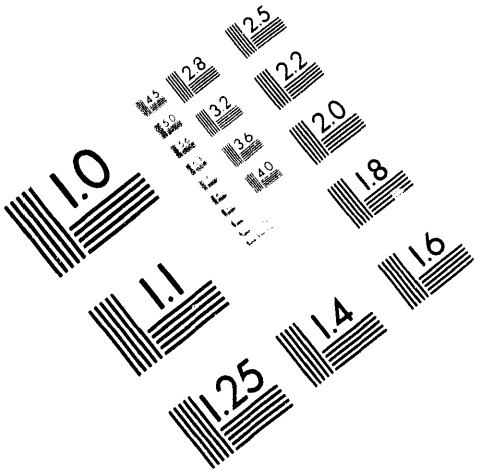

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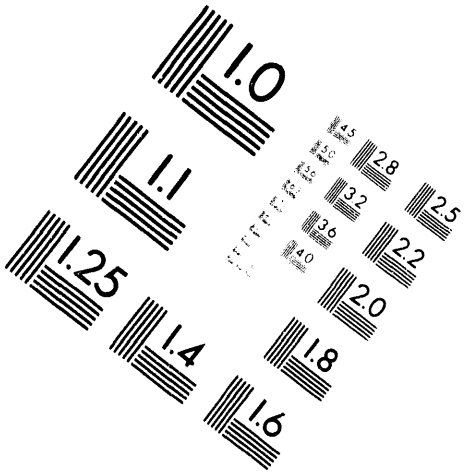

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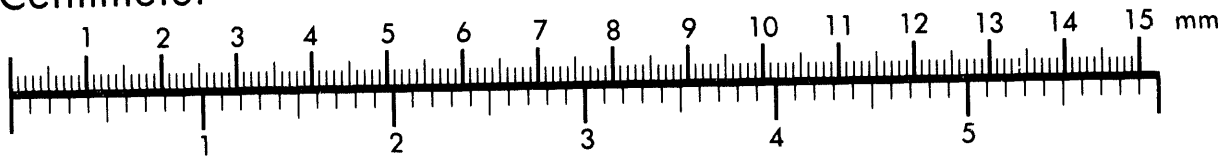

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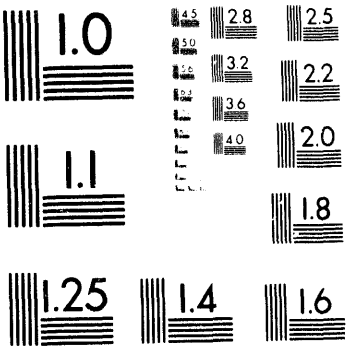

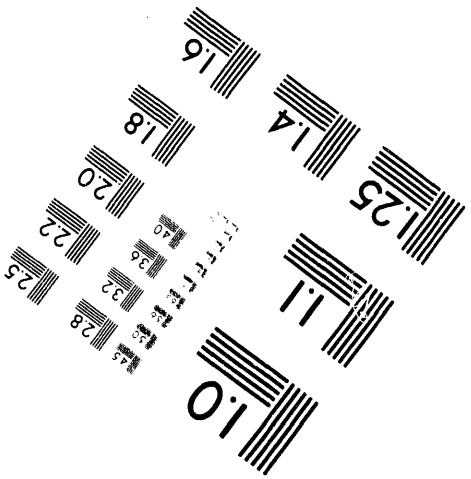

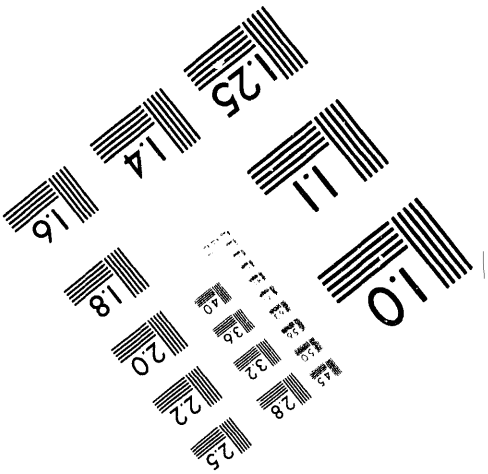

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100 AREAS TECHNICAL ACTIVITIES REPORT - ENGINEERING

AUGUST, 1947

CORROSION AND BLISTERING - W. K. Alexander, C. P. Caboll, R. A. Rohrbacher

Summary

There were seven charges of metal inspected during the month for corrosion and blistering studies. There were no unusual cases of blistering noted and the corrosion rates were normal for this time of year.

Boroscopic examination of the graphite packing around the "B" Hole in the F Pile revealed that the graphite is no more severely cracked than in the D Pile when it was inspected about a year ago. Examination of the graphite at the downstream end of Tube 1385-D did not indicate that any damage had been done by the leak in that tube.

Forty one tubes have been charged in the F Pile on Production Test 105-90-P, "Exposure of TX Metal Slugs."

The routine job of taking vertical bowing measurements was turned over to the Instrument Department after working with them once in each Area.

Installation of Van Stone test units was completed and a brief run was started.

Van Stone flanges at both ends of 64 process tubes in both the B and F Piles were measured with a micrometer to determine the minimum amount of metal remaining.

Details (Alexander, Rohrbacher)

Listed below in tabular form are the data obtained from inspection of exposed slugs:

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Tube No.	Type	Exposure Days	Exposure MD	O.K.	Blistering Sl.	Blistering Mod.	Ext.	Penetration Mils/Mo. Ave.	Penetration Mils/Mo. Max.
0989-D	Corrosion	221	26.4	3	27	2	0	0.04	0.06
1783-F	Corrosion	257	32.2	2	27	3	0	0.05	0.06
3175-D*	Regular	156	25.0	10	20	0	0	——	——
2079-F	Papoose	346	43.4	5	27	0	0	——	——
1970-F	Low Density	353	44.6	2	30	0	0	——	——
2279-F	Borderline	353	44.5	1	29	2	0	——	——
2669-F	Warped	353	44.9	5	27	0	0	——	——

*Only 30 slugs picked up out of 32 discharged.

Borescoping

After the thimble had been removed from the "B" test hole at 100-F Area the graphite surrounding the hole was borescoped to determine the extent of the cracking which had taken place due to expansion. Blocks bearing the following process tubes were found to be cracked: 2189, 2191, 2277, 2278, 2279, 2280, 2282, 2283, 2284, and 2286. It was not possible to get further than the 76 row (vertical) because of time limitations. The cracks appeared to be about 1/32" wide.

After the leak in Tube 1385-D had been found to be in the most downstream 18" of the tube the borescope was used to determine the exact location. The hole was easily located as it was a sharp, distinct hole in the tube wall. It was about 0.1 x 0.3 inches. After the tube had been taken out the graphite at the end of the gun barrel was examined to see if the water had had any detrimental effect. The gun barrel was quite badly rusted on the inside but the graphite did not appear to be damaged in any way although it was wet for several feet from the end of the gun barrel.

Details (C. P. Cabell)

Discharge of Stuck Slugs - Problem Assignment No. 7-P

The design of the expanding mandrel, mentioned in last month's report, was modified for easier construction, and the mandrel is now being built in the 105-F shops. The ultimate purpose of the mandrel is to support charge-face Van Stone joints so that a maximum of 8000 pounds pushing force may be used on a tube. It is felt that this first mandrel will probably not support more than about 4000 pounds, but its construction and testing will provide valuable design data for further development. The mandrel under construction is of the mechanical screw type; some thought is also being given to a hydraulic expanding mandrel.

It has been decided to measure the force obtainable by the hand charging machine by mounting the machine on the elevator on its normal support and applying force to compress a calibrated spring. This test is now being arranged for early September.

105-D Tube Leak

We reviewed the gas analysis data collected by the "P" Department for various plenum chambers during the course of the study of the tube leak at 105-D. The data, while very useful in helping to locate the leak, actually is of a qualitative

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nature only, since uncontrollable variations in the moisture content of the inlet gas caused wide variations in the readings obtained in the plenum chambers. This irregularity made it difficult to calculate exactly what the moisture pick-up was in any given chamber or zone, and made it impossible to draw any conclusions as to the course of the water vapor through the unit.

It is generally agreed that the use of the plenum chamber data alone would have made it necessary to test a very great number of tubes for leaks. The data on the "B" riser test, which showed that the leaking tube was in the chilled zone on the far side, were required to make the plenum chamber data of greatest value.

As a matter of interest, the "P" Department Process Control Group has now found from Wilmington files that in all three 100 areas plenum chamber #91 is located on the near side of the unit and chamber #100 is on the far side of the unit.

Production Test 105-114-P, Accelerated Van Stone Flange Corrosion

The "hot flow laboratory" was completed during the month, after several delays to repair leaks in the stainless steel threaded joints. A brief run was made, but the apparatus was shut down again because of a leak in the steam line inside the barricade.

During the test a flow of 7.5 gpm was obtained, and a maximum temperature on the hot side of over 100°C. was obtained. This is in excellent agreement with design predictions.

The steam leak will be repaired on September 2 and a test started with 90°C. water on the hot side. The purpose of this test will be to compare the effectiveness of annealed 2-S aluminum, annealed 52-S aluminum, and 72-S aluminum rings as anodic protectors for the Van Stone flange. These rings will be tested at process water exit temperature (about 38°C.) and at 90°C. with suitable controls.

General Study of Van Stone Corrosion

The data taken earlier in the month by the group at 105-B were correlated. It was found that the data obtained by measurements on Van Stone flanges on the unit followed the same pattern as data obtained by microscopic examinations of cross sections of Van Stone flanges. However, subsequent measurements by the "P" Department covering the four lower rows of the pile indicated substantially greater corrosion than was shown by the overall survey data taken by Technical for the entire pile. The cause of this discrepancy is being investigated.

Data taken during a similar overall survey of the "F" pile were evaluated. These data, representing 62 tubes on the front and 64 tubes on the rear face, are as follows:

100-F Data on Van Stone Flanges on Aluminum Process Tubes

Percent with less than thickness shown

Mils	Total		0.140 zone		0.240 zone	
	Front	Rear	Front	Rear	Front	Rear
10	0	1.6	0	3.7	0	0
20	0	3.2	0	11.1	0	0
25	1.6	21.8	4.0	37.0	0	7.2
30	4.8	48.4	12.0	77.9	0	28.6
35	9.7	65.6	28.0	85.0	0	50.0

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Mils	Total		0.140 zone		0.240 zone	
	Front	Rear	Front	Rear	Front	Rear
40	19.4	82.8	40.0	100.0	0	75.0
45	33.9	95.5	60.0		7.2	96.5
50	53.1	98.5	84.0		25.0	
55	67.8		96.0		48.2	
60	87.0				71.5	
65					100.0	

Mr. Butler's group is reviewing the data from 100-F in detail to evaluate its statistical significance, and to determine the number of tests required on an operating unit to obtain reliable results. These tests will be conducted on one of the operating piles in the near future.

Preliminary work has been done this month in laying out a test program. A literature survey has been made, and a number of conferences with qualified personnel have been held. A large number of proposals for reducing pitting at the Van Stone flanges have been studied.

It is our tentative conclusion that the pitting is caused by two factors; viz., galvanic corrosion between the 18-8 (Type 304) stainless steel of the nozzle and the aluminum of the Van Stone flange, (with perhaps some galvanic action between the stainless steel dummy slug and the aluminum flange), and, secondly, concentration-cell corrosion between the gasket and the aluminum flange because of the stagnant water present, and concentration cell corrosion in the pits themselves.

To reduce the action between the stainless steel dummy slug and the flange, the most logical approach would be to cut about one-half inch off the 1-inch diameter section of the dummy. This will permit the next slug to cover the Van Stone joint completely, and protect it from any action from the dummy slug. This will also set up greater velocities in the region of the joint, and reduce the possibility of forming concentration cells.

In the present tube loading, the next slug upstream from the stainless steel dummy is an aluminum-jacketed lead slug. It is quite possible that by having this slug extend into the flange it may be preferentially corroded instead of the Van Stone joint. We propose to make a series of tests under these conditions.

It would perhaps be advantageous from a corrosion standpoint to make this slug out of some metal which would be anodic to aluminum and thereby to protect the aluminum flange from attack by the stainless steel. Although this proposal would complicate the work of the "P" Department since it would add a new type of slug to be handled, it is planned to make a number of tests using a zinc slug upstream from the stainless steel slug. (One perforated tubular aluminum slug would be removed from the column, and the exit "lead" slug moved back 8" to permit use of the zinc slug.)

Chicago reports that zinc is anodic to aluminum at a pH of 7.5 and below, offering practically complete protection. At a higher pH, the protection is only partial.

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Our present pH in the unit is 7.65, and it is believed desirable to run tests at this pH on the unit, and at the same time to make solution potential measurements in the flow laboratory at pH of 7.65 and also at pH of 7.5. We have determined that it will be entirely practical to supply the units with water of pH 7.5. This will require merely minor treatments in the lime feed in 183 building, will not result in excessive iron pick-up in the water treatment lines, and will not harm the flocculation operation. Water of a pH of 7.5 will also be similar enough to our present water to cause no concern as far as corrosion of concrete is concerned. Furthermore, the final Chicago reports evaluating the possibility of decomposition of the dichromate to the trivalent (film-forming) ion indicated that a pH of 7.5 would not cause trouble.

The proposal to lower the pH will not be made, of course, until after pilot tests have been run in the flow laboratory. If the pH is lowered, we would make careful checks on dichromate decomposition and on film-build up until satisfied that no trouble would occur.

Another proposal which we propose to evaluate in the flow laboratory and then try on the unit is to replace the present "Cranite" asbestos gasket with a soft metal gasket, such as aluminum or zinc. It is hoped that such a gasket would corrode preferentially over the aluminum Van Stone, since it would undergo accelerated corrosion by being in direct electrical contact with the stainless steel. It is possible that corrosion of the Van Stone flanges might actually be increased if an aluminum gasket were used in place of non-conducting Cranite.

Replaceable rings for preferential corrosion are being considered, as reported above, and will be tested in the "hot flow lab." However, in order to insure proper alignment of the gun barrels and the nozzles, it will probably be necessary to machine out the nozzle flanges enough to accommodate the extra thickness of the preferentially corroding metal and whatever extra gaskets are used. Under present conditions, the male end of the gun barrel carrying the Van Stone flange projects about 3/32-inch into the female end of the nozzle flange. The clearance on the diameter of these two pieces is 0.015-inch, and this interlocking action is used by Maintenance to align the nozzles properly.

We have also been considering the possibility of eliminating the corrosion between the aluminum joint and the stainless steel by eliminating the stainless steel. The general proposal is that the shoulder against which the Van Stone joint rests be replaced by an expendable aluminum piece. The most practical idea on how this could be accomplished was submitted by W. P. McCue, who suggested that we place an aluminum sleeve in the hole through the flange and form a Van Stone collar to cover the top of the shoulder. One of these units has been made up for test. It appears to be mechanically sound, but requires considerable machining of the flange.

It has been proposed that in order to correct badly corroded Van Stone flanges they be soldered with the new aluminum solder.

We have requested the Maintenance Department to investigate the possibility of metallizing the stainless steel flanges with aluminum, but this proposal will require considerable shop work, including possibly machining the flanges for smoothness after the metallizing.

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GRAPHITE EXPANSION - W. R. Lewis, J. T. Carleton

Summary

Preliminary measurements of the stress existing in the top shield of the D Pile have been made. A stress of 42,000 psi was indicated at one point in one weld.

The coating of aluminum tubes with "Aquadag" has been recommended for reducing galling of a new tube as it is pushed into the pile if the old tube were badly galled during removal.

Jacking tests at the D Pile indicate a more rapid reduction in gun barrel sum-clearance at the top of the pile than in the center of the pile.

Details

A preliminary investigation of the stress in the Biological Shields was made by Mr. D. R. Miller of the General Engineering and Consulting Laboratory during his visit to this plant. This work is described in a memorandum from D. R. Miller to file, Document HEW-7374.

Tube 4385-B was removed several months ago in connection with studies of gun barrel binding and endwise graphite expansion. When a new tube was inserted in this position a force of 500 to 1000 pounds was required to push the tube in and the tube was badly galled. In order to eliminate or reduce this galling a tube was coated with "Aquadag" to serve as a lubricant. A force of 100 pounds or less was required to push this tube into the unit which indicates that the galling was greatly reduced. Samples of "Aquadag" were tested in the 305 Pile for neutron absorption. The results indicate that if all tubes in the unit were coated the loss of reactivity would be about one i.h. The possible corrosion of aluminum when coated with "Aquadag" will be investigated but because the possibility of corrosion is remote the use of "Aquadag" has been recommended on replacement tubes if the old tube were badly galled during removal.

The gun barrel sum-clearance of eight tubes at the D Pile was measured on August 19. Previous jacking tests of these tubes had indicated gun barrel binding or a very small clearance. The nozzles were removed from the tubes and each gun barrel pushed into the unit with a force of 1500 pounds. The projection of the tube was then measured. Tests made in this manner should give a better indication of the gun barrel clearance than tests in which the tube complete with gun barrels and nozzles is jacked as a unit. However, it is still possible that more clearance exists between the gun barrel and graphite. This clearance would be available only if the tube were under more than 1500 pound tension. The data obtained is given in the following table:

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GUN BARREL CLEARANCE TESTS

D PILE

AUGUST 19, 1947

Tube	Movement of Front Gun Barrel	Force Required on Front	Movement of Rear Gun Barrel	Force Required on Rear	Tube Projection at Front	Tube Projection at Rear	Total Tube Projection	Sum Clearance at 5°C. Aug. 1946	Jan. 1947	Aug. 19, 1947
3366	0	1500#	16/32"	500#	0	16/32"	16/32"	14/32"	11/32"	10/32"
3959	7/32"	700#	13/32"	600#	0	14/32"	14/32"	14/32"	12/32"	8/32"
3974	4/32"	900#	12/32"	600#	0	16/32"	16/32"	----	----	10/32"
3985	4/32"	900#	12/32"	600#	0	10/32"	10/32"	----	----	4/32"
4088	0	1500#	11/32"	1100#	0	6/32"	6/32"	----	----	0
4188	7/32"	800#	7/32"	500#	3/32"	12/32"	15/32"	16/32"	12/32"	9/32"
4474	4/32"	900#	6/32"	600#	0	7/32"	7/32"	11/32"	7/32"	1/32"
4574	0	1500#	11/32"	1300#	0	8/32"	8/32"	----	----	2/32"

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IRRADIATION STUDIES - S. S. Jones and J. C. Chatten

Summary

The thermocouple slug assembly in Tube 1367-F was discharged on August 10 after an average accumulated exposure of 210 MD/ton. The thermocouple assembly in Tube 2679-F indicated no significant change in slug axial temperature during the month.

An empirical relation has been obtained for determining the thermal resistance between a slug and a dry tube.

A recommendation has been made to P Department concerning the allowable time that the water flow may be interrupted from a process tube after shut-down. The experimental data thus far obtained have agreed with theoretical calculations.

Fabrication of the bending and tensile machine and of the hardness testing machine for the underwater laboratory has continued.

Design of the can opener facility has been modified to permit several varieties of special slugs which are being proposed.

Close liason is being maintained with Project Engineering in the design of a rear face charging mechanism to be used in conjunction with the two-step irradiation of uranium.

Details (S. S. Jones)

Measurement of Slug Axial Temperature (Production Test No. 105-80-P)

The first thermocouple slug assembly to be charged into the 100-F Pile was discharged on August 10. The metal in the tube had accumulated an average exposure of 210 MD/ton, while the thermocouple slug had an exposure of 305 MD/ton. No difficulties were encountered during the discharge; metal flashing was suspended under the outlet end of Tube 1367 to prevent any entanglement of the assembly with the outlet nozzles, pigtails, etc., and the hand-charger was used to avoid any sudden surges of the charge which might cause the assembly to swing out and become entangled. The detailed procedure will be reported in a forth-coming interim report.

There was no significant change in the thermocouple slug axial temperature during the month. The data are shown in Table I.

TABLE I

SLUG AXIAL TEMPERATURE

Tube No.	1367	2679	2679	2679
Date	Aug. 1		Aug. 15	Aug. 26
Exposure $\frac{\text{Meg. W. Days}}{\text{Adj. Ton}}$	305	175	103	202
Test Duration - Weeks	29.3	16.7	18.7	20.3
Slug Axial Temp. °C.	128	115	113	117
Inlet Water Temp. °C.	19.1		19.9	20.1

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TABLE I (continued)

SLUG AXIAL TEMPERATURE

Local Water Temp. °C.				
from Adj. tubes	38.0	32.2	32.6	33.1
from test tube	41.5	35.3	35.8	36.1
Slug Temp. above Local Water (Δt_s)				
based on Adj. tubes	90.0	81.9	80.0	83.9
based on test tube	86.5	79.7	77.2	80.9
Local Water Temp. above inlet Water (Δt_u)				
based on Adj. tubes	18.9	13.1	12.7	13.0
based on test tube	22.4	16.2	15.9	16.0
Ratio: ($\Delta t_s/\Delta t_u$)				
adj. tubes	4.75	6.25	6.30	6.45
test tube	3.86	4.92	4.85	5.05

Heat Transferred from Slug in Dry Tube

Chatten and Jones obtained experimental data on the rate of heat transfer from a copper slug in a dry process tube to this process tube which was kept in a constant temperature water bath. This data is about to be issued as a report, but is briefly summarized below.

The three heat transfer paths from the slug to the tube are:

1. Radiation from hot slug to cold tube wall.
2. Conduction and convection of heat across the air annulus.
3. Conduction of heat across the tube ribs.

There is considerable difference in the relative importance of these three paths. Below a slug temperature of 250°C. the radiation effect accounts for less than 2 per cent of the heat transfer. Up to this temperature the conduction and convection of the heat through the air accounts for an average of 60 per cent and the tube ribs account for approximately 38 per cent.

An empirical dimensional equation was developed that should apply to cases where a gas other than air is used in the annulus, as follows:

$$g_r = (54\, k_a + 0.47)\Delta t$$

Where g_r = radial heat flow from slug to tube, watts per foot of length.
k_a = thermal conductivity of gas, BTU/(hr.)(ft.)(°C.)
Δt = temperature difference between slug and tube, °C.

Interruption of Water Supply to Tube During Pile Shut-down

The results of theoretical calculations on this subject have been summarized in a letter, S. S. Jones to J. E. Maider, August 26, 1947. Subsequent to this letter experimental data were obtained on this subject by use of the thermocouple slug in Tube 2679-F.

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TABLE II - INCREASE IN SLUG TEMPERATURE UPON INTERRUPTION OF WATER FLOW

Time after Shut-down Hours	Time water has been shut off Minutes	Rate of Temperature Rise of Slug, °C./min. Calculated	Exp.	Steady State Slug Equil. Temp. above inlet water temp., °C. Calc.	Experimental
1.5	2	5.5	9	—	—
	3		7	—	
	4	5.4	4	—	—
3.7	2	4	3.5	—	—
	3	4	3.0	—	—
5.0	54	—	—	51	32

A comparison of the experimental and the calculated data is shown in Table II. It should be noted that because of cooling effects we should expect the thermocouple to give a lower equilibrium temperature than the maximum value for the metal in that tube. The rate of temperature rise, however, after the initial gradient has been set up should be in good agreement. This is essentially the case with the calculated values giving somewhat more conservative results.

Details (J. C. Chatten)

Underwater Laboratory (Building 212-N)

Combined Bending and Tensile Machine

During the month of August, fabrication of this machine has proceeded to an estimated 90% of completion. At this writing, installation in Building 212-N is scheduled to start September 9, 1947.

A proposal to provide stress and strain measuring facilities for this machine was received during the month from the General Engineering and Consulting Laboratory. This proposal was examined and found to be satisfactory, and an order was placed with the laboratory for fabrication. The design of a Foot Block for this machine has been held up pending receipt of this proposal. Since the space requirements of the strain gages is now established, it is possible to complete the machine design and fabrication.

Hardness Machine

Fabrication of the equipment necessary to adapt the Universal Testing Unit (Rockwell Hardness) to underwater work is estimated to be 40% complete. Installation is scheduled to start in Building 212-N September 9, 1947 and to proceed along with shop fabrication.

Profilometer

Little progress has been made during the month on the design of equipment for

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reproduction of the surface contour of blistered slugs. A 6-inch Atlas Bend Lathe has been received for modification into the Profilometer. Electrical and electronic phases of the design will be handled by the Instrument Department, and the mechanical design and fabrication by Project Engineering.

Can Opening Facilities

The design of facilities to open irradiated receptacle slugs and withdraw capsules is 85% complete.

Three models of slugs are under consideration for opening; (a) 300 Area Plant Assistance Group design for 1/2-inch tube irradiations, (b) alpha experiment designed by the Research Laboratory (R. Kanne), and (c) Iron can, sodium filled, designed by General Engineering Laboratory (D. R. Miller).

The facilities are being designed for remote operation inside casks. Shielding is being incorporated in the casks to permit handling without encountering radiation levels above tolerance.

Segmented Discharge

Two design engineers and two draftsmen of the Project Engineering Group are independently working on the design of equipment for remote rear face charging of dummy slugs. Present thinking is directed towards charging uranium slugs in place of front face (upstream) dummy slugs. All charging of uranium would be handled from the front elevator in normal fashion. A push rod would be used to discharge rear face (downstream) dummy slugs and a segment of the irradiated uranium. The rear face charging machine would be remotely operated to place downstream dummys in the column.

Facilities will be designed, built and operated on mock-up tubes to prove successful operation prior to application on the units.

W. K. Woods

W. K. Woods
Technical Department

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