300	400	500
Total Gas Rate, SCF/T	20,000	20,000	20,000	20,000	20,000	20,000
Gas Temperature, ^oF	150	150	150	600	600	600

Liquid rate was chosen so that it simulated an impacted liquid stream equal to 50% of the oil that would be recovered from 28 gal/ton shale at 90 Vol. % Fischer Assay yield.

Actual Rates						
Superficial Gas Velocity In Shale Bed, Feet/Second	1.0	1.3	1.6	1.7	2.3	2.8
Volumetric Liquid Rate cc/min	36.5	48.6	60.7	36.5	48.6	60.7
Visual Observations	Liquid drained downward through shale bed. No significant liquid holdup other than surface wetting. No splashing at (a).	No loading in shale bed. No splashing at (a).	No loading in shale bed. No splashing at (a).	No loading in shale bed. No splashing at (a).	Some significant holdup of liquid in the shale at (a).	Incipient flooding. Significantly increased splashing at (a). Local accumulation of liquid at that point.

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B. Significance of These Model Studies in Analyzing Retort No. 3 Operations

Conditions in the shale downcomers during Runs C1057 and C1058, in Retort No. 3, were in the flooded to superflooded range of operation. One might logically ask why these operations failed.

In Run C1057, it is likely that a significant quantity of oil condensed below the deck during startup. This may be inferred from the 350 F deck temperature observed early in this run and the concurrent symptoms of clinkering. (Eventually, in this run, 500 to 550 F deck temperatures were realized.) From the first of these model studies, it may be concluded that the upward flow of liquid with the gas into the shale downcomer would not occur at 300 mass rate at the gas velocities and temperatures used. Local accumulations of liquid below the deck could and presumably did occur.

In Run C1058, diverging chutes were installed below the shale downcomers to prevent the local accumulation of oil at the free surface of shale where it flowed from the chute. The startup mass velocity was also increased from 300 to 400. These decisions were based on some preliminary parts of the second of these studies. At the same time the shale downcomers were shortened without lowering the deck portion of the liquid disengager. The distance from the air distributor to the bottom of the shale downcomer was increased from about 3 to 6 feet. In effect, the bed height between the shale downcomers and the air distributor was now about equal to what would normally exist between the air inlet and the shale inlet chutes in the conventional process. The result that might be expected, occurred. Low deck temperatures (250 to 350 F) were observed. Even at the 400 to 500 mass rate conditions used in this operation, a significant local accumulation of oil below the deck would be expected to occur. Clinkering suggests that it did.

VI. ENGINEERING AND ECONOMIC ANALYSES (K. I. Jagel, Jr. and R. A. Reitz)

A. Crushing Research Program (R. A. Reitz)

1. McLanahan Secondary Crusher Tests

Earlier this year, some primary jaw crusher product was shipped to McLanahan Corporation for secondary crushing tests with a tooth-type, double roll crusher. The reasons for doing this test work were (1) to give McLanahan experience in crushing oil shale to our desired product size and (2) to see if McLanahan had developed any special techniques in their past experience with oil shale that would give them an advantage over Allis-Chalmers. McLanahan had originally planned to crush the shale in a commercial machine; however, none with the proper teeth configuration were built during this time so they performed the test in a laboratory crusher.

The results of the test work are shown on Table 10, which was compiled by McLanahan. Figure 22 is a plot of the McLanahan open circuit test data, along with two open circuit size distributions from the Allis-Chalmers secondary crusher in service at Anvil Points. The McLanahan data show a definitely lower percentage of fines (1/4 inch minus) for a given top size when compared to the Allis-Chalmers crusher. The lower fines level may be the result of different tooth designs or different roll speeds (110 RPM for the Allis-Chalmers crusher versus 150 RPM for the McLanahan crusher) between the two crushers.

A closed circuit test with about 10% circulating load gave 2% passing 1/4 inch for a 2 1/2 inch minus product. This is slightly better than the Allis-Chalmers closed circuit tests have shown. However, the important fact that recycling a small amount of oversize material gives a significant reduction in 1/4 inch minus fines has now been demonstrated in two, independent tests.

The receipt of the McLanahan test data concludes the Crushing Research Program. Crushing tests were carried out by Allis-Chalmers, Stedman Foundry and Machine Company, and McLanahan. Although it was hoped to carry out cone crusher tests with Nordberg, no suitable commercial machine was found.

2. Allis Chalmers Flowsheet Type Design

The flowsheet type design report was received from Allis-Chalmers at the end of August. This completes the Crushing Research Program being carried out by Allis-Chalmers. The report was distributed to the Participating Parties in the first part of September.

TABLE 10

TEST RESULTS

Company: Mobil Oil Corporation
Location: Rifle, Colorado
Material: Oil Shale
Feed Size: +2-1/2" scalped oversize from Primary Jaw Crusher Product.
Max. piece in sample received 4" x 12" x 15"
Desired Product:
Test 1. minus 3" in open circuit (allowable 2% oversize)
Test 2. minus 2" in open circuit (allowable 2% oversize)
Test 3. minus 2-1/2" in closed circuit w/10% recycle load.

Date: September 7, 1967

Type Test: Crush and Screen
Machines Used: Laboratory 24" dia. x 6" Double Roll; Gilson Screen
Misc. Information: (1) Rolls both with 5/8" and 1/2" teeth #8302
(2) Roll Speed 150 R.P.M.
(3) All screens with square openings.

TEST #1 -- Roll setting body to body 2-1/4" for a -3" product, open circuit.

Screen Size	Cumulative Percent Passing
4"	100.00%
3"	96.2%
2"	68.9%
1-1/2"	33.9%
1"	17.8%
3/4"	12.9%
1/2"	8.1%
1/4"	3.7%

TEST #2 -- Roll setting body to body 1-7/8" for -2" product, open circuit.

Screen Size	Cumulative Percent Passing
3"	100.0%
2"	96;8%
1-1/2"	73.7%
1"	29.5%
3/4"	19.0%
1/2"	11.9%
1/4"	5.5%

TABLE 10 (CONTINUED)

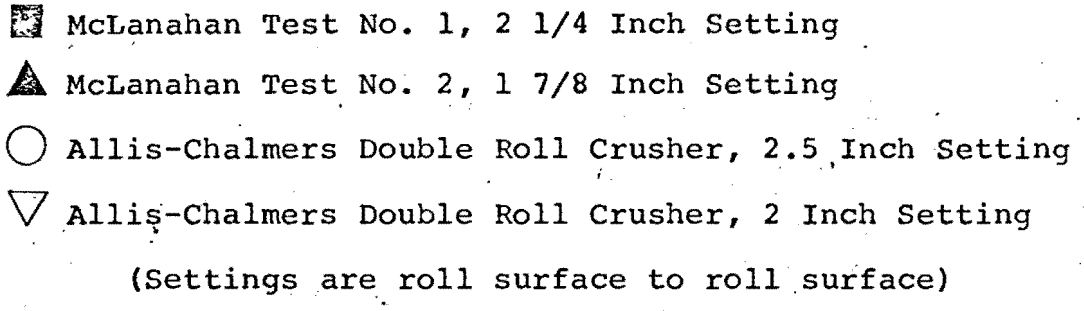
TEST #3 -- Roll setting body to body 2-1/4" for -2-1/2" product, closed circuit, planned recycle load of 10%. Note: product shown is second rerun, feed included +2-1/2" oversize from previous run.

Screen Size	Cumulative Percent Passing (total crusher product)	Cumulative Percent Passing (-2-1/2" fraction only)
3"	100.0%	
2-1/2"	92.5%	100.0%
2"	71.4%	77.0%
1-1/2"	30.2%	32.6%
1"	13.0%	14.1%
3/4"	9.0%	9.9%
1/2"	5.7%	6.1%
1/4"	2.7%	2.9%

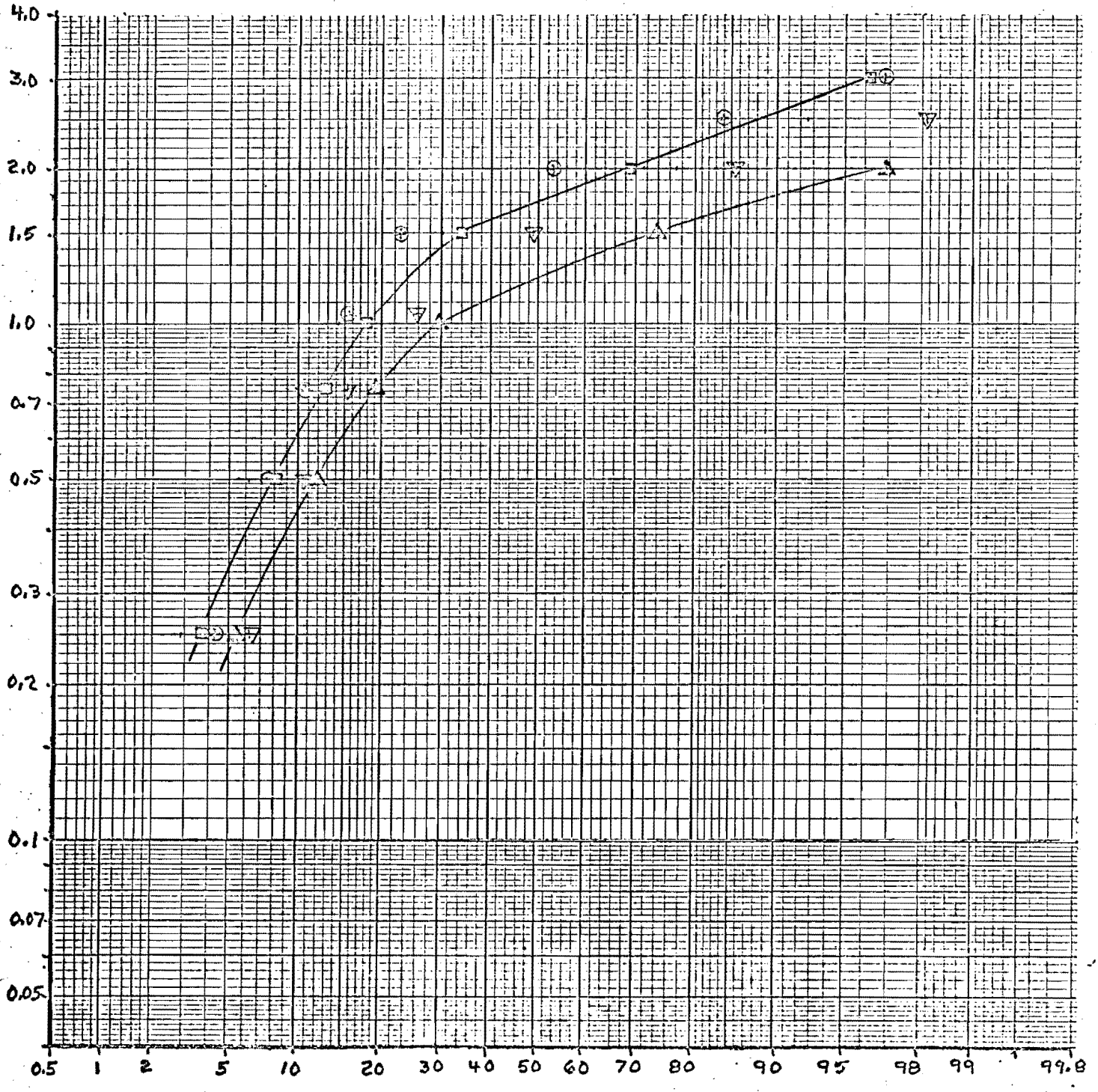
McLANAHAN CORPORATION
Hollidaysburg, Penna.

FIGURE 22

SHALE SIZE DISTRIBUTION



(Settings are roll surface to roll surface)



Tyler Screen Size, Inches

Percent Passing Through Screen

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VII. ANALYTICAL LABORATORY SECTION (D. Liederman)

A. Laboratory Shutdown

At the conclusion of Retort No. 3 operations, the Analytical Laboratory has been placed on a standby condition. Equipment and chemicals have been inventoried and stored; sensitive equipment has been plastic-wrapped to minimize dust damage. Laboratory operating records, such as analysis work sheets, log books, and analysis workbooks, have been packaged and will be filed with other project records.

A revision of Technical Memorandum No. 65-5, "Analytical Laboratory Methods" is being prepared. The revision will contain all methods that were routinely used at Anvil Points; it will include new ones that have been added since the last memorandum, and old ones brought up to date.

B. Personnel

Since the inception of the Anvil Points Program, we have hired personnel with a wide variety of experience and proclivities. These selected personnel were trained, under close supervision, for up to three weeks. In almost every case, they have demonstrated that people available in this area can, with interest and education, become excellent laboratory technicians, capable of serving a shale oil installation here.