HDC-1601

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January 16, 1950

GENERAL ELECTRIC COMPANY

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HANFORD WORKS

DESIGN AND CONSTRUCTION DIVISIONS

REACTOR DIVISION

PROGRESS REPORT NO. 2

DESIGN OF NEW PILE AREA "G"

PROJECT C-300

ATOMIC ENERGY COMMISSION DIRECTIVE HW-104

PERIOD JUNE 1, 1949 TO DECEMBER 31, 1949

RECEIVED
JUL 27 1956
300 AREA
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Submitted by P. E. Lowe
1/24/50

Approved by W. E. Johnson
1/27/50

This document consists of
83 pages [redacted]
[redacted]

[redacted]

Plus attachments consisting of 32 Figures:

√ HDC 4001 copy 33, B p. 59	√ SP 10431 p. 44
√ HDC 4002 copy 33, B p. 49	√ SP 10255 p. 45
√ HDC 4003 copy 33, B p. 51	√ SP 10307 46
√ HDC 4004 copy 33, B p. 67	√ SP 10206 47
√ HDC 4005 copy 33, B p. 67	√ SP 10213 48
√ HDC 4006 copy 33, B p. 56	SP 10387 63
√ HDC 4007 copy 33, B p. 58	SP 10351 64
√ HDC 4008 copy 33, B p 54	SP 10584 66
√ HDC 4009 copy 33, B p 55	SP 10426 69
√ HDC 4010 copy 33, B p. 32	SP 10595 71
	SP 10591 72
√ HDC 3935 copy 33, B p 41	SP 10452 75
√ HDC 3936 copy 33, B p. 39	SP 10691 77
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Plus 5 other figures in Section III and 2 other figures in Section II

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-2-

January 16, 1950

GENERAL ELECTRIC COMPANY

NUCLEONICS DEPARTMENT

HANFORD WORKS

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REACTOR DIVISION

PROGRESS REPORT NO. 2

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ATOMIC ENERGY COMMISSION DIRECTIVE HW-104

PERIOD JUNE 1 1949 TO DECEMBER 31, 1949

Approved: W.E. Johnson
Date 1/27/50

Submitted by: P.E. Lowe
Date Jan. 24, 1950

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GENERAL ELECTRIC COMPANY
NUCLEONICS DEPARTMENT
REACTOR DIVISION

January 16, 1950

W. E. Johnson, Manager
Design & Construction Divisions
HANFORD WORKS

PROGRESS REPORT NO. 2

DESIGN OF NEW PILE AREA "G" - PROJECT C-300

Transmitted herewith is the progress report for the design and development of Pile Area "G", to cover the period June 1, 1949 to December 31, 1949.

This project now represents the major effort of the Reactor Division of the Design and Construction Divisions. It is being pursued with the aim of being able to incorporate the major project objectives in a finished pile design if this design is begun about January, 1951.

Comment on the content is invited from those to whom the report is directed.

P. E. Lowe

Manager
Reactor Division

PE Lowe:jm

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-4-

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PROGRESS REPORT NO. 2

DESIGN OF NEW PILE AREA "G" - PROJECT C-300

INDEX

Index
Progress Report No. 2 - Design of New Pile Area "G" - - Page 2

Section III - Hanford D&C Test Program (Continued)

Index
Progress Report No. 2 - Design of New Pile Area "C" - Page 3

SECTION IV - REFERENCE DOCUMENTS

HDC 1601

SECTION I

INDEX

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INTRODUCTION

GENERAL

During the past seven months, Reactor Division (D&C) efforts have been increasingly directed to the design and development of an improved thermal reactor. This work, entitled "Design of New Pile Area "G", is authorized under Project C-300, original Directive HW-104.

This report is complementary to the Progress Report dated May 25, 1949, (Document HDC-1176). It is written to present the progress toward firm design bases during the report period, and to clearly establish the position of the program with respect to the original schedule.

PROGRESS TO DATE

There has been no major modification of the design bases in the report period. The principal components have been analyzed and the design objectives have been set for each as a "subproject". Noteworthy progress by subproject has been tabulated under the summary. Five are emphasized here.

Equipment is on order for the basic heat transfer tests and the water study "recirculation" tests. Plans are near completion for installation in Bldg. 189-D and Bldg. 105-H respectively.

Temperature coefficient test results from the start-up of the 100-H Pile are of major significance, as reported by the Pile Technology Division. The coefficient, which has been observed to be positive for the wet pile, is negative for the dry pile. This consideration has reduced the needed safety control by 20 per cent. At the lower control level, sheet rods and cylindrical rods are essentially equivalent. This will permit selection of rod design upon an engineering basis.

Design has been completed for charge-discharge equipment capable of operation at full coolant flow. Fabrication and test of components is underway.

Preparation for exponential pile tests have been started by the Pile Technology Division. These are to provide the basic matrix dimensions for the "G" design. It is worthy of note that the date on which this specification is available is the limiting one for starting the finished design.

DELAYING FACTORS

Two important delaying factors have been encountered since HDC-1176 was written: 1) procurement of essential test equipment components was held up approximately three months pending allocation funds, 2) high priority requests for assistance from the Hanford Technical Division threatens to interfere with the assistance needed in the development of Pile "G".

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Efforts to somewhat offset the delays are being made, principally through: 1) expediting delivery of test components, and 2) sponsoring a series of Reactor Division Production Tests to reduce requirements of the Technical Division.

SCHEDULE

Consideration of the above factors indicates that firm design criteria will not be available prior to January, 1951. With the start of final design at that time, the schedule on Page 7 will apply. This represents a six-months' extension of the previous schedule.

FINANCES

Close control is being maintained of all expenditures under the program. A tabulation of costs, plus commitments, to December 31, 1949, is presented on Page 8. The budgeted amounts of $1,129,812.00 total to June 30, 1950, and $4,157,100.00 for completed design, including $1,200,000.00 for Architect-Engineer services remain valid.

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HDC 1601

DEVELOPMENT STATUS

H. E. Grantz

ULTIMATE OBJECTIVE

The ultimate objective of the "G" Reactor program is to prepare and have available a complete detailed design of a graphite moderated, water-cooled pile incorporating the best practice in the nuclear field and capable of operating at 800 MW. The objective is further described in Project Proposal HDC-1365.

In order to achieve this ultimate objective, the following supporting objectives must be attained:

1. The experimental and developmental programs, now planned and/or in progress, must be completed in order to obtain the factual data upon which the design will be based.

2. The design studies must be carried out in parallel with the above programs so that the results of either activity can be reflected in the other as effectively as possible, and without both a serious loss of time and additional expense.

3. The supporting investigations at offsite facilities must be continued and completed as expeditiously as possible so that the results will be obtained when required.

The above major phases must be carried out in such a manner that ALL the results will be obtained at the time required for detailed design. Otherwise, work will be held up or changed with resulting increase of both cost and time to complete.

SUMMARY

At the beginning of this report period (June 1, 1949), the exploratory studies (Phase I), as well as supporting design investigations, had been completed and the general objectives of the program had been established.

During the following seven months, preliminary designs were well developed on the critical subprojects of this program. In many cases, the preliminary designs were completed to the point where experimental samples could be made and tests were run or are in process to evaluate design proposals and also to provide valuable data.

Considerable effort was applied in the design, analyses, planning and procurement associated with the complex Process Tube Heat Transfer and Recirculation Water System Programs. Both of these tests should be set up and running by June 30, 1950.

Investigations were started at various sites to obtain the physical properties of materials being considered for process tubes and control rods. A corrosion test program was started at Hanford using actual pile process water. Corrosion tests in pile gas atmosphere will be started soon. The use of rare earths (such as gadolinium) is being investigated thoroughly for control rods.

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HDC 1601

Development Status (Summary) - Continued

The following progress can be reported for each major subproject:

Subproject	Summary	Full Report on Pages
1. Process Tube Heat Transfer	Test arrangement design completed. Installation approved for Bldg. 189-D. Test Equipment ordered. Considerable effort spent on analyses.	9, 21, 31, 22 and 32
2. Water System Studies	A test recirculating water system was designed for operation in "H" pile. Test authorization written and material and equipment ordered.	17 and 35
3. Third Safety Device	Ball system selected. Test equipment designed.	12 and 34
4. Materials	Rare earths alloying investigations started. Encouraging results obtained alloying gadolinium and titanium on laboratory scale. Process tube creep and corrosion tests started.	11, 23, 20, 36 and 37
5. Control Design and Development	Full-scale sheet rod drop tests run with graphite stack straight and also bowed to simulate conditions of pile distortion.	9, 12 and 25
6. Shielding	Design and physics studies of concrete shield in process. Preliminary structural design 60% complete.	14
7. Metal Handling - Continuous Charging Equipment	Detail drawings of charging machine 90% complete. Discharging machine drawings being checked. Test program being planned.	13, 19, 28, 21, and 30
8. Moderator	Preliminary design of external binder for moderator block 60% complete. Layouts made for "special purpose" process tubes.	16, 27, and 33

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HDC 1601

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Development Status (Summary) - Continued

Subproject	Summary	Full Report on Pages
9. Gas System	Preliminary graphite drying tests completed. Report HDC-1424 issued on cooling of control rods.	15 and 24

[redacted]

[redacted]

OVERALL COST ESTIMATES

E. A. Smith

PHASE I

The first phase of Project C-300 consisted of a series of studies which resulted in a definition of the extent to which design for the new pile is to be refined. This work was completed in fiscal year 1949.

$250,000.00 was allocated to this portion of the project. Expenditures amounted to $159,812.00, leaving an unexpended balance of $90,188.00.

PHASE II

Phase II consists of developmental design work to take place during fiscal years 1950 and 1951. It was estimated that a total of $970,000.00 would be required in fiscal 1950. In addition to the unexpended balance of $90,188.00 from fiscal year 1949, new funds in the amount of $879,812.00 were requested in July, 1949. This request was deliberated for approximately three months. In October, an emergency appropriation of $40,000.00 was granted in order that the engineering force might be maintained and limited design continued.

During this interim period, expenditures for experimental tests and materials were held to a bare minimum. Purchase requisitions for long term delivery items had to be delayed until funds were appropriated.

The request for additional funds was formally approved on November 1, 1949, and the full-scale program was immediately launched.

Presently, it appears that the estimate of $970,000.00 for fiscal year 1950 is ample. Actual expenditures for the first half of the fiscal year are under 20% of the total estimate of $970,000.00. However, it is expected that, due to the stepped-up program during the next six months, total expenditures will be approximately as estimated.

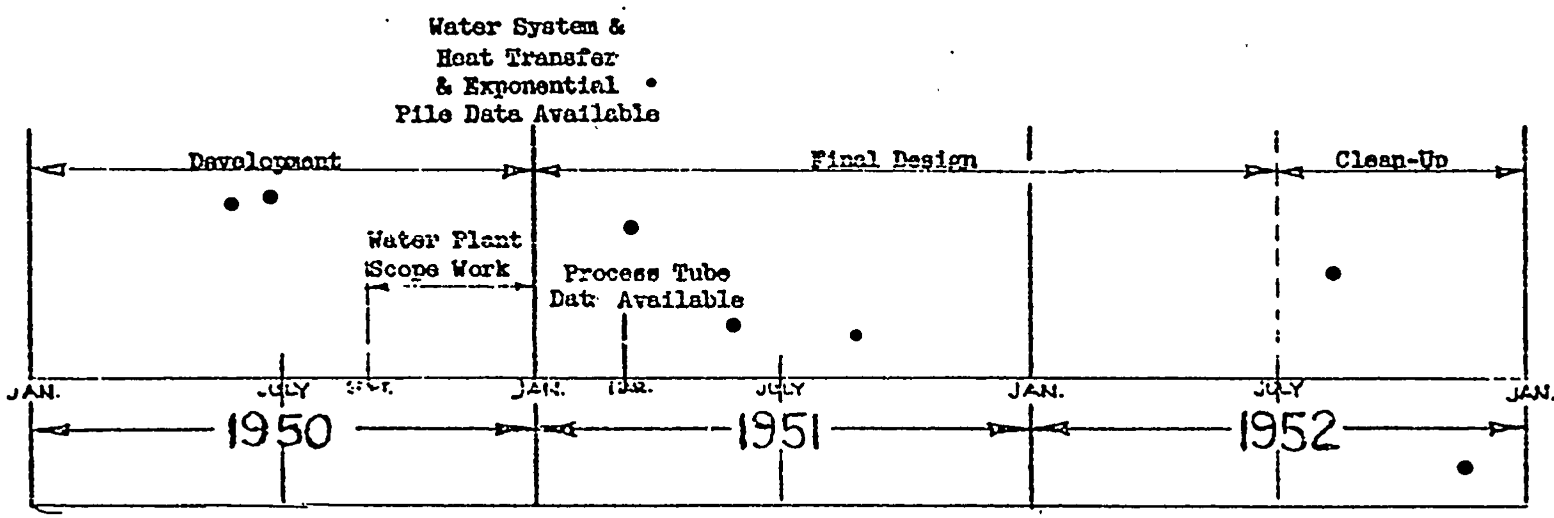
The following financial statement shows cost plus commitments for the first half of this fiscal year, estimated expenditures for fiscal 1950, and the balance to be expended in the last half of the fiscal year.

[redacted]

January 1950

REACTOR DIVISION

Design Schedule for 100-G Area



HDC 1601

-16-

HANFORD WORKS - REACTOR DIVISION
FINANCIAL STATEMENT PILE AREA "G"
FISCAL 1950 - PERIOD ENDED 12-31-49

JOB TITLE	Budget Estimate: Engineering	Budget Estimate: Drafting	Budget Estimate: Experimental Test: Material	Budget Estimate: Experimental Test: Direct Labor	Budget Estimate: Total 2	Balance 3 (1 minus 2)	Actual Expenses: Reactor Division	Actual Expenses: P. & M. Division	Actual Expenses: Total Engineering	Actual Expenses: Drafting	Actual Expenses: KAPL and Consulting Laboratory	Actual Expenses: Other Hanford Divisions	Actual Expenses: Other Agencies	Actual Expenses: Experimental Test: Material	Actual Expenses: Experimental Test: Direct Labor	Actual Expenses: Indirect Expense	Actual Expenses: Commitments	Actual Expenses: Total 2
Heat Transfer	47,715	11,700	159,132	41,495	260,042	85,886	11,174		11,174	3,001	1,287			650	979	2,304	154,761	174,156
Third Safety	35,746	22,580	5,000	24,000	87,326	50,807	7,197		7,197	6,275						1,437	21,610	36,519
Control Rods	57,074	25,100	17,929	41,369	141,472	91,672	11,939	493	12,432	6,662				9,650	1,878	2,732	16,446	49,800
Shielding	19,716	18,254	6,000	38,400	82,370	70,088	5,279		5,279	5,811						1,192		12,282
Water Plant/Studies	26,755	7,000	51,300	72,000	157,055	8,317	5,025	1,723	6,748	3,253						951	137,786	148,738
Moderator	14,584	11,500	2,505	12,004	40,593	28,808	3,496		3,496	5,793				[illegible]	[illegible]	732	1,332	11,785
Gas System	9,448	5,100	210	8	14,766	11,282	1,748		1,748	910				27	8	366	465	3,524
Process Tubes	25,676	17,200	7,975	12,684	63,535	14,823	3,496		3,496	3,139				485	84	732	776	8,712
Metal Handling	20,314	24,400	5,291	15,117	65,122	30,639	3,154		3,154	20,139				1,320	743	655	8,476	34,483
Instrumentation	5,263	2,900	2,724	5,402	16,289	10,958	1,653	246	1,899	774				1,228	900	339	191	5,331
Other Engineering	10,577				10,577	9,039	1,200		1,200							338		1,538
Administration and Control	40,853				40,853	33,779	5,827		5,827							1,251		7,078
Total	303,721	145,734	258,066	262,479	970,000	476,054	61,188	2,462	63,650	55,757	1,287			13,764	4,596	13,029	341,863	493,946
(a)																		2,320
																		496,266

This report covers actual expenses to 12-1-49 and commitments to 12-31-49. Engineering and Drafting for December was estimated and is included.

(a) $2,320.00 Assessments from Manufacturing Divisions. Detailed analysis is being made and charges will be distributed to applicable sub-projects.

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SECTION II

ANALYSES, DESIGN AND INVESTIGATIONS

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SECTION II

ANALYSES, DESIGN AND INVESTIGATIONS

1. PILE PHYSICS DESIGN - P. F. Gast (Pile Technology Division)

The major development in pile physics as applied to the "G" Pile design was the demonstration that the present Hanford lattice has a negative reactivity temperature coefficient when the cooling tubes contain no water. This demonstration was made experimentally during the "H" Pile start-up program. The requirements for safety control can now be considerably reduced since it will not be necessary to compensate for an increase in reactivity due to fission product heating of a pile which has lost its cooling water. Sufficient control can now be provided by a vertical rod pattern similar to that of the present piles in which a choice of round rods or flat sheet rods can be made on engineering grounds alone.

Information was provided to the Design Division on the following points:

1. Reactivity changes to be expected from change in pile dimensions.

2. Reactivity loss from increased cooling water annulus.

3. Effects of flattening on the neutron distribution.

4. Shielding effectiveness of proposed gun barrel designs.

2. EXPONENTIAL PILE PROGRAM - P. F. Gast

Permission to proceed with the program of exponential experiments directed toward improved graphite lattices using natural uranium was received from the Atomic Energy Commission on October 31.

These experiments will be carried out in space formerly used for inspection and test lay-up of graphite for the piles. Preparation of this location and installation of the necessary facilities is in progress. At the end of the report period graphite was being machined for a standard pile to be used throughout the course of the experiments for calibrating and checking foils, foil counters, and neutron counters.

3. HEAT TRANSFER PROGRAM - H. S. Isbin (Reactor Division)

This program was initiated to obtain basic design data for process tube heat transfer in order that the selection of tubes for the proposed "G" reactor will be on a sound factual basis. Factors being considered include power level, temperature characteristics and pressure requirements.

[redacted]

[redacted]

Section II (Heat Transfer Program) - Continued

Other phases of this program include graphite temperature calculations, determination of water requirements, and an analysis of power limitation factors. These phases will be evaluated by the Reactor Division in cooperation with the Technical Divisions.

POWER LEVEL AND TEMPERATURE CHARACTERISTICS

An 800 MW power level has been selected as a design basis. This basis, established in Document HDC-1176, does not necessarily represent an optimum design, but does present significant improvements whose achievements will markedly advance the reactor program.

The maximum performance tube load design has been set at 552 KW corresponding to a maximum heat generation of 33.6 KW per foot. Whereas the active section is to be the same as for present pile, the annulus is to be increased from 0.351 sq. in. to 0.439 sq. in. For a flow rate of 34.6 g.p.m. (inlet temperature of 70°F) the outlet temperature is 179°F, and the maximum surface temperature (clean tube, no rib effect) is 190°F. The temperature distributions with length of active zone for the water, slug surface, and slug center temperatures are given in Figure 1.

PRESSURE REQUIREMENTS

Experimental tests have been completed to determine pressure drops for both water-steam and water flow through standard process tube assemblies. The correlations, reported in Documents HDC-1560 and HDC-1565, have been adapted for the calculation of the pressure-flow curves shown in Figure 2. The conditions selected for presenting the pressure drop over a tube assembly (including inlet and exit pigtail, but with no orifice) are noted as the following: clean tube, increased annulus cross-section (0.439 sq. in.), 552 KW heat load, standard dummy section (B, D & F piles), standard pigtail assemblies.

The calculated normal operating pressure drop from inlet to exit nozzle for the "G" process tube with a 34.6 g.p.m. flow rate is 180 p.s.i., which is the same as that for present operation in "H" with a flow rate calculated to be 23.3 g.p.m.

The "G" Pile calculated boiling peak pressure drop from inlet header to exit header (including critical discharge pressure) can be compared to 500 MW pile operation (HDC-1565) with tubes of present design.

KW Per Tube	Oper. Level MW	Peak Pressure Drop
552	800	390 p.s.i.a.
412	500	340

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HW 1301

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— Fig. 1 —

MAXIMUM PERFORMANCE TUBE TEMPERATURE CHARACTERISTICS
800 MW POWER LEVEL

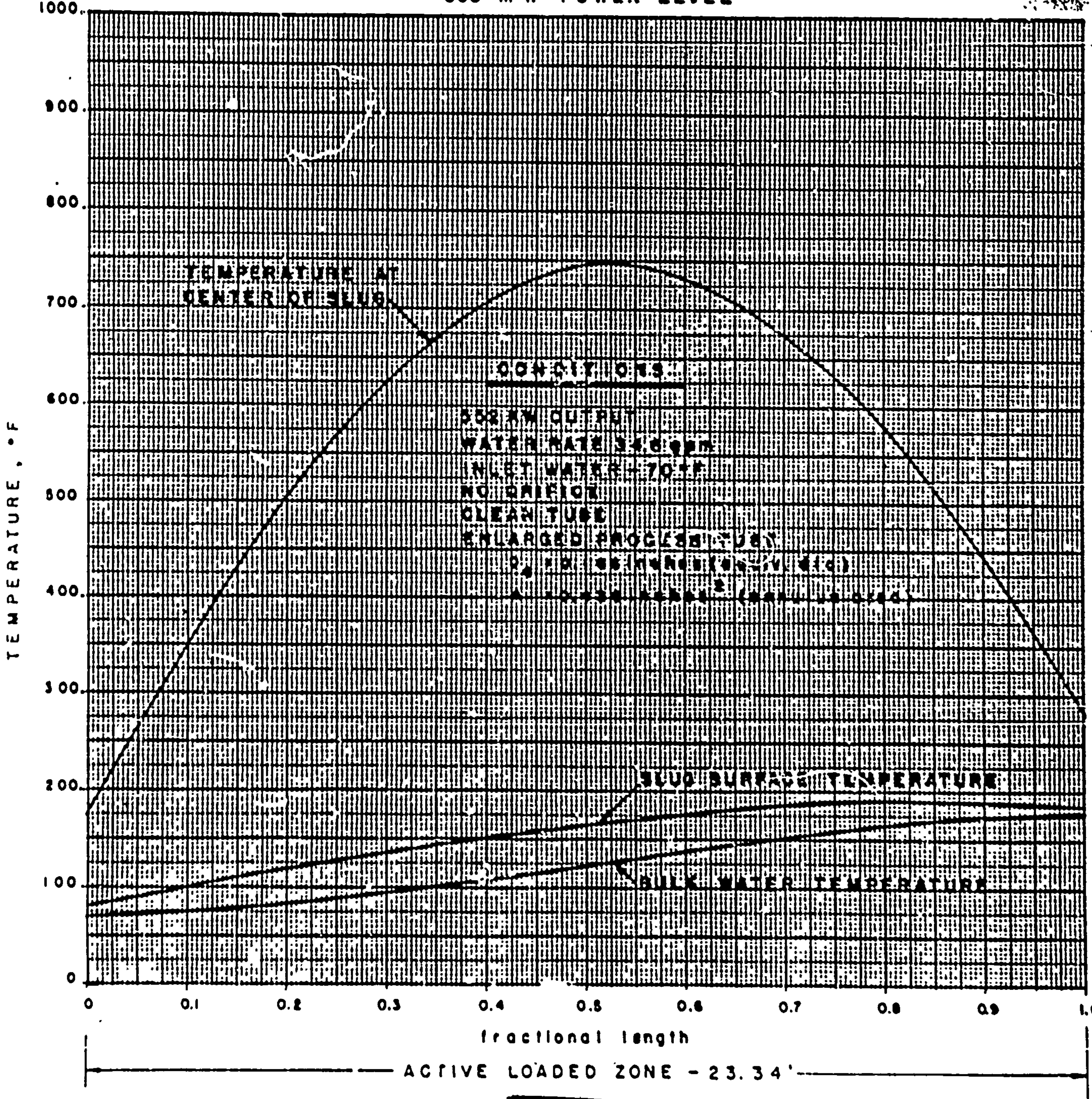

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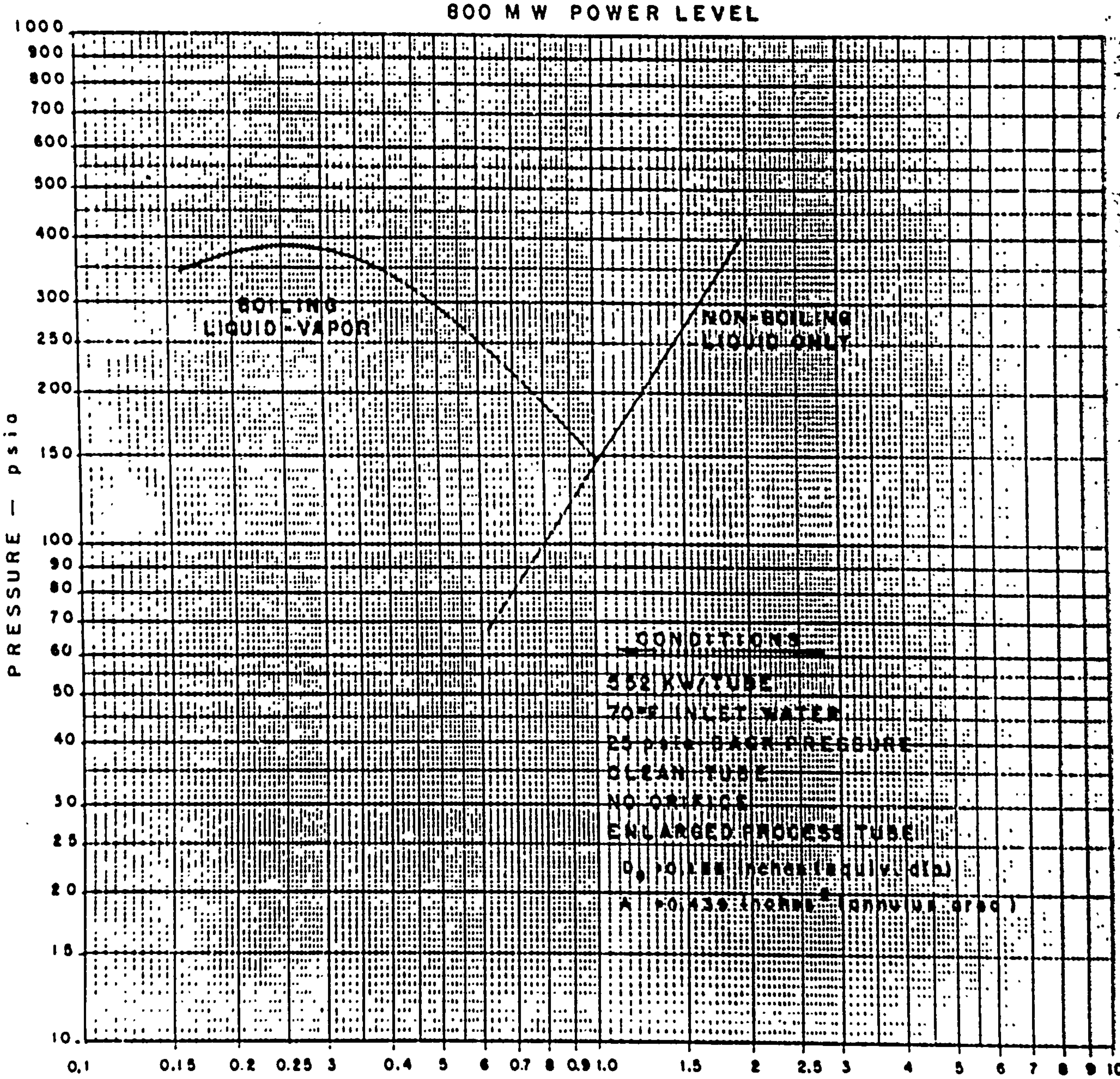
Fig. 2

MAXIMUM PERFORMANCE TUBE PRESSURE FLOW CURVES
800 MW POWER LEVEL



$\frac{W}{10^4} = \frac{lb}{hr}$

(FOR gal/min., MULTIPLY SCALE BY 20)

[redacted]

Section II - Heat Transfer Program (Continued)

Specification of the header pressure characteristics is to be determined upon the basis of the results obtained from the heat transfer tests.

HEAT TRANSFER TESTS

Heat transfer tests are to be conducted with full-size process tubing and simulated slug heating conditions. Progress on the design and construction of the full-scale and short-length tests is described in Section III, Hanford Tests. These investigations will more clearly define the "boiling disease" and results and conclusions from these tests will establish the design basis for determining operating pressure requirements and verify the above stipulated operating conditions.

4. MATERIALS DEVELOPMENT - R. J. Schier (Reactor Division)

Design objectives set forth in this project required two principal metallurgical developments: (1) process tube materials and (2) control and safety rod materials. Since useful design data on possible materials for these two components are practically non-existent (in some cases, suitable materials were non-existent), it has been necessary to establish development programs at Hanford and other sites to obtain these data. These programs have been set up to find suitable materials for a first pile design in the shortest possible time, but long-range programs are in effect to develop optimum constructional materials.

PROCESS TUBES

The most severe operating conditions contemplated for process tubes are a wall stress of 5860 p.s.i. at 100°C. To be satisfactory, a tube material must have a creep rate less than 0.09% per year (corresponding to a diameter expansion of about 0.001" per year) under these conditions with adequate corrosion resistance to process water.

A creep test program on 2S process tubing has been started at Hanford to determine whether the present 2S aluminum constructional material is satisfactory. Supplementing this test, a similar testing program has been arranged at Battelle to obtain more precise and complete design data which will permit a comparison with comparable data on possible aluminum alloy substitute materials should the present 2S aluminum prove to be inadequate. A corrosion test program is under way at Hanford to evaluate both standard and new aluminum alloys in process water to check these substitute aluminum alloys.

The meager data available on zirconium indicates that it shows promise of being an excellent tubing material for a Hanford reactor. A long-range program is underway to evaluate the physical properties, fabrication and corrosion resistance of zirconium. Investigation of the corrosion characteristics of this material in process water, underway at Hanford is the first step.

CONTROL AND SAFETY RODS

The different conditions under which the safety and control rods will be required to function permits a choice of materials for those two types of rods. For the first design, Type 304 stainless steel has been selected as a base metal for neutron absorbing alloys in spite of its less desirable nuclear properties (high gamma activity after irradiation) because of its known adequate physical properties at temperatures up to 600°C. The alloy of stainless steel with boron (1 to 3%) has been selected for safety rods and with gadolinium (1 to 3%) for control rods. A program has been started at the General Electric Research Laboratory in Schenectady to develop alloying techniques and suitable alloy compositions.

In a long-range program both titanium and vanadium presently appear to be satisfactory base metal for control rod alloys. Development programs have been started to evaluate titanium base alloys containing up to 5% boron and 5% gadolinium. Design of equipment for evaluating the corrosion resistance of these alloys in simulated pile atmospheres at Hanford has been completed.

5. CONTROL SYSTEM DESIGN - A. T. Strand (Reactor Division)

The objective of the control system design is to provide an integrated control system which has sufficient inhour capacity to adequately control the process unit under all conditions of operation and emergency. In addition, the control system should be simple, safe, and economical in construction, operation, and maintenance.

Design is proceeding on an all-vertical rod system. Original plans for ninety rods have been reduced to approximately forty, depending on configuration. The 11¼" wide sheet rods are essentially equivalent to 3" dia. cylindrical rods. A total of 2500 inhours of control is required as determined from data obtained by the Technical Divisions during "H" Pile start-up. The control effectiveness is being further analyzed.

Rod design problems, including heat transfer, "poison" burn out, and "poison" concentrations are being studied intensively.

The following results can be reported from these studies:

1. Gas cooling of gadolinium alloyed control rods is feasible, but water cooling will probably be required for boron alloyed rods.

[redacted]

Section II - Control System Design (Continued)

2. The following percentages of alloying agent will be required:

Rod Material	Safety Rod	Control Rods
Stainless Steel - gadolinium	0.33%	3%
Stainless Steel - boron	1.2%	2%
Titanium - gadolinium	0.60%	5.2%
Titanium - boron	2.0%	3.5%

A rod drive using friction rollers (similar to that used on a board drop hammer) and powered by a hydraulic motor is being designed to drive the rod. The hydraulic system may also serve to decelerate the rod at the end of a normal, free fall operation. An inverted thimble for a gas seal around the rod, and incorporating the rod guide rollers, has been determined to be the most feasible type of seal and design is proceeding on this basis.

Full-scale components for mechanical evaluation of the control systems have been fabricated and assembled at the Test Tower previously built for 105-DR and "H" pile tests. Sheet rod bowing and drop tests are approximately two-thirds complete and show that a sheet rod may be dropped within three seconds, even though the graphite slot is bowed to a maximum of four inches at the center. Negligible graphite wear has been observed in these tests.

An auxilliary safety control system is being designed consisting of "poison" balls stored in hoppers located in the shield, with mechanisms to release the balls into the rod slots in the graphite. Calculations indicate that this ball system will give as rapid and effective control as the sheet rod pattern. Mechanical evaluation tests for the ball system are planned and underway.

A "postum" production tube pattern of approximately 85 tubes, perpendicular to the process tube pattern, has been included in the design plans. A safety control system that would inject "poison" solution into these tubes is being studied.

6. <u>CHARGING MECHANISMS AND METAL HANDLING</u> - Phil P. Smith (Reactor Div.)

CHARGING MECHANISMS

Pursuing the dual course outlined in HDC-1176, work on methods for charging the pile during full power operation has progressed as follows:

Method I - Layout design of a piece-by-piece charging system developed

Section II - Charging Mechanisms & Metal Handling (Continued)

by R. F. Klein has been completed. Further mechanical design is being held in abeyance until a satisfactory sealing gasket material is selected. Observation of radiation damage to possible materials is underway. Reference - HDC-972.

Method II - Two pressurized machines have been designed to provide a system offering the advantages of mechanical charging. One machine described on Drawing SP-10079 will effect remotely controlled discharge at the rear face, and the other described on SP-10080 provides for charging at the front face.

Detailed design of both basic machines is virtually complete except for dimensional checking, and it should soon be possible to enter upon a program for testing the prototype machines. Reference: HDC-987.

METAL HANDLING

A preliminary report, in a limited edition (HDC-1406) has been issued. This report presents suggestions and recommendations for planning the metal handling facilities of the pile building.

7. SHIELDING - R. T. Jaske (Reactor Division)

Work on pile shielding has followed the original consideration of producing a shield of maximum effectiveness at lower cost. Tentatively magnesium oxychloride shielding concrete has been selected as the primary shielding material for the faces and top. Heavy aggregate concrete with Portland cement is recognized as an acceptable alternate. The side shields are to be of ordinary concrete, with a dual function of shielding and support for the control system and upper portions of the building.

Since the knowledge of shielding materials is developing rapidly, final material selection has been left as flexible as possible, with present emphasis on structural design. Assumptions of shield properties such as density (5.8), and strength, have been made where necessary to make design calculations. This has produced a construction plan using permanent steel forms, shop fabricated for ease of handling, as shown on Drawings SP-10618 and SP-10671. The process tube entry is made through a tapered annulus which should allow elimination of complicated assemblies, greater tube flexibility, and greatly increased construction tolerances.

[redacted]

SECTION II - Shielding (Continued)

Arrangements for test pours are well underway. These will include tests for voids and consistency of aggregate distribution.

Some general shielding analysis has been done on such problems as control rod activity, metal storage basin depth, and shielding for special problems. Tentative techniques are under study for disposing of depleted, but active, control rods and handling special requests. It is anticipated that a comprehensive shielding layout for the entire process can be outlined by February 1, 1950.

Final selection of shielding material is still to be made, depending in part on the results of tests to be obtained from O.R.N.L. This information has been considerably delayed, but should produce usable data during the balance of fiscal 1950.

8. REACTOR GAS SYSTEM - R. T. Jaske (Reactor Division)

Little work was done on the overall system because of its inherent dependence on other features of the reactor. Review of the requirements has eliminated the possibility of cooling the thermal shield with gas; however, the function of control rod cooling may well be the primary consideration of the "G" design.

Study of gas quantities for rod cooling is underway. The decision to use a gamma radiating absorber has allowed marked reduction in the gas circulation, as compared to an alpha emitting absorber. (See Materials and Control Sections).

Selection of atmosphere is still to be made, pending heat transfer work on the moderator. Present indications are that high enough moderator temperatures may be achieved by coring and undercutting tube blocks to allow use of helium, thereby eliminating some of the problems involved in handling carbon dioxide such as graphite oxidation and control rod corrosion.

One unique problem imposed by higher operating temperature is the oxidation of graphite by oxygen and carbon dioxide in the circulating system. The associated problems are being studied.

A preliminary drying test was made on graphite to determine drying curves and investigate the dependence of drying on gas velocity. Drying rates seem initially dependent on gas velocity, but the temperature effects seem to predominate. Graphite wetting is subject to considerable variation (5-12% dry basis). Further study of these problems must be made.

[redacted]

Section II - Reactor Gas System (Continued)

The problem of leak detection is basically one of proper sampling and instrumentation. One possible sampling technique under study involves sampling gas directly from the annular gas passage around the tube. Providing enough sampling points are available, leak detection by this method may be a matter of hours.

9. MODERATOR - R. T. Jaske (Reactor Division)

Information available at the inception of the "G" design project made it desirable to design for a rate of stack expansion equal to, or greater than, that experienced in the present design. Accordingly, a preliminary design based on eight inches total expansion at the center of the stack, distributed according to a cosine function, was attempted. Considerable effort was expended on keying arrangements which would provide integration of the stack while undergoing maximum distortion. A fully satisfactory design for such large distortion will be difficult.

Special problems imposed by the "G" control systems resulted in severe compromise in moderator design. On one hand, it was desirable to have great rigidity to contain the forces imposed by the 3X balls when inserted in the rod slot, and, on the other hand, it was equally desirable to have a maximum of flexibility to permit overall growth. The control sheets cut across 80% of the effective cross block surface, and the combination of high distortion allowance and high strength through this section could not be reached without sacrifice of some desirable property. Accordingly, the sheet rod channels were designed as a separate structure, with the balance of the stack aligned by the binder. This binder assembly serves a double function as a thermal shield and structural support to control lateral pile motion due to growth, holding the upper portion of the sides of stack to a smooth curve for easy control rod entry.

Basic developments in the relation of graphite temperature to rate of expansion and loss of conductivity now indicate that expansion may be reduced to one-tenth of that of present piles if graphite temperatures are maintained above 275°C. Considerable study has been started or scheduled in order to determine the decrease in conductivity possible by shaping of tube blocks. Undercutting and coring around the process tube have been considered. Efforts will be made to flatten the heat distribution from front to rear as well as to raise the overall graphite temperature to an average above 300°C. Reactivity losses due to decreases in graphite density produced by coring or undercutting may be compensated for by reactivity gains from higher moderator temperatures.

[redacted]

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Section II - Moderator (Continued)

In view of the temperature information, effort will be concentrated on designing rigidity into the channels with allowance for some growth two to four inches in the center as a maximum practical value. Accordingly, the problem will be reviewed and a revised design prepared based on the new data on growth phenomenon. The evolutionary work accomplished has been very instructive and will serve as a basis for continuing study.

10. PROCESS TUBE ASSEMBLY - J. B. Medlin (Reactor Division)

The purposes of the process tube assembly are:

1. Provide holes in the pile for the entry of slugs with facilities for charging and discharging.

2. Provide means of carrying slug cooling water.

Fundamentally, "G" will be similar to existing units with the design being concentrated on reducing fabrication, erection, and maintenance costs and incorporating technical advances to date. Since the process tube assembly design is dependent on the outcome of other designs, such as shielding, only a limited amount of work has been done. Drawings have been prepared showing different arrangements of parts for reducing water pressure loss, increased allowable flexure of the gun barrel and elimination of the process tube van stone flanges. These arrangements are shown on the following study drawings:

1. SP-10322 - Gun Barrel Assembly - Proposal #1

2. SP-10335 - Gun Barrel Assembly - Proposal #2

3. SP-10380 - Gun Barrel Assembly - Proposal #3

4. SP-10560 - Gun Barrel Assembly - Proposal #4

Approximately three months after the shielding, moderator, charging and discharging designs are fixed, the process tube design would be ready. At the end of the fiscal year 1950, a design will be set, based on requirements at that time. The design will be adjustable so that any future changes in related parts can be easily adapted.

11. WATER SYSTEM STUDIES - P. M. Murphy (Reactor Division)

Since it is not now known whether the "G" reactor will be built as a replacement for one existing pile, as a replacement for two existing piles, or separately in connection with a new pile area, the requirements of the water plant facilities cannot be completely formulated at this time. However, subsequent to the receipt early June, 1949, of the Giffels & Vallet Water Study Report carried out under Design Study GED-13, and the analysis of these reports by the Design Division, further work in connection with the Water Plant for 100-G Area has been directed primarily toward the development of a process water recirculation system.

This choice appears attractive for two reasons: (1) because of the possible marked reduction in river contamination, and (2) because of possible operating economies to be derived from reduced process water filtration costs. Experimental data with which to establish basic design criteria for such a system are to be obtained from a one-tube recirculation test on an operating pile. This test is described in Section III of this document.

Should the forthcoming recirculation test show that such a system is impractical, the water plant now being designed for the "DR" Pile will be studied to determine the factors involved in its application to the 100-G Area.

For system design purposes, the upper limits of cooling water requirements are 62,000 g.p.m. at 550 p.s.i. header pressure. A "bulk" temperature rise of 49°C. would result under 800 MW operation.

SECTION III

HANFORD D & C TEST PROGRAM

I N D E X

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SECTION III

HANFORD D & C TEST PROGRAM

INTRODUCTION

The general objective of the Test program is to confirm performance of critical "G" Reactor components within the time schedules allotted for the over-all design These test projects include mechanical and hydraulic tests, heat transfer and fluid flow investigations, exposure of materials and assemblies to pile irradiation and miscellaneou physical and material tests of a non-radioactive nature.

Briefly, the status of the test program is as follows:

Total Tests Requested	23
Total tests completed irrespective of final report (All but two are covered by a final report)	9
Incomplete tests for which runs have commenced	4
Incomplete tests in planning and procurement stage	7
Tests cancelled before initiation of testing	3

The following is an enumeration and description of the investigations included in the Test Program to date.

I PRELIMINARY SLUG DISCHARGE TESTS (TEST PROJECT #2)

A. Object

These tests were needed to provide information concerning discharge bucket dimensions for the design and development of a new type of discharge equipment. Further details relating to the purpose of these tests will be found in the Test Project Proposal (Preliminary Slug Discharging Tests) prepared by H. J. White and dated 2-17-49.

B. Method

Slugs were pushed, one at a time, into a length of 10" steel pipe to determine the volume which a load of 128 standard 4" slugs would occupy when arranged in a random pattern. The angle of inclination of the pipe from the horizontal was varied to determine the minimum practical slope required. The test apparatus which was used is shown in Figure 1.

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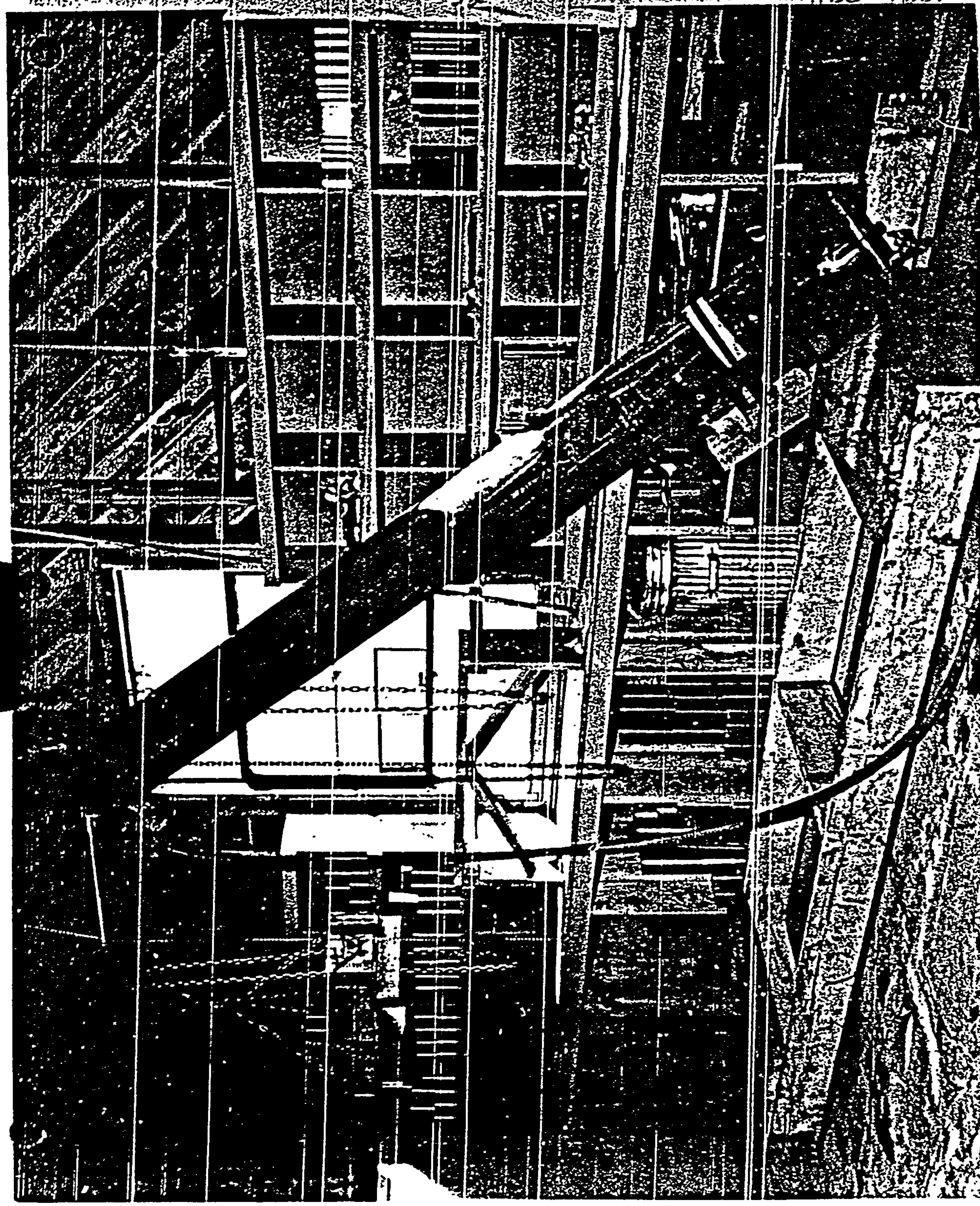


Figure No. 1

Section III - Preliminary Slug Discharge Tests (Continued)

C. Results

Only three feet of a 10" (inside) diameter bucket were required to contain 128 four-inch uranium slugs when the discharge bucket was set at an angle of 60° from the horizontal. No tendency was observed for the slugs to jam or bind at any angle of the bucket when the discharge gate was released. All slugs slid freely from the bucket.

A Test Report covering this investigation was issued as HDC-1132 (3-23-49).

II PRELIMINARY RUBBER IRRADIATION TESTS (TEST PROJECT #3)

A. Object

These tests were intended to investigate the physical resistance of various synthetic rubbers and rubber-like compounds to pile irradiation. It has been proposed to utilize such materials for process tube outlet glands (Collins Seal type) in connection with continuous discharging equipment.

B. Method

Small samples (approximately 1" x 1/4" x 0.10") are being exposed at the "E" Test Hole at 100°F.

Initially, very short periods of exposure were used between inspections and manipulation. The exposure has been gradually increased for samples showing satisfactory results. Those specimens which successfully withstand the present qualitative investigation will be subjected to more rigorous physical tests for hardness, elasticity, tensile and compressive strength.

More detailed test plans will be found in the Test Project Proposal (Preliminary Rubber Irradiation Tests), prepared by H. J. White and dated 3-17-49.

C. Results

After a total of 40 hours, two of the original assortment, (1) a silicone rubber and (2) a Buna N synthetic, had failed through embrittlement and loss of elasticity. The remaining eight samples, although exhibiting some evidence of surface hardening, retain satisfactory flexibility and elasticity after a total of approximately sixty-two hours.

[redacted]

III PROCESS TUBE FLOW CALIBRATION TESTS (TEST PROJECT #4 - PART I)

A. Object

These tests were intended to provide experimental data on the magnitude and distribution of pressure losses through a process tube and its components. Various combinations of orifice size and tube loading were to be investigated for isothermal flow conditions. Further details will be found in the Test Project Proposal - HDC-1183.

B. Method

A full-length process tube was used containing canned lead slugs (standard dimensions) and appropriate dummies. These tests were carried out at the 105-F Flow Lab. The general arrangement of apparatus and instrumentation is shown in Figure 2. Figure 3 presents the "standard" slug loading arrangement used in these tests.

C. Results

The findings of this test are contained in the form of tabulated data in the Test Report - HDC-1255 - and the correlation of the data is reported in HDC-1560. In the report HDC-1560 equations have been developed from the data and adapted for the calculation of pressure drops or flow rates for clean tubes in pile operation. A systematic procedure is outlined for determining the pressure drops through each portion of the tube assembly. A method is presented for calculating the flow rate through a process tube from header pressure and panellit gage readings. The Design Staff has incorporated these results in development plans for the Two-phase Flow and Heat Transfer Tests.

IV MOVEMENT OF SLUGS IN PROCESS TUBES (TEST PROJECT #4 - Part II)

A. Object

These tests were intended to determine whether, during discharge operations at full water pressure and flow, uranium slugs would be propelled hydraulically out of the process tubes into a discharge hopper. This information was necessary for the design of continuous discharging equipment. Further details will be found in the Test Project Proposal - HDC-1183.

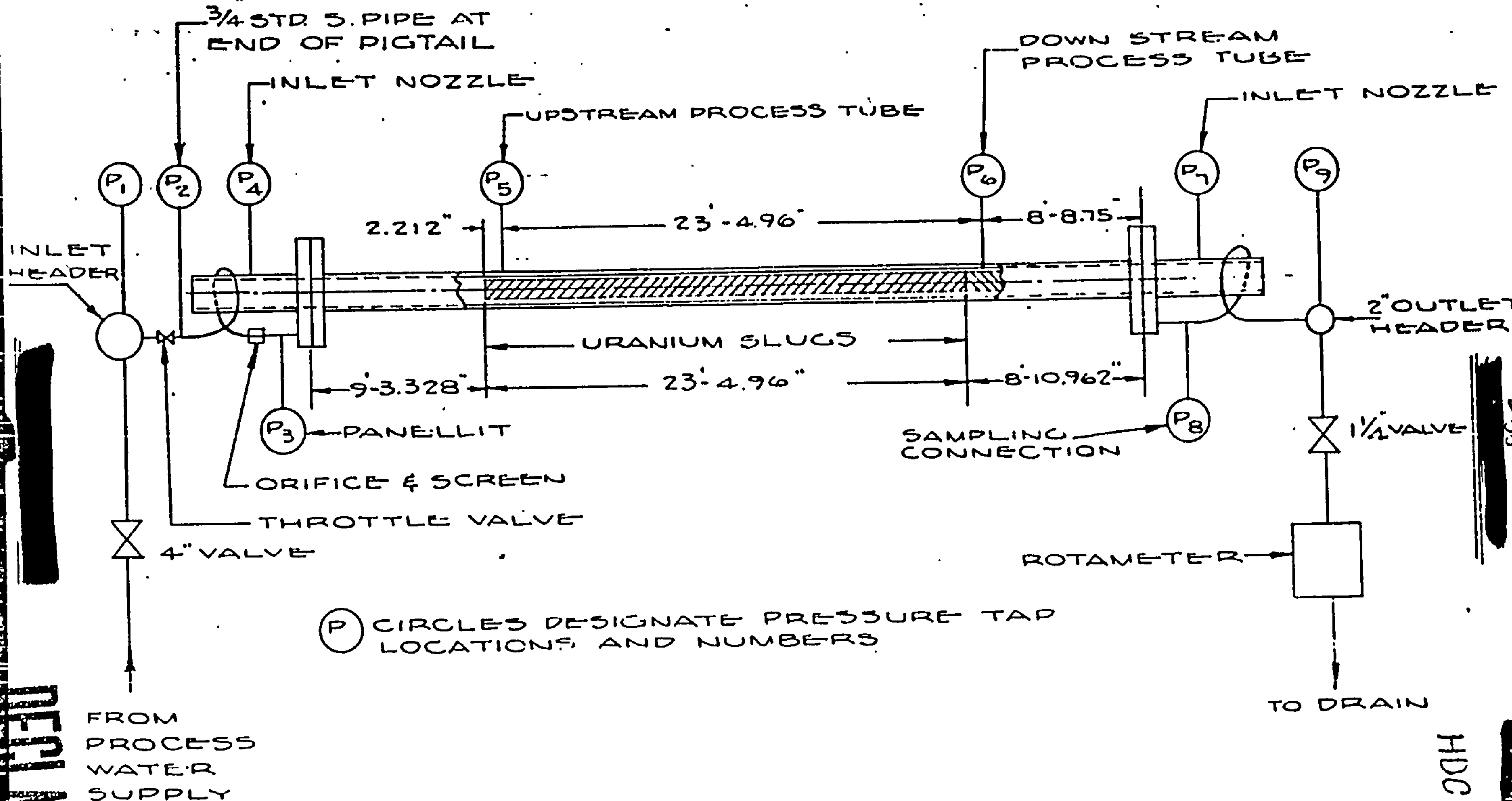
B. Method

A full-length process tube containing 64 four-inch (nominal) canned uranium slugs was used for these tests which were carried out at the 105-F Flow Lab. The dummy slugs, except for those in the outlet nozzle, were omitted. Slug movement was ascertained by audible impact of the first uranium slug upon the stainless steel dummy. Process water pressure (and flow) were increased by increments (at 5-minute intervals) until this occurred. The general arrangement of the apparatus is shown in Figure 3.

[redacted]

[redacted]

HDC 1661

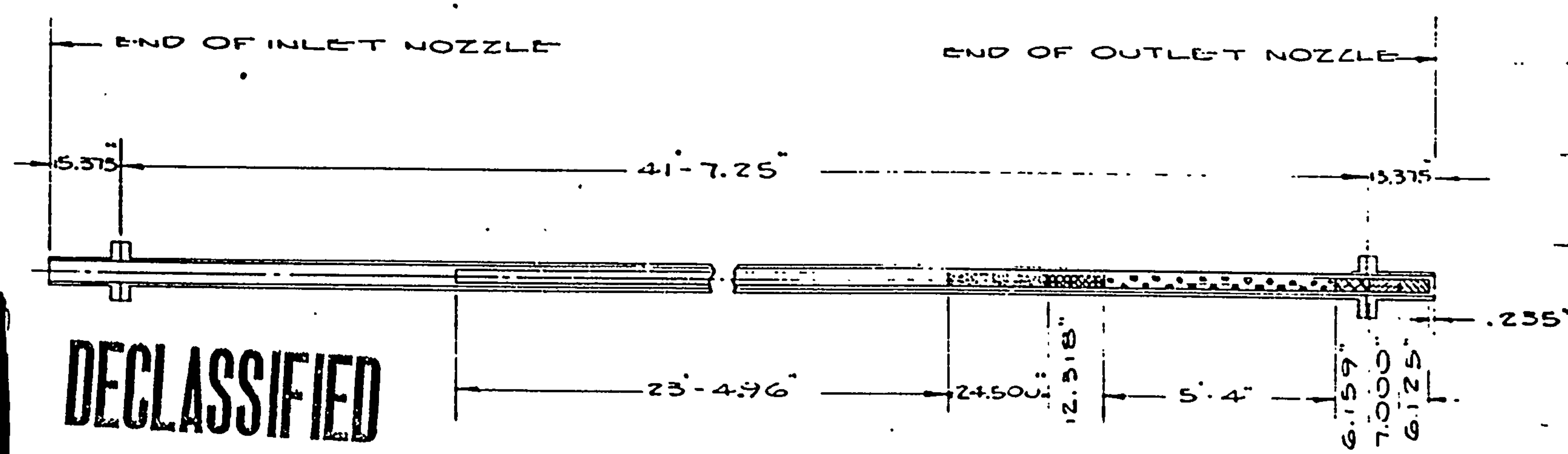


SCHEMATIC SKETCH OF TEST EQUIPMENT

FIGURE No. II

[redacted]

PROCESS TUBE SLUG LOADING ARRANGEMENT



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ALL SLUGS WERE 1.440" IN DIAMETER
THE SLUG LOADING ARRANGEMENT,
STARTING FROM THE DISCHARGE END
WAS AS FOLLOWS

1 - 6.125" LONG STAINLESS STEEL
1 - 7.000" LONG STAINLESS STEEL (SEE SKETCH)
1 - 6.159" LONG CANNED LEAD
8 - 8.000" LONG PERFORATED ALUMINUM (SEE SKETCH)
2 - 6.159" LONG CANNED LEAD
4 - 6.125" LONG SOLID ALUMINUM
64 - 4.390 LONG CANNED LEAD

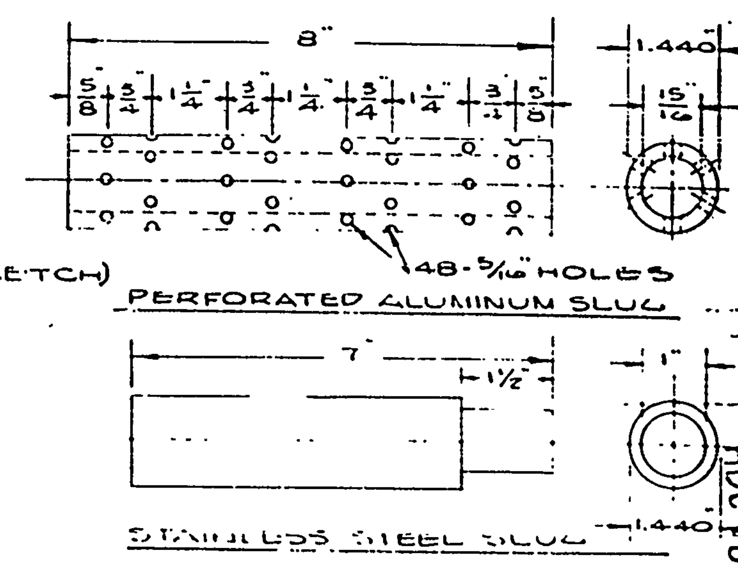

FIGURE No. III

HDC 1601

T-36

[redacted]

Section III - Movement of Slugs in Process Tubes (Continued)

C. Results

Slug movement was observed in a clean, film-free, level process tube with standard values of header pressure (inlet and outlet), when the flow rate was restricted by a .240" diameter orifice. All of the slugs were propelled downstream to the maximum possible extent with a .270" (or greater) orifice. Further particulars are contained in the Test Report - HDC-1255.

V TWO-PHASE FLOW AND PRESSURE-DROP MEASUREMENT (TEST PROJECT #5)

A. Object

These tests were conducted to measure pressure drop through the dummy and exit sections of a full-scale B, D, F-type process tube with simulated boiling conditions. These tests were intended to compare calculated pressure losses for two-phase flow with experimental results. Further information concerning the purpose and application of these tests will be found in the Test Project Authorization - HDC-1259.

B. Method

This investigation was carried out in the 105-F Flow Laboratory. The test apparatus was a "semi-closed" flow system as is shown diagrammatically in Figure 4. Steam and water were separately measured for enthalpy and flow rate, suitably throttled, mixed and passed through the test section as a two-phase flow. The outlet mixture was condensed, weighed (to determine flow rate) and a portion thereof was returned through a rotameter to the mixing valve for recycling. Portions of the test apparatus are shown in Figures 5, 6, and 7.

C. Results

Measured pressure drop for two-phase flow across sections of solid dummy slugs was approximately 30% higher than was predicted from earlier calculations. Actual pressure drop in the pigtail was 30% higher than indicated by previous calculations. However, measured pressure drop across a short section of perforated dummy slugs was nearly 70% less than equations would indicate.

The maximum pressure required, if boiling occurs, appears higher than was indicated by previous calculations, but lower than the available 375 p.s.i header pressure. The required header pressure (for a hypothetical 412 KW tube) is approximately 308 p.s.i.a., rather than 291 p.s.i.a.

Further details and elaboration are to be found in the Test Report - HDC-1565.

[redacted]

[redacted]

HDC 1601

SCHEMATIC SKETCH OF TEST EQUIPMENT FOR

TWO PHASE FLOW PRESSURE DROP MEASUREMENTS

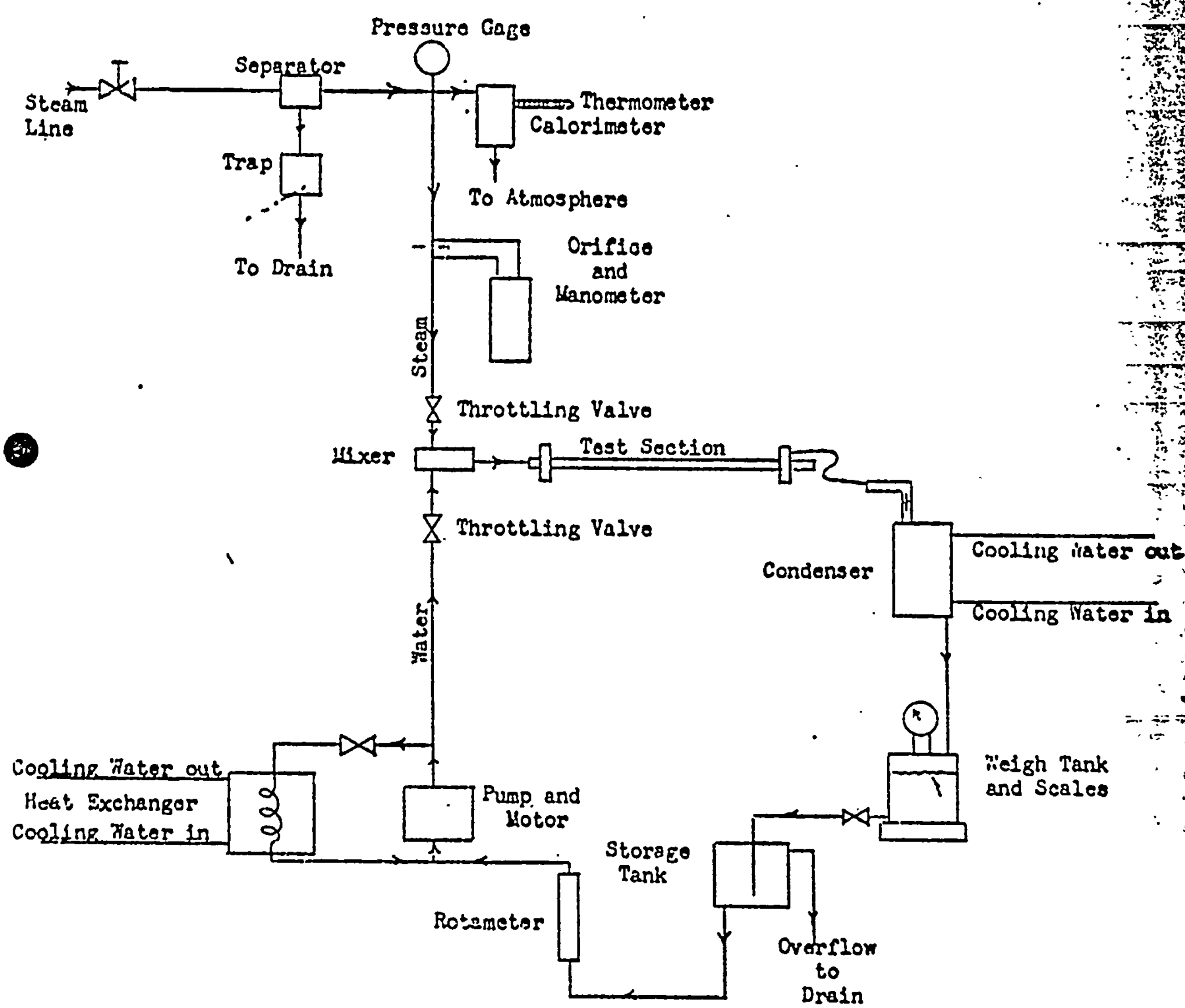

FIGURE IV

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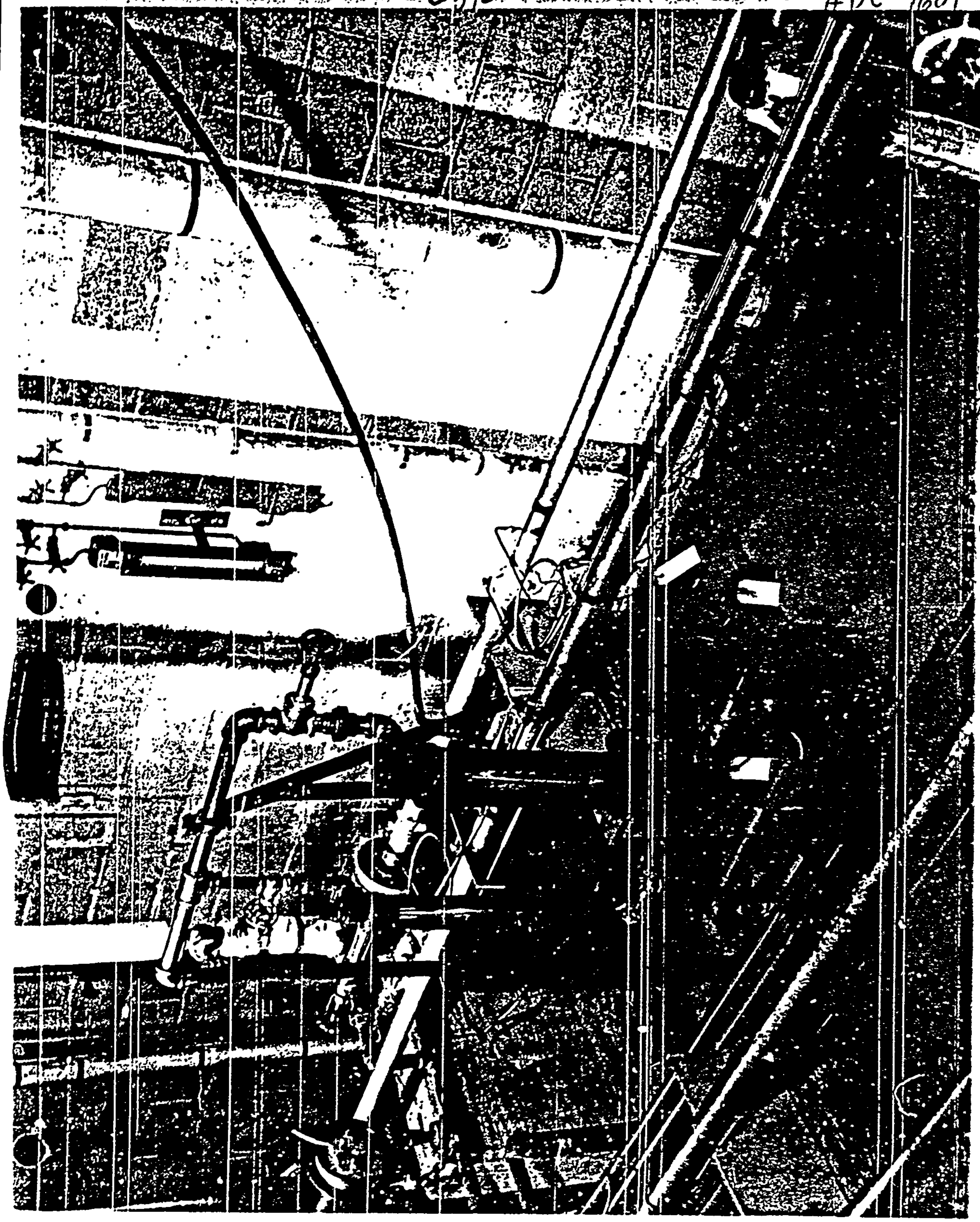

Figure No. 5

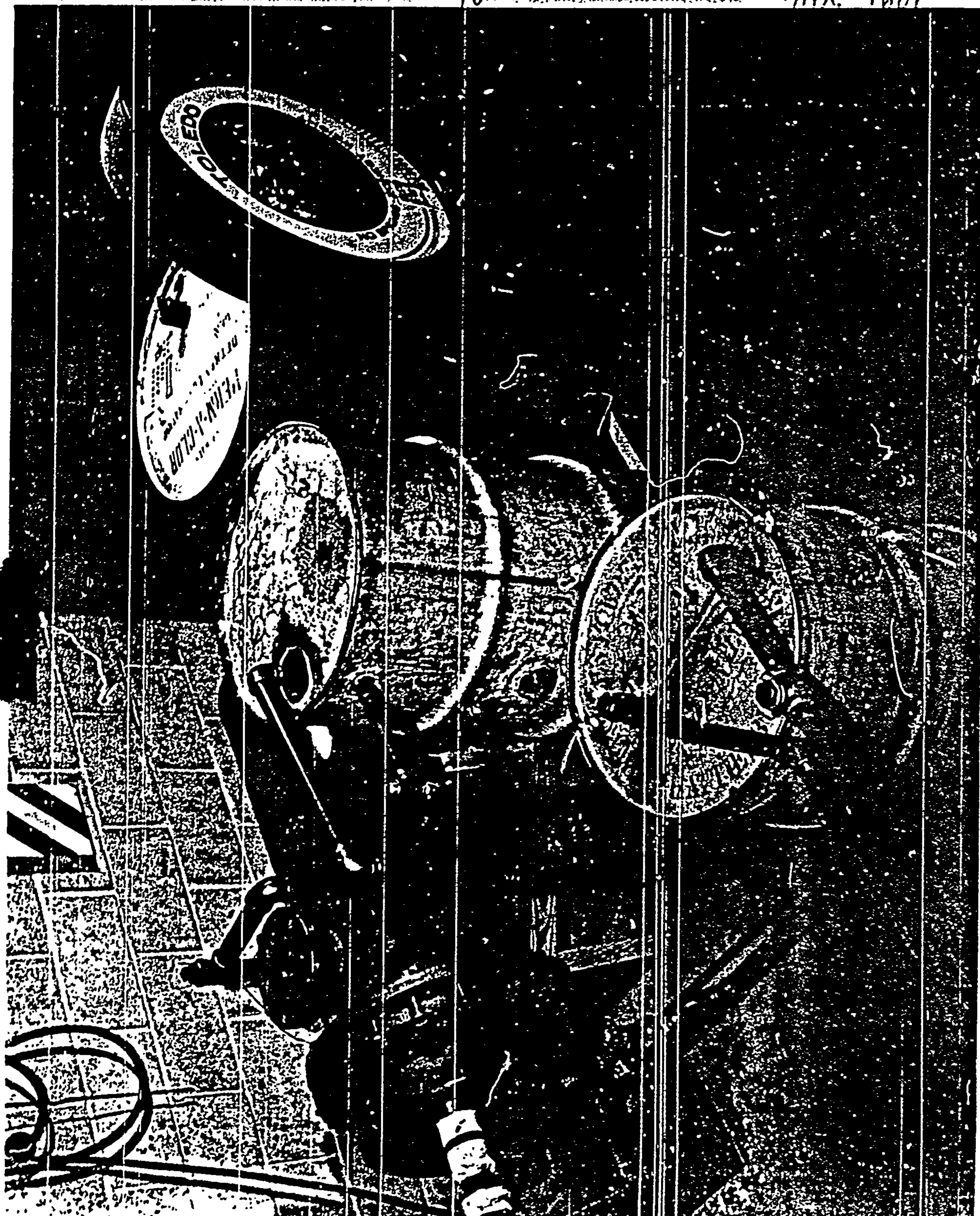

Figure No 6

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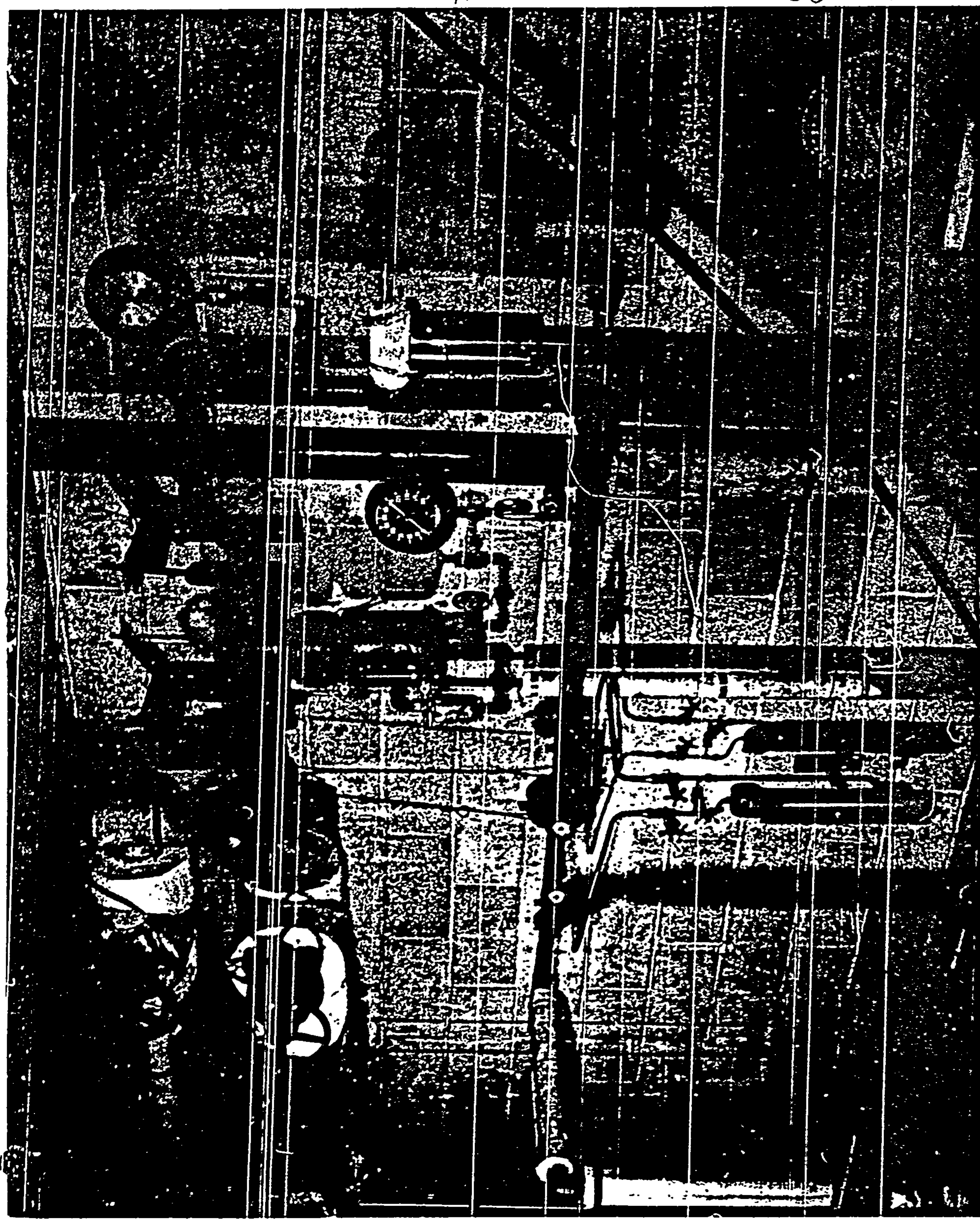

VI TEST DATA ON VARIOUS BAR PLUGS (TEST PROJECT #6)

A. Object

To compare the functional characteristics of several types of "flexible" bar plugs. This device is a component of a continuous discharging machine and serves both to push uranium slugs back into the active zone following discharge and to provide a portion of the shielding function which is now borne by the dummy slug arrangement. Further details are to be found in the Test Project Authorization - HDC-1318.

B. Method

A single tube of the Nine-Tube Mock Up in the 305-A Bldg. (300 Area) was utilized for these tests. A new process tube was installed with provision for vertical deflection to a maximum slope of 1/2" per foot. Each of the 8 1/2' bar plugs was tested by thrusting it into a tube which was loaded (dry) with 64 standard uranium slugs. The forces necessary to move the bar plugs and slug column were measured by the hydraulic pressure required to move the assembly. Two configurations of process tube and gun barrel were tested, as shown in the sketch, Figure 8.

The three types of bar plug tested are presented in Figures 9, 10 and 11. A "bayonet wrench" for inserting and locking the bar plugs and the special nozzle into which the wrench was locked were tested simultaneously with the bar plugs. These are shown in Figures 12 and 13, respectively.

C. Results

Both the ball-and-socket and tubular bar plugs were found to operate satisfactorily in a dry tube, although some galling of the aluminum was detected. The tubular type bar plug showed the best all-around utility for this application.

The flexible cable type bar plug proved to be too flexible and weak under column loading. Complete details are reported in the Test Report - HDC-1417.

VII RADIAL CREEP TEST ON ALUMINUM PROCESS TUBING (TEST PROJECT #8)

A. Object

The object of this test is to determine the creep resistance of a standard aluminum process tube at elevated temperatures and pressures. It specifically intends to investigate creep characteristics of these tubes at a temperature of 100°C. and with pressures of 400 and 600 p.s.i.g. These data are necessary for the design of process tubes capable of withstanding the higher water temperatures and pressures contemplated for an 800 MW reactor. Particulars concerning the test objectives are in the Test Project Proposal, dated 4-2?-49 prepared by C. D. Emmons.

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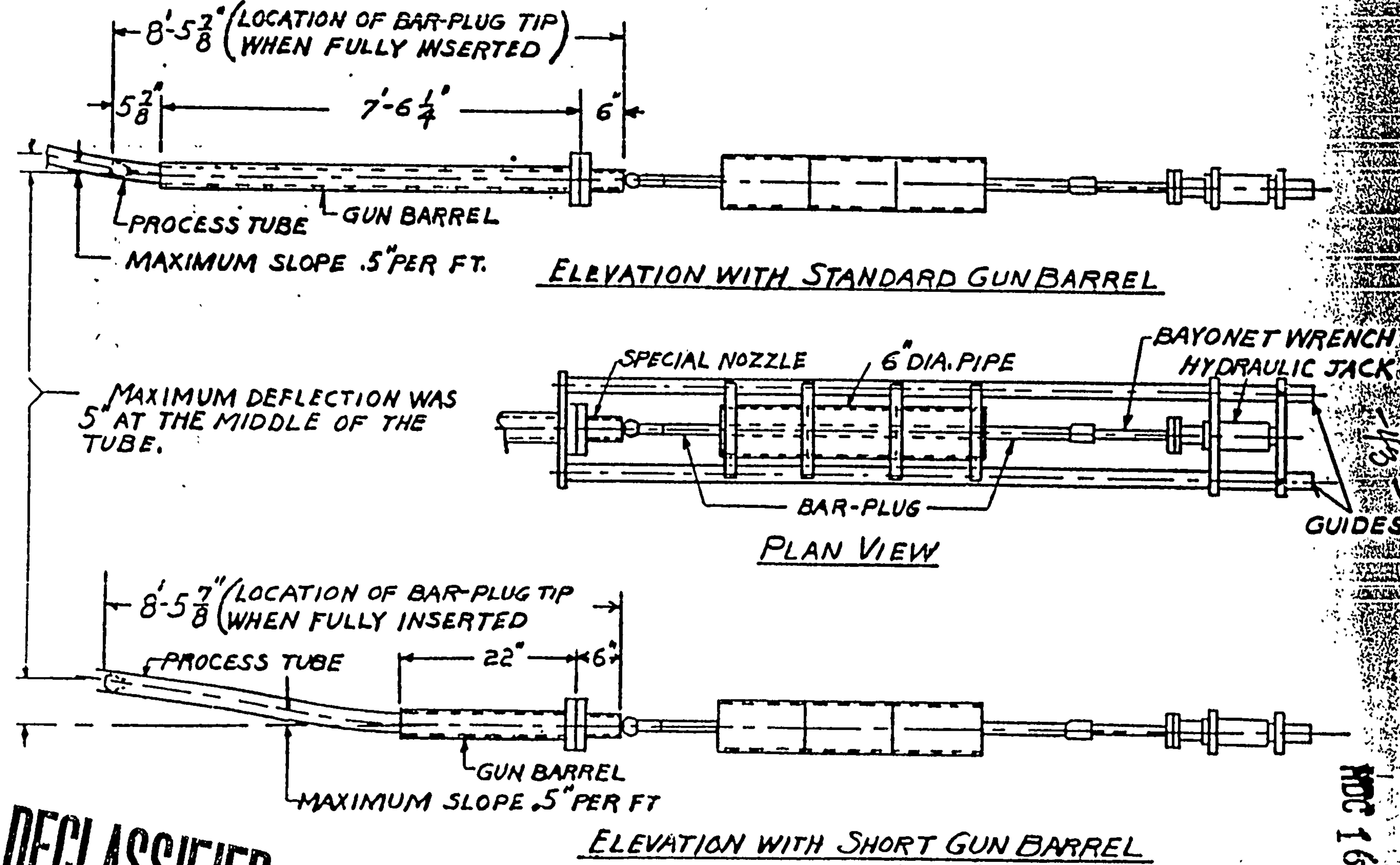
TEST DATA ON VARIOUS BAR-PLUGS
TEST PROJECT No. 6



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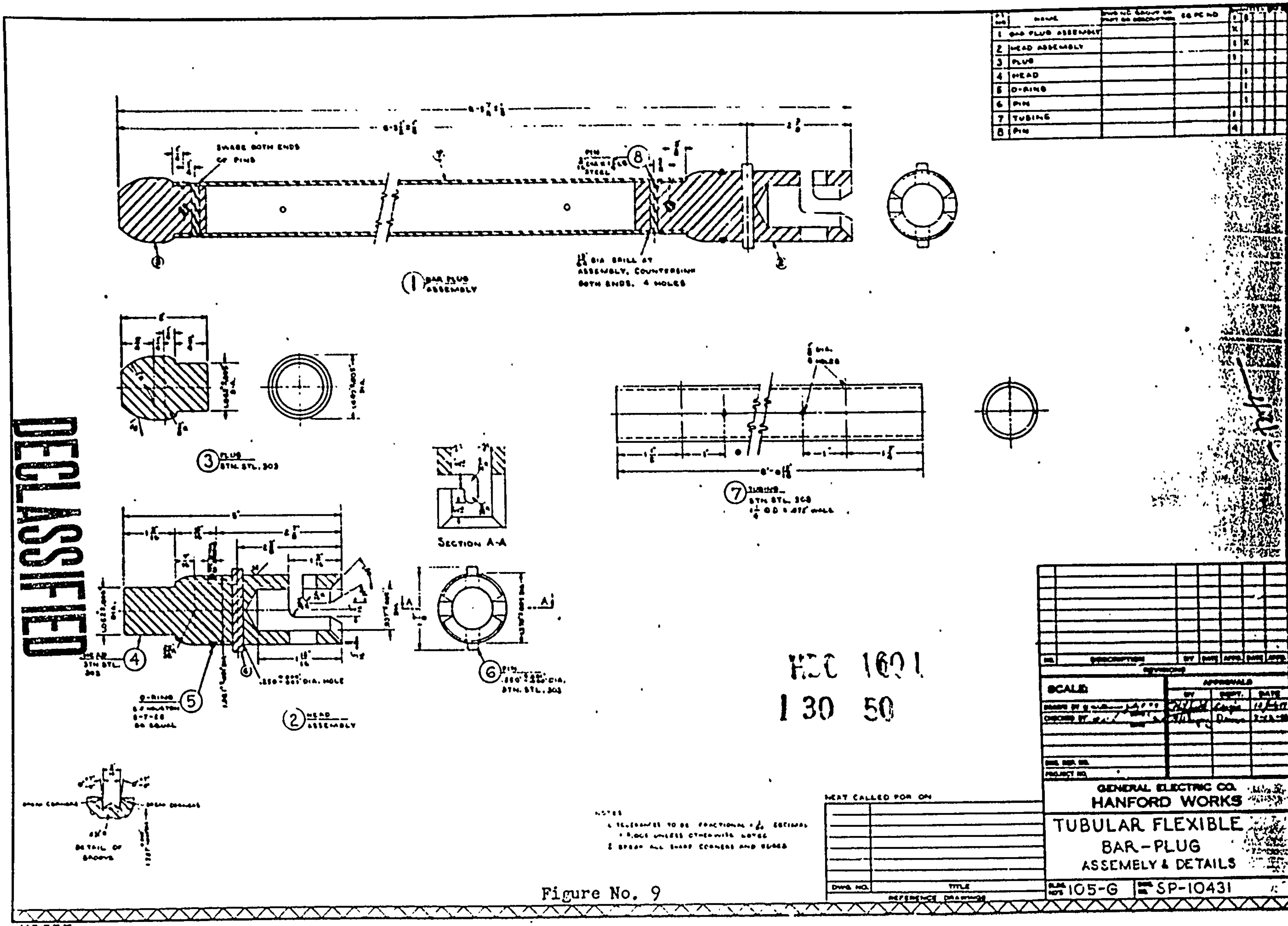
ARRANGEMENT OF BAR-PLUG TEST EQUIPMENT
FIGURE NO. 8



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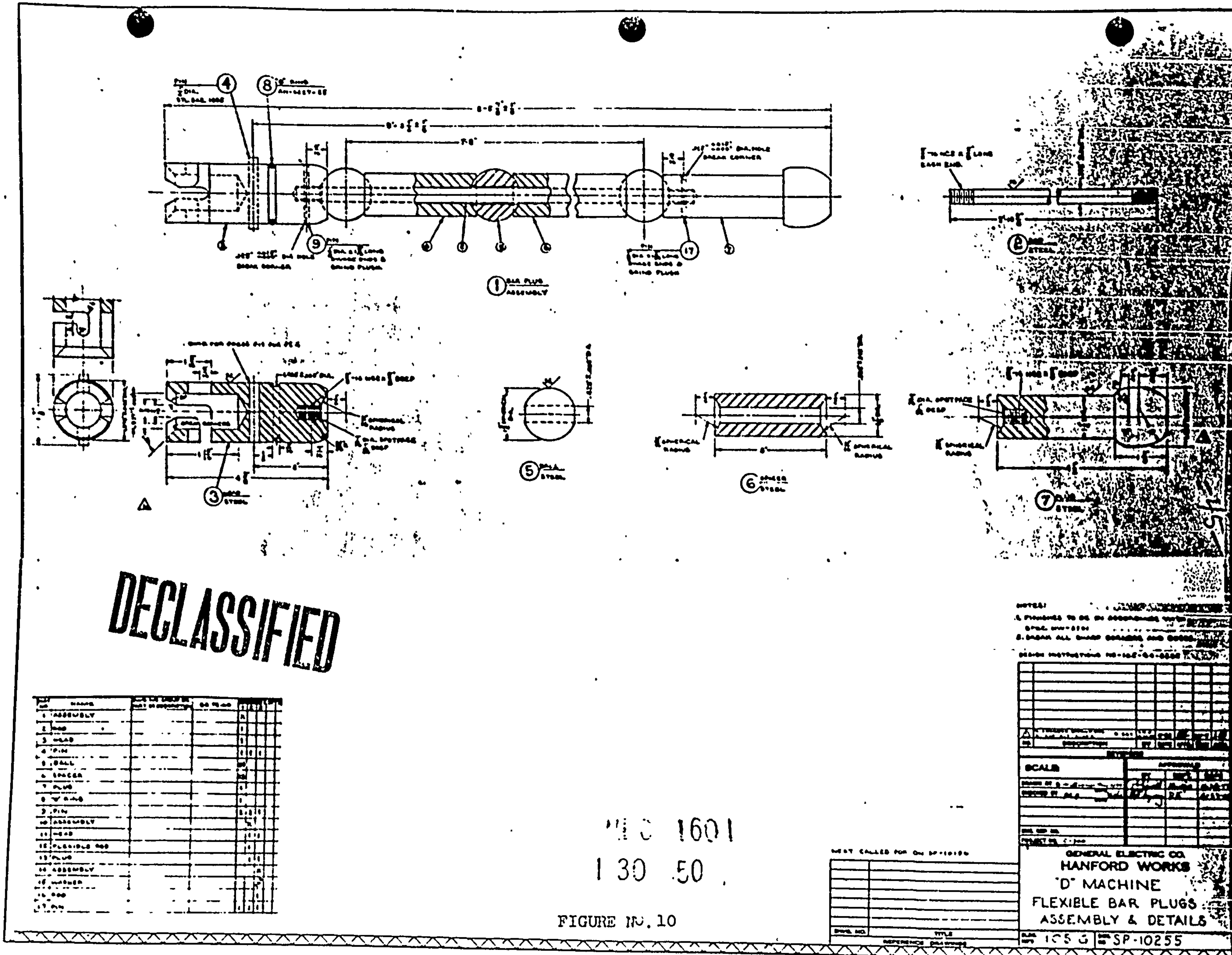
HDC 1601
1 30 50

Figure No. 9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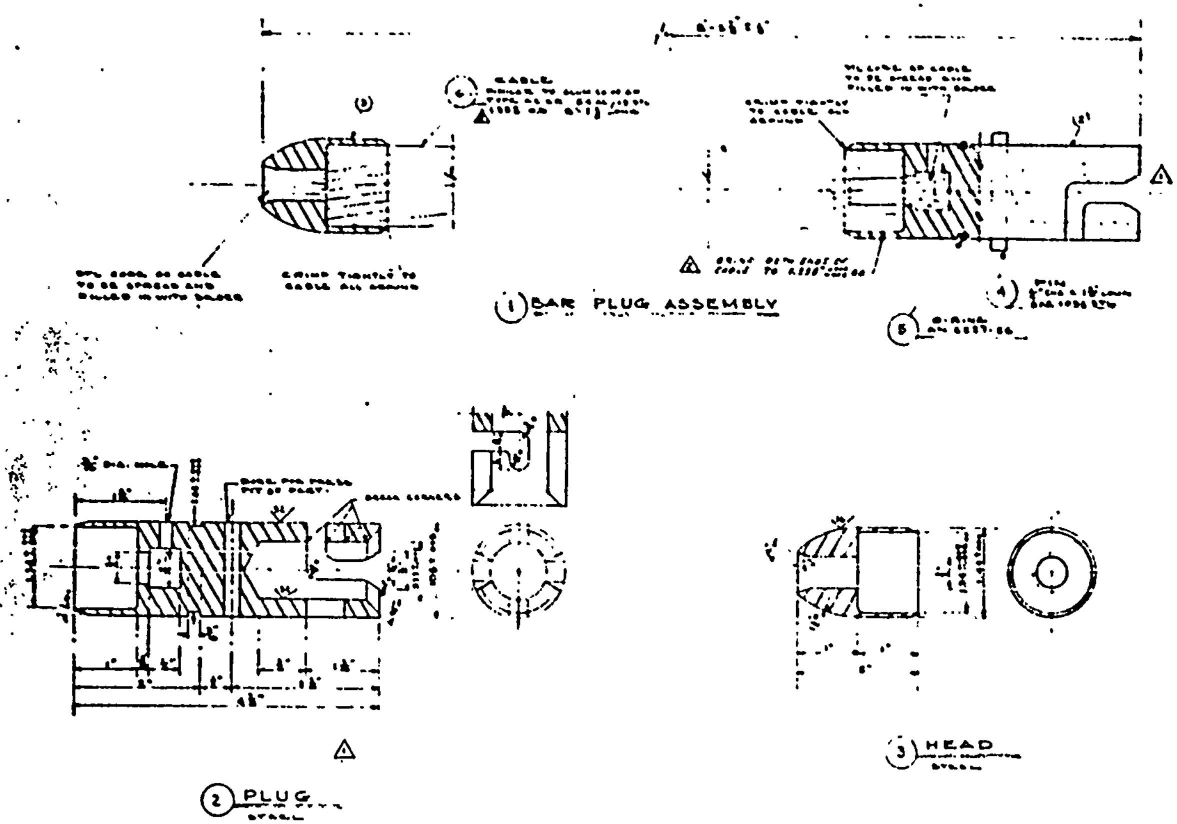
1 BAR PLUG ASSEMBLY
3 HEAD STEEL
5 BALL STEEL
6 SPACER STEEL
7 PLUG STEEL
SCALE
GENERAL ELECTRIC CO.
HANFORD WORKS
"D" MACHINE
FLEXIBLE BAR PLUGS
ASSEMBLY & DETAILS
SP-10255
1601
1 30 50

FIGURE NO. 10



-46-

GENERAL ELECTRIC CO.
HANFORD WORKS

"D" MACHINE
FLEXIBLE CABLE BAR PLUG
ASSEMBLY & DETAILS

SCALE: FULL SIZE

105-G SP-10507

HDC 160
1 30 60

FIGURE NO. 11

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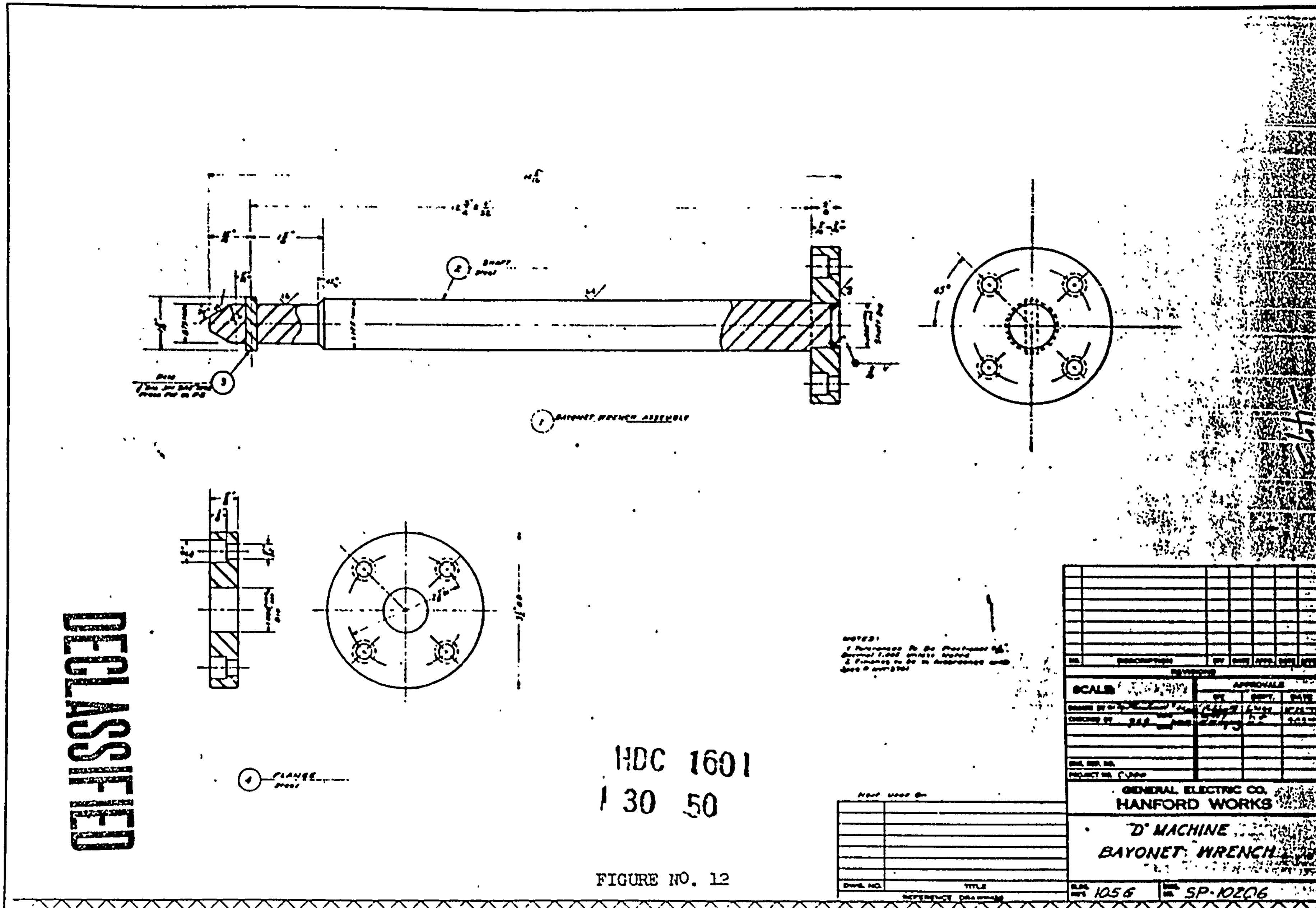


HDC 1601
1 30 50

FIGURE NO. 12

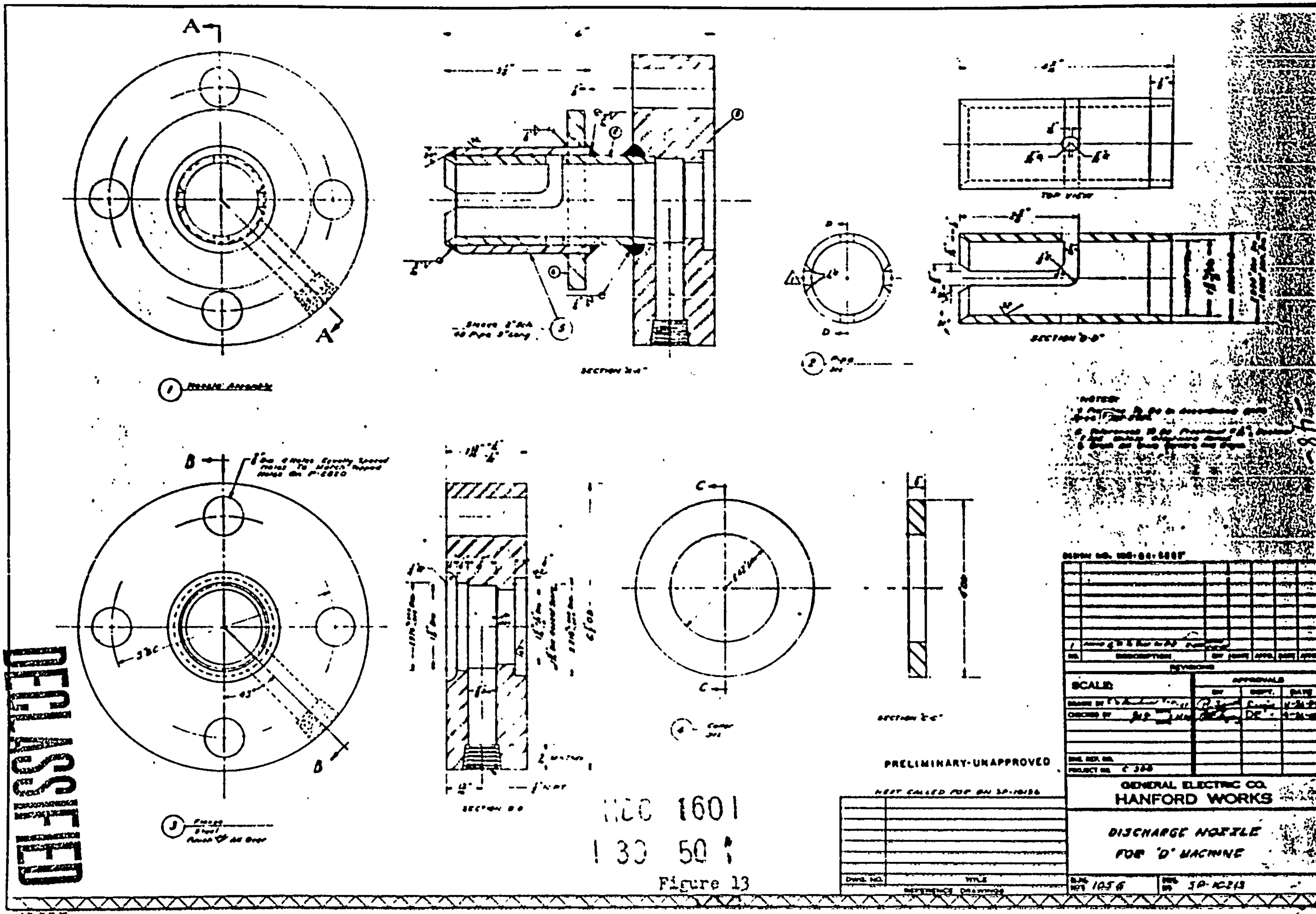
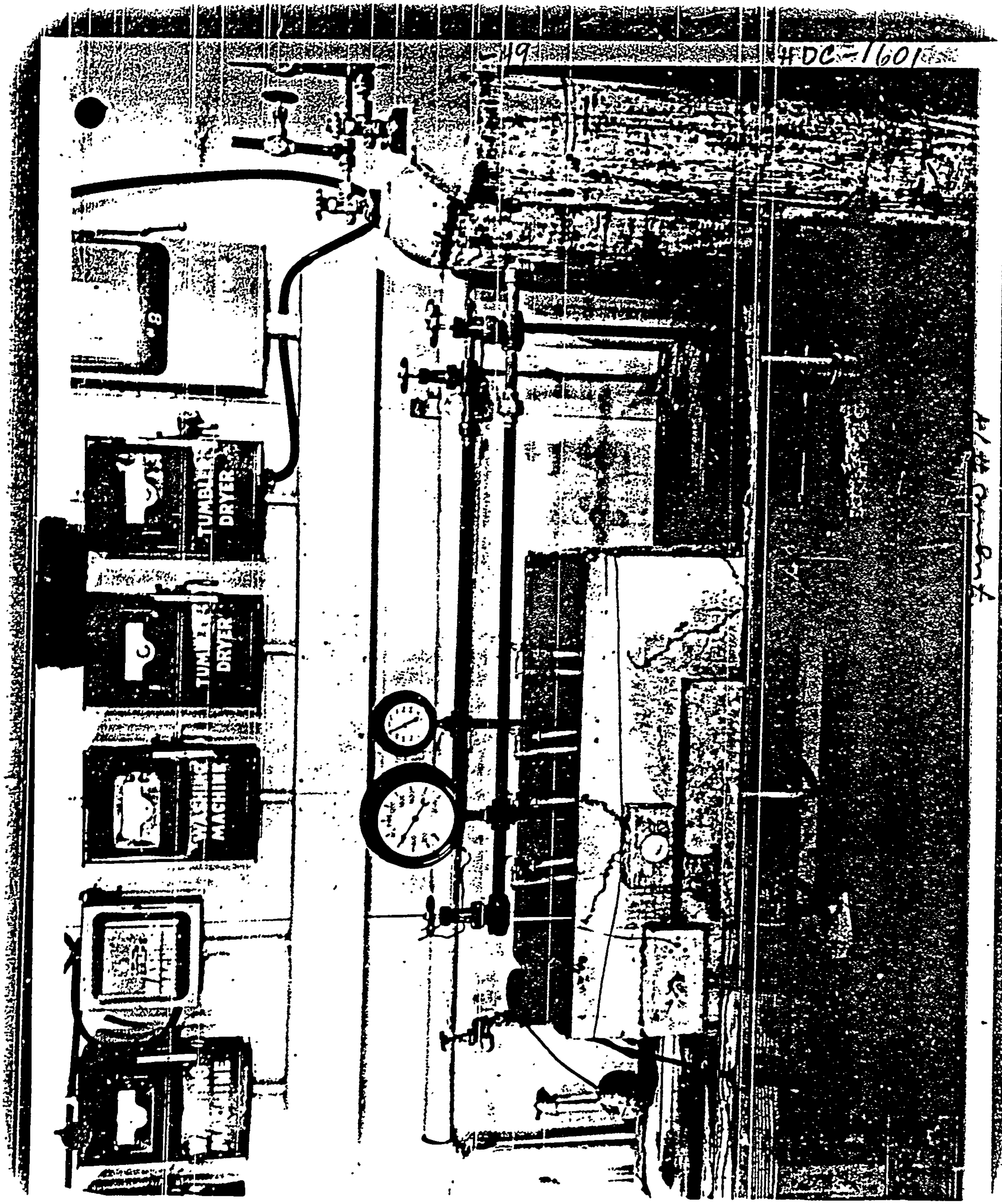

SECTION "A-A"
SECTION "B-B"
SECTION "C-C"
SECTION "D-D"
TOP VIEW
NOTES:
PRELIMINARY-UNAPPROVED
GENERAL ELECTRIC CO.
HANFORD WORKS
DISCHARGE NOZZLE
FOR 'D' MACHINE
SCALE
REVISIONS
APPROVALS
DESCRIPTION
REFERENCE DRAWINGS
DWG. NO.
TITLE
SP-1C213
HCC 1601
1 30 50

Figure 13

HDC-1601



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Section III - Radial Creep Test on Aluminum Process Tubing (Continued)

B. Method

Two, independent, hydrostatic pressure systems were set up, each arranged to test three 18" tube sections. These short sections were immersed in an oil bath which was maintained thermostatically at 100°C. The tubes were pressurized by gas bottles through dual regulator valves and pressure accumulators which permitted water pressure instead of gas to be applied to the actual test sections.

A thorough dimensional inspection of all tubes was made before installation and pressurization. Subsequently, daily measurements have been made of the circumferential growth of four of the tubes: two at 400 p.s.i.g. and two at 600 p.s.i.g. Tests have continued for approximately three months without interruption, excepting for maintenance.

Figure 14 shows a portion of the test apparatus and includes the pressure accumulator bottles at the extreme right. The actual tube sections are out of sight in the oil bath tank. Figure 15 is a close-up of the oil bath which shows the four dial gauge assemblies which provide measurement of circumferential creep or expansion.

C. Results

There is some doubt as to the validity of the initial creep data which were obtained during the period of most rapid expansion, i.e.: during the first four weeks after pressurization. This uncertainty resulted from two unavoidable shut-downs for maintenance to the heater and control elements. However, over the recent eight weeks of uninterrupted operation, the average diametrical expansion for the tubes at 600 p.s.i.g. has been of the order of .00005"/month, and for those at 400 p.s.i.g, approximately .00001"/month.

Within a month a complete changeover will be made to six new tube sections, and to a new and revised heater and thermostatic control system. It is expected that valid data, covering the entire creep history of these tubes, can be obtained.

VIII PRELIMINARY DETERMINATION OF GRAPHITE DRYING RATE (TEST PROJECT #10)

A. Object

It was the objective of this test to obtain preliminary information on the drying rate of water-saturated graphite by means of a small-scale experiment.

These data would indicate whether further, full-scale tests would be necessary for design of the "G" reactor gas drying system. Results would be valuable in designing for rapid reactivation of the pile flooded by a ruptured tube or a (proposed) water 3-X system. Further details will be found in the Test Project Proposal, dated 5-5-49 written by H. J. White.

[redacted]

HDC-1601

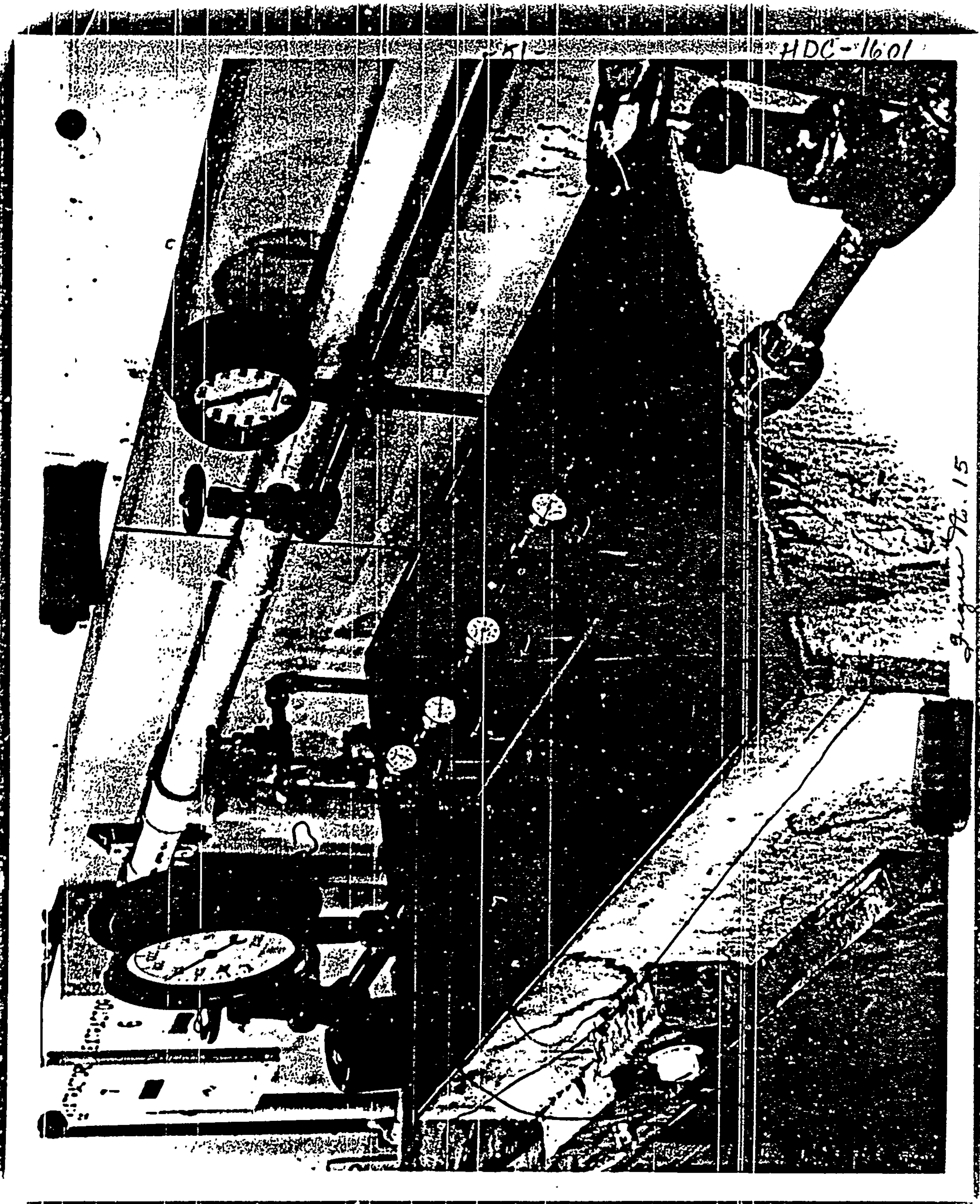

Figure No. 15

Section III - Preliminary Determination of Graphite Drying Rate (Cont.)

B. Method

Tests were conducted in two parts: 1) at elevated temperature with no air flow and 2) at room temperature in an air stream. Identical samples of graphite 4" x 4" x 2" and 4" x 4" x 1" were tested under both conditions. Three blocks of each size were investigated to determine consistency of results. Considerable effort was spent to obtain, as nearly as possible, complete and uniform absorption of water into blocks of similar size.

The tests at elevated temperature were made in an oven at 130°F. with approximately constant humidity. The forced drying tests were in a duct receiving air from the laboratory compressed air system at nearly constant velocity (30 f.p.s.) and approximately constant temperature and humidity. Removals for weighing at hourly or semi-hourly intervals were made as brief as possible.

C. Results

A considerable difference in graphite drying characteristics was found between the two types of drying. Oven drying showed dehydration in two phases: constant rate and falling rate. Forced drying was found to be solely of the falling rate phase. Increasing the block thickness by a factor of two had little effect upon the oven drying rate, but made a significant difference in the forced drying rate.

It was found that ordinary water immersion resulted in markedly different values of water absorption and, consequently, divergent drying rates among similar blocks. A Test Report, "Preliminary Determination of Graphite Drying Rate", was prepared by H. J. White and issued 9-27-49.

IX SHEET ROD TESTS (TEST PROJECT #11)

A. Object

This test was planned to investigate the over-all mechanical feasibility of a vertical sheet rod and its components. Tests were to provide information on the following:

1. Mechanical performance of the rod.
2. Effect of graphite growth on rod operation.
3. Rate of descent with repeated drops.
4. Performance and endurance life of all components of the assembly.

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Section III - Shoot Rod Tests (Continued)

Further details, particularly as related to the components of the shoot rod assembly, are contained in the Test Project Authorization, HDC-1332.

B. Method

These tests are being carried out at the 90' Test Tower at White Bluffs. This structure permits a 42' rod to be dropped a total of 33' into a graphite mock-up which simulates the reactor entry slot. The present test rod is 11 1/4" wide by 3/16" thick. It is operated by a standard Whiting-Crane winch, as used in the existing piles.

Provision has been made for bowing and deflecting the graphite slot with respect to its vertical axis to simulate graphite growth. An adjustable "step plug", a tight-fitting member which will attenuate neutron leakage where the sheet rod passes through the "B" Shield, allows the clearance to be varied over a wide range.

Figure 16 is a view of the test tower between levels 0' and 50'. Vertical columns and horizontal framing are spaced at 10' intervals. The 32' graphite stack is contained in the tower enclosure. Figure 17 shows the tower from level 10' to 80'. A portion of the sheet rod may be seen extending up beyond the roof of the sheathed enclosure at the 50' level. The shoot is constrained by channel guides and bearings at the edges. The base of the graphite stack is seen in Figure 18 with the cut-out "door" which permits inspection for, and removal of, any graphite dust and particles resulting from abrasion by the shoot rod.

A close-up of the spring bumper plate assembly is shown in Fig. 19. This device, acting upon the crosshead at the top of the rod, serves to support the sheet rod in its fully-down position and to decelerate the rod in the event of a failure of the winch braking system, or of the cable. The cross head and supporting sheave assembly are seen in Figure 20. In addition, this photograph shows the lower portion of the channel guides which extend up beyond the fully-out position of the rod.

The large disk at the left is a portion of the cable-and-pulley drive for the displacement-time recorder. A view of the recorder is presented in Figure 21. The recording drum with a chart attached revolves about a vertical axis at constant speed while the curve is drawn by the moving head (to the left of the drum) which is tied in to the movement of the sheet rod. This instrument yields an accurate plot of displacement against time.

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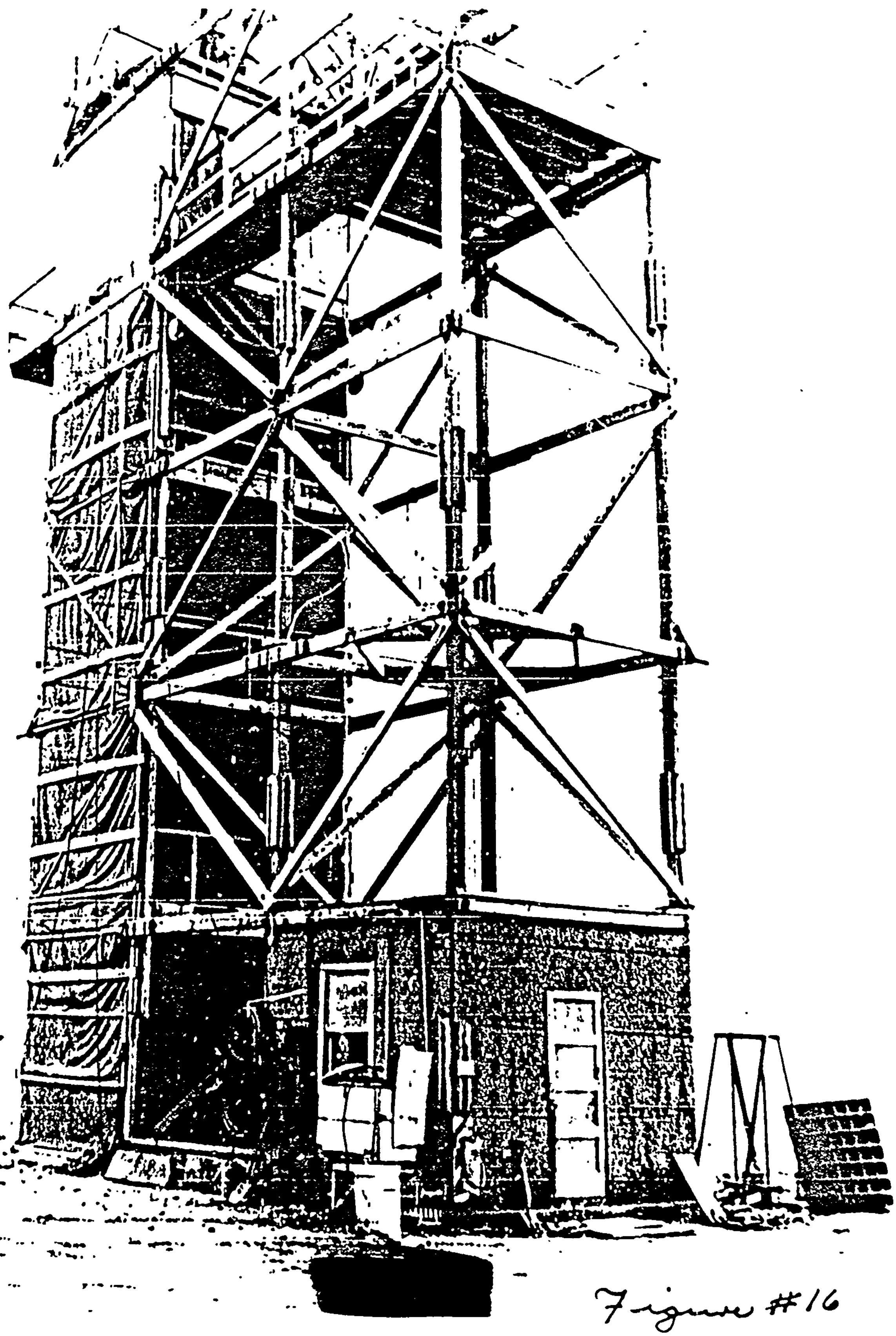

Figure #16

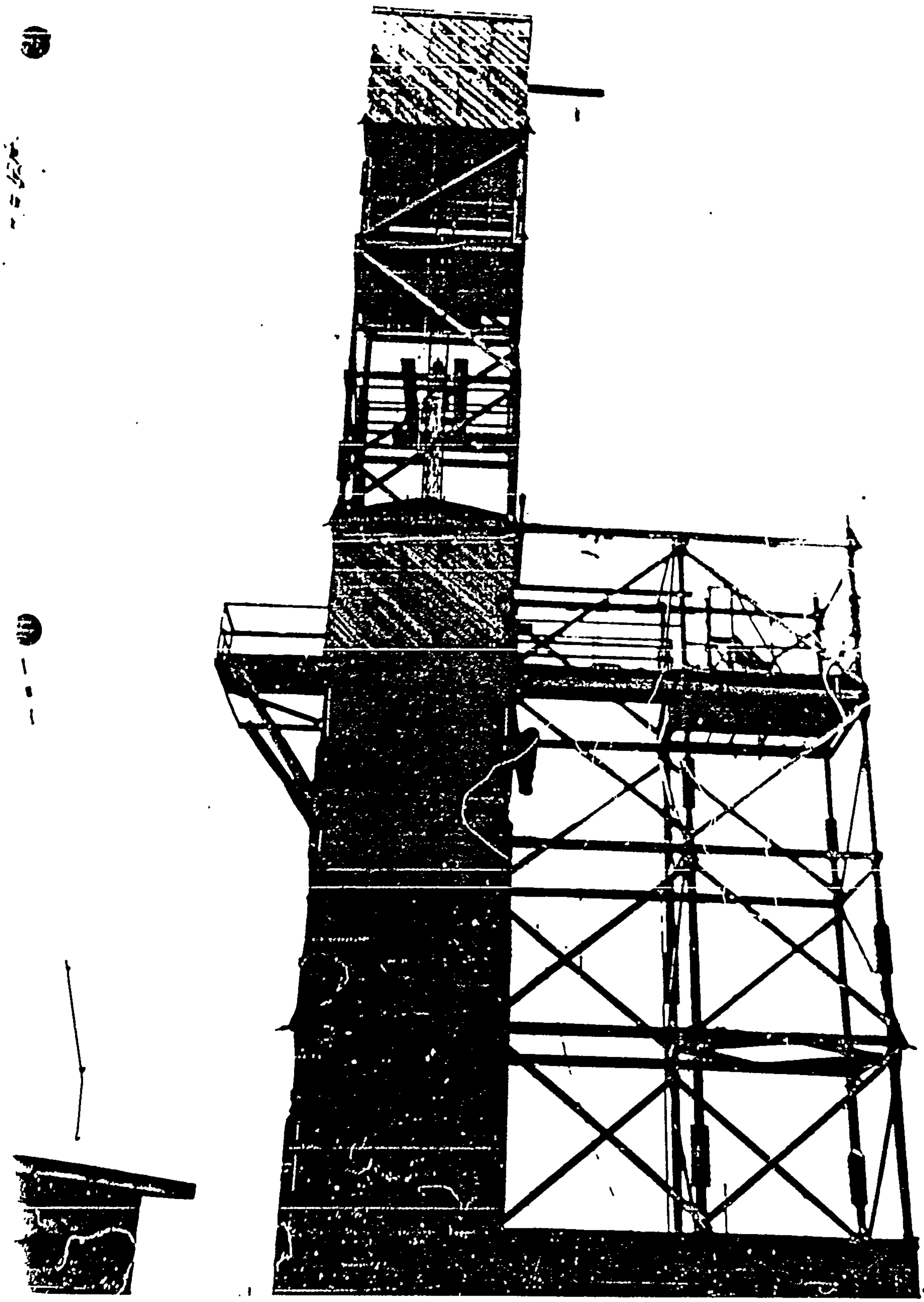

Figure No. 1

HDC-1101

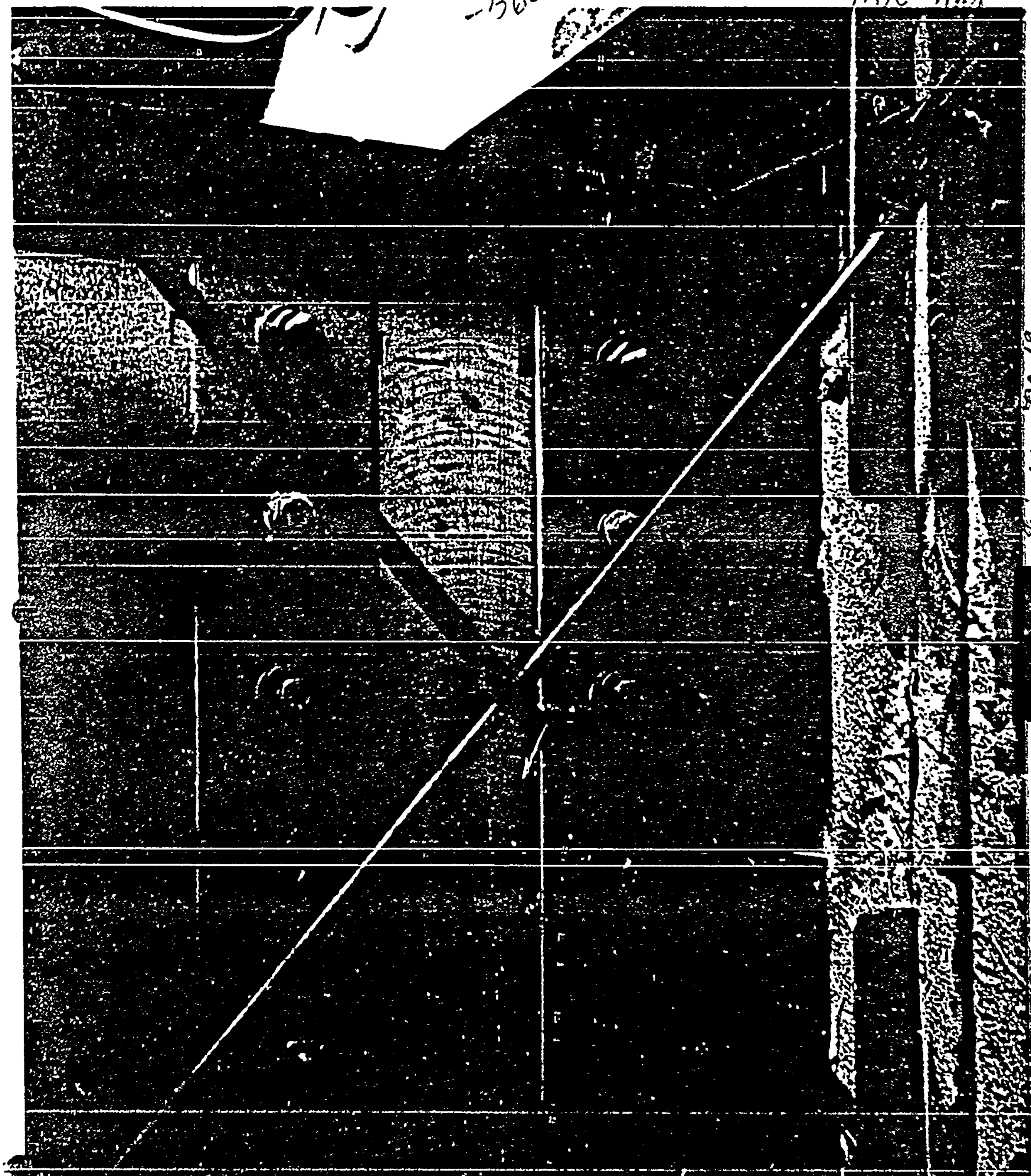

Figure No. 18

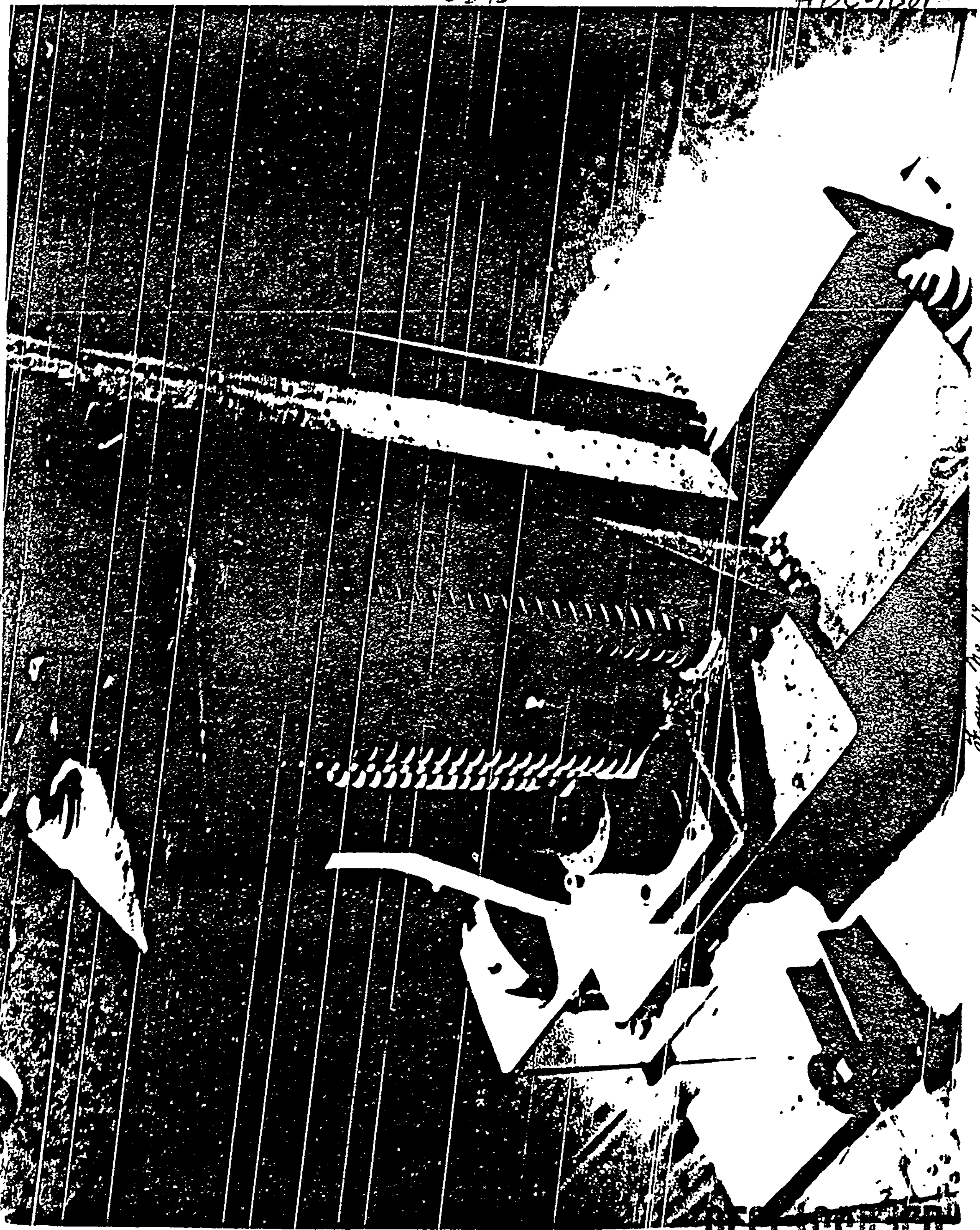

Figure No. 17

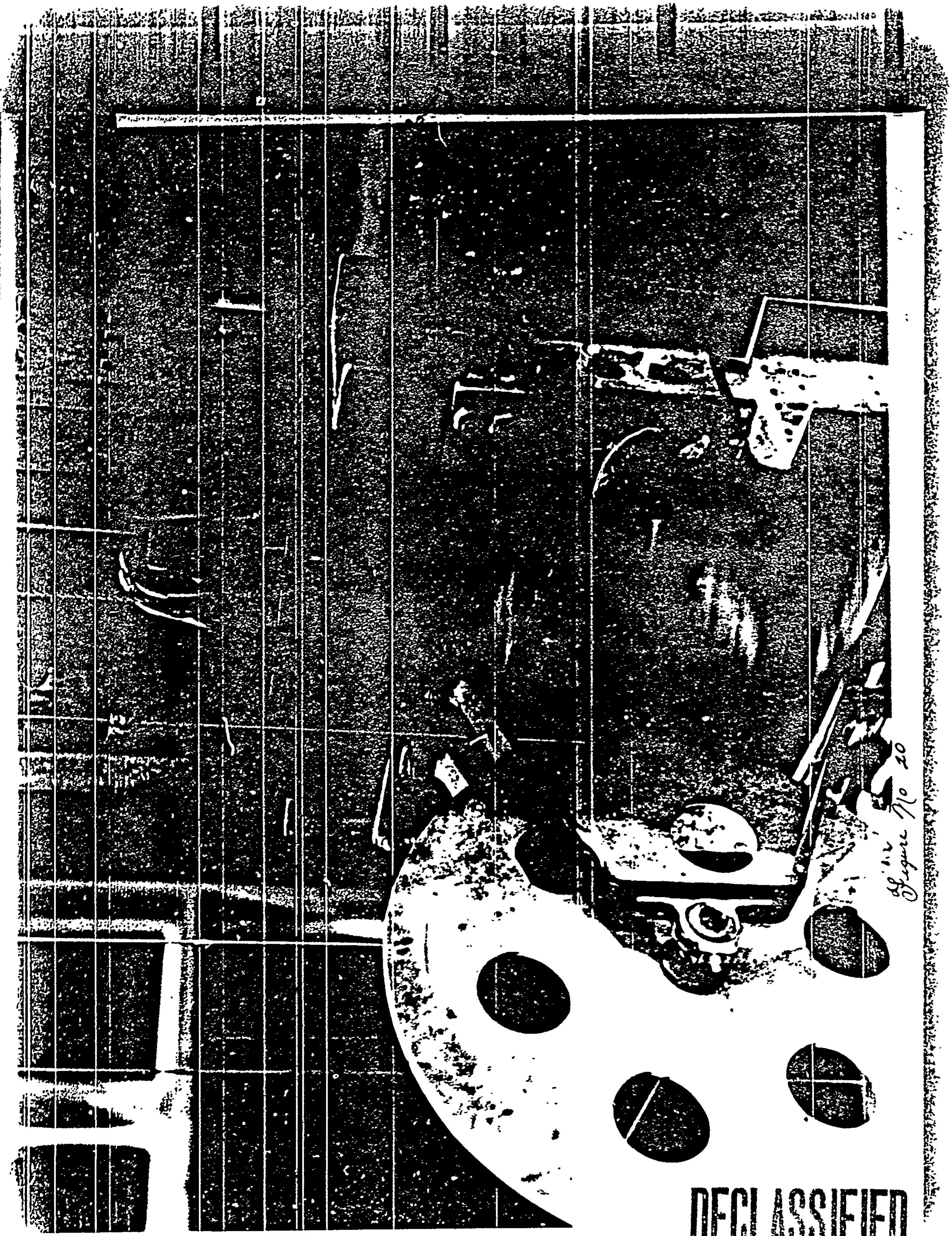

Figure No 20

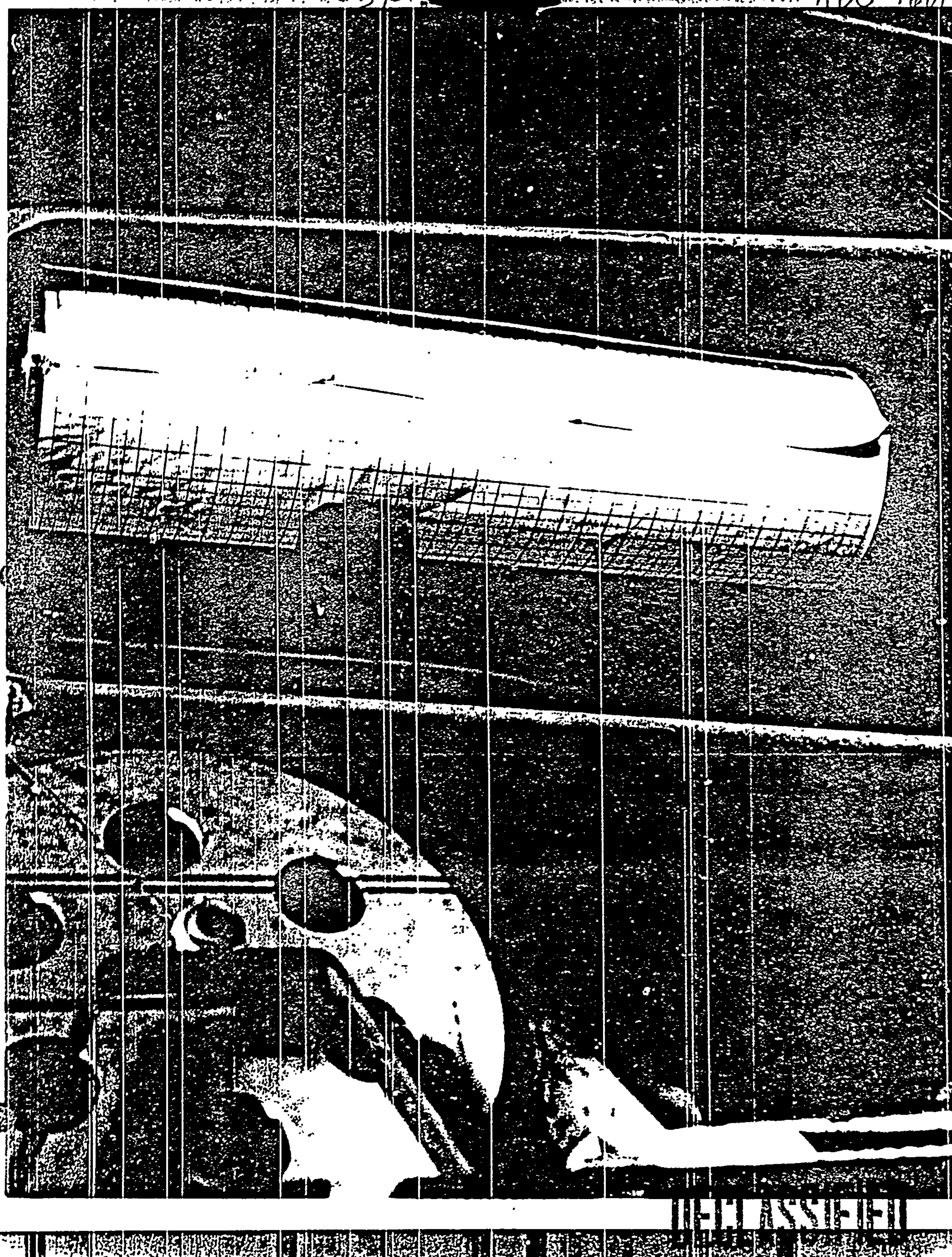

Figure No. 21

C. Results

Phase I of the sheet rod tests has been completed. This phase consisted of drop-testing the rod with various types and degrees of bowing in the graphite slot with the tight-fitting "step plug" assembly (see Method above) omitted. Bowing perpendicular to the plane of the sheet was carried to a maximum of 4" at the center of the slot. No apparent reduction in rate-of-descent was occasioned by bowing the graphite. Approximately 2.2 seconds were required for the rod to drop 31', or approximately 94% of its full travel at all conditions investigated.

For Phase II, the step plug was installed and drop tests were made for various clearances between the "sandwich plates" and the sheet. These initial "calibration" tests were made with the stack undeflected. It was found possible to reduce the total metal-to-metal clearance to 0.010" before the rate-of-descent wa decreased. Drop tests with successively more severe graphite bowing are currently under way.

Tests to date have shown the sheet rod to be a practicable design.

X COEFFICIENT OF FRICTION OF GRAPHITE (TEST PROJECT #12)

A. Object

This test was planned to determine the effective coefficient of friction of graphite blocks as finished by the Sundstrand Duplex milling machine, and to investigate effects of the following variables upon the friction coefficients:

1. Effect of unit pressure upon static coefficient.
2. Effect of unit pressure upon sliding coefficient.
3. Effect of orientation of extrusion axis upon static coefficient.
4. Friction of graphite on steel (static).
5. Friction of graphite on aluminum (static).
6. Friction of graphite on cast iron (static).
7. Friction of graphite on steel wool (static).
8. Friction of graphite on aluminum foil (static).
9. Effect of irradiation upon static coefficient, graphite on graphite.

These tests were necessary to obtain design data relating to pile stability and "anti-growth" measures. The amount and degree of structural binding will be governed to a considerable extent by the frictional forces which these members must overcome. Further particulars are recorded in the Test Project Authorization, HDC-1280.

[redacted]

[redacted]

Section III - Coefficient of Friction of Graphite (Continued)

B. Method

Both static and sliding coefficient tests were made with graphite-on-graphite. Only static tests were made for the other materials listed above. The general method for obtaining static values is shown in the sketch (Figure 22). Variation in unit pressure was obtained by placing lead blocks upon the moveable graphite block. Sliding coefficient was obtained by pulling the blocks at constant velocity while the spring scale was read. Full-sized bars were used for Tests 3 through 8, above.

The direction of motion was varied with underlying static members to determine effect of orientation.

C. Results

1. Values of c_f increased slightly with increase in unit loadings up to 100 p.s.i.

2. An increase in c_f up to 50% was caused by rubbing the surfaces together following machining. The c_f for new surfaces ranged from .235 to .301", whereas for rubbed surfaces it varied from .269 to .393.

3. Irradiated graphite was found to possess a c_f approximately 10-20% higher than that for non-irradiated material. Further data and details will be found in the Test Report, HDC-1398.

XI FUNCTIONAL TESTS OF SLUG EJECTOR COUNTER AND NOZZLE SEAL (TEST PROJECT #13)

A. Object

The objective of this test is to investigate the operating characteristics of the slug ejector-counter--its endurance and reliability. In addition, it is desired to determine the effectiveness and durability of the special Goodrich seal which has been designed to seal the entire "Y-Piece" assembly onto an outlet nozzle. The "Y-Piece" mechanism is a part of the discharge machine, presently being designed for the "G" reactor, which will permit continuous charging.

Further details are to be found in the Test Project Authorization, HDC-1510.

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COEFFICIENT OF FRICTION TEST

TEST PROJECT #12

TEST EQUIPMENT

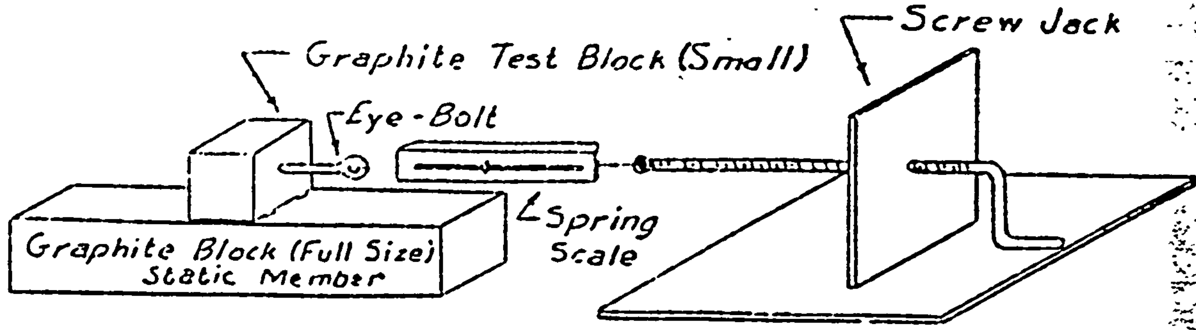

Figure 1

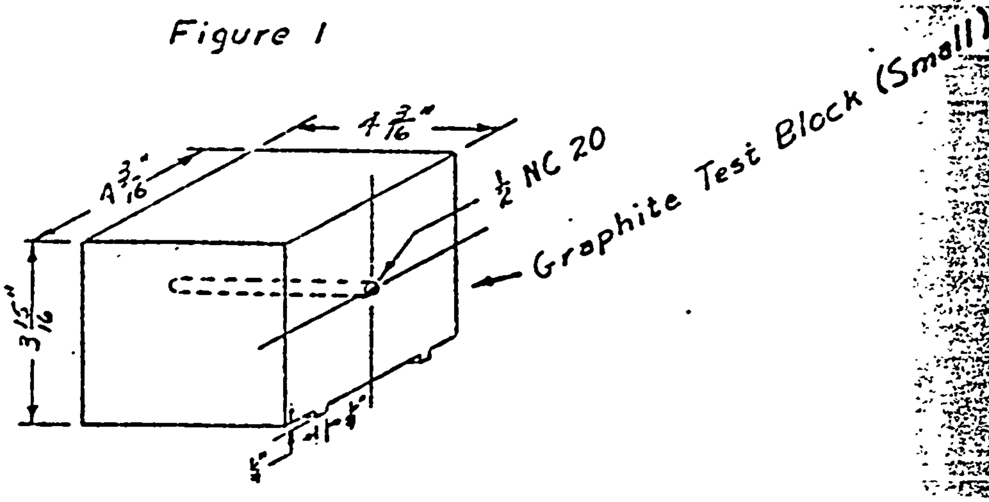

Figure 2

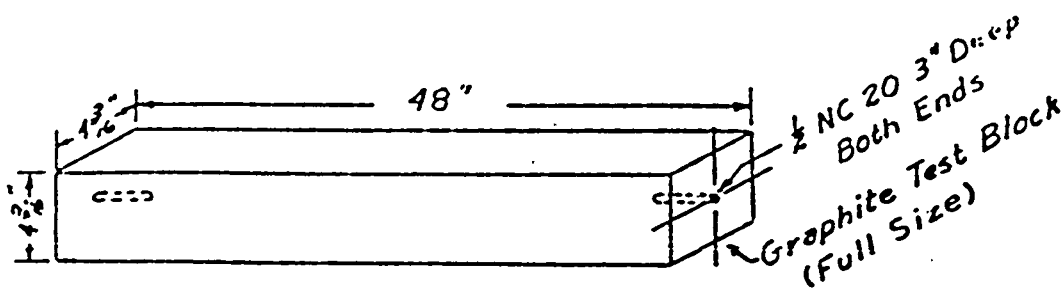

Figure 3

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[redacted]

Section III - Functional Tests of Slug Ejector Counter and Nozzle Seal (Continued)

B. Method

A full-length process tube and the facilities of the 100-F Flow Lab will be used for these tests. Canned lead (or uranium) slugs will be used to load the process tube and test the ejector. Repeated slug loads will be discharged into the test unit until it is felt that representative data have been obtained.

A drawing of the "Y" Assembly test stand, which shows the outline of the "Y Piece" mechanism in phantom, is presented in Figure 23. In Section "A-A", the ejector-counter is seen in its normal, horizontal position at the top, with the transition piece and slug hopper fittings below. Figure 24 shows the actual ejector-counter in more detail and shows, in addition, the chevron-type Goodrich seal at the left in Section "A-A". Tests of the seal will consist of repetitive dry insertions of the nozzle into the seal and periodic pressure tests to determine leakage.

C. Status

Procurement of components of the test equipment has been initiated. The completed design of the overall mechanism is in the final stages. It is expected that testing will start approximately 4-1-50.

XII VERNATHERM FUNCTIONAL TEST (TEST PROJECT #14)

A. Object

The purpose of this test is to ascertain the error, if any, caused by exposure of a standard Vernatherm power unit to irradiation from the outlet process water. This unit is a temperature-sensitive capsule which translates change-in-temperature to mechanical movement of a steel plunger. It is being considered for monitoring the outlet water temperatures of individual process tubes. Its size - approximately 3/4" in diameter and 1 1/4" in overall length - would lend it to installation in a nozzle or pigtail fitting.

Further information will be found in the Test Project Authorization, HDC-1507.

B. Method

This test will be performed in two parts, simultaneously. For Part I, two Vernatherm units will be installed in a special 9" aluminum "slug". This assembly will be placed in a bucket and will be surrounded by radioactive slugs in the discharge basin. A

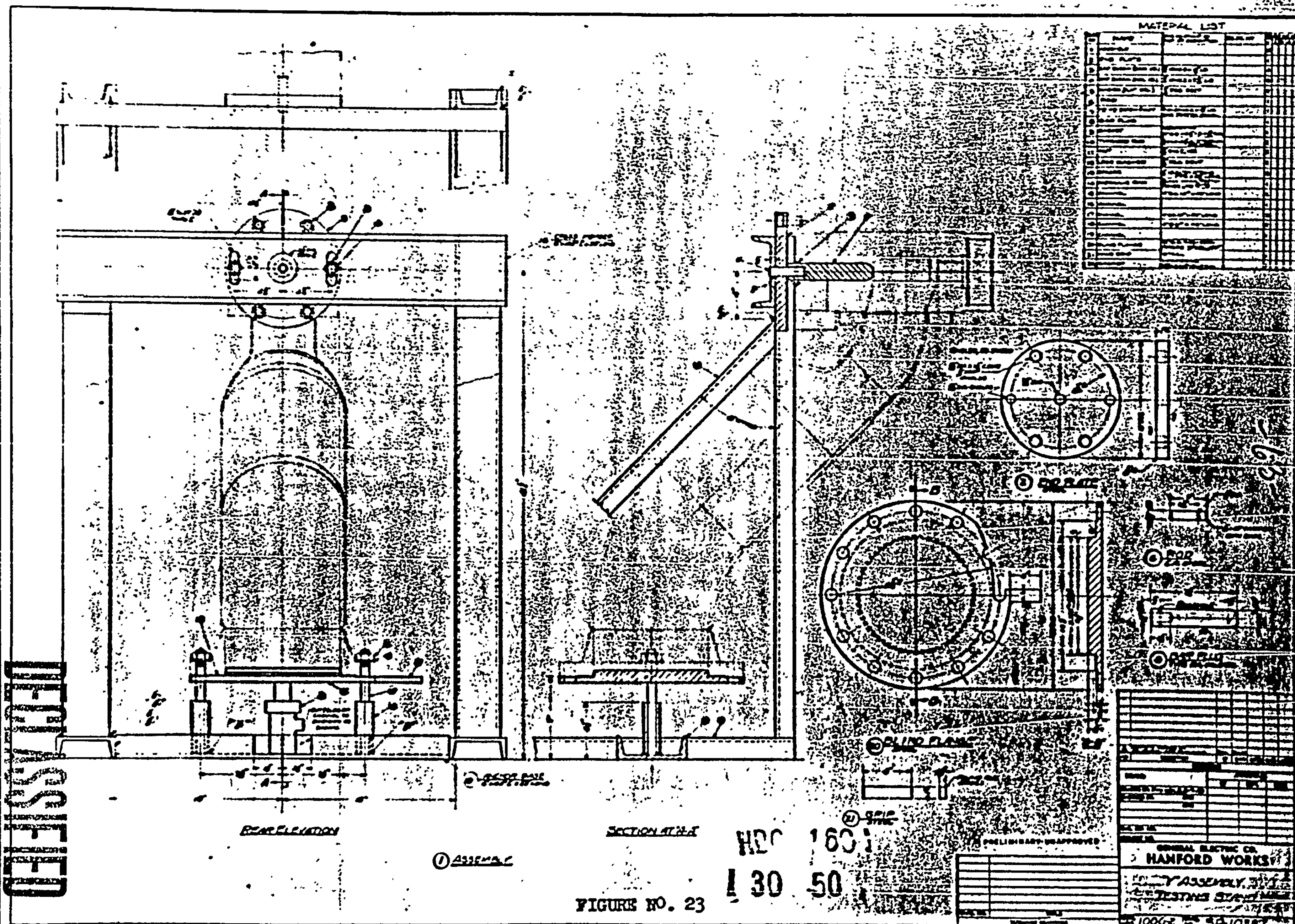
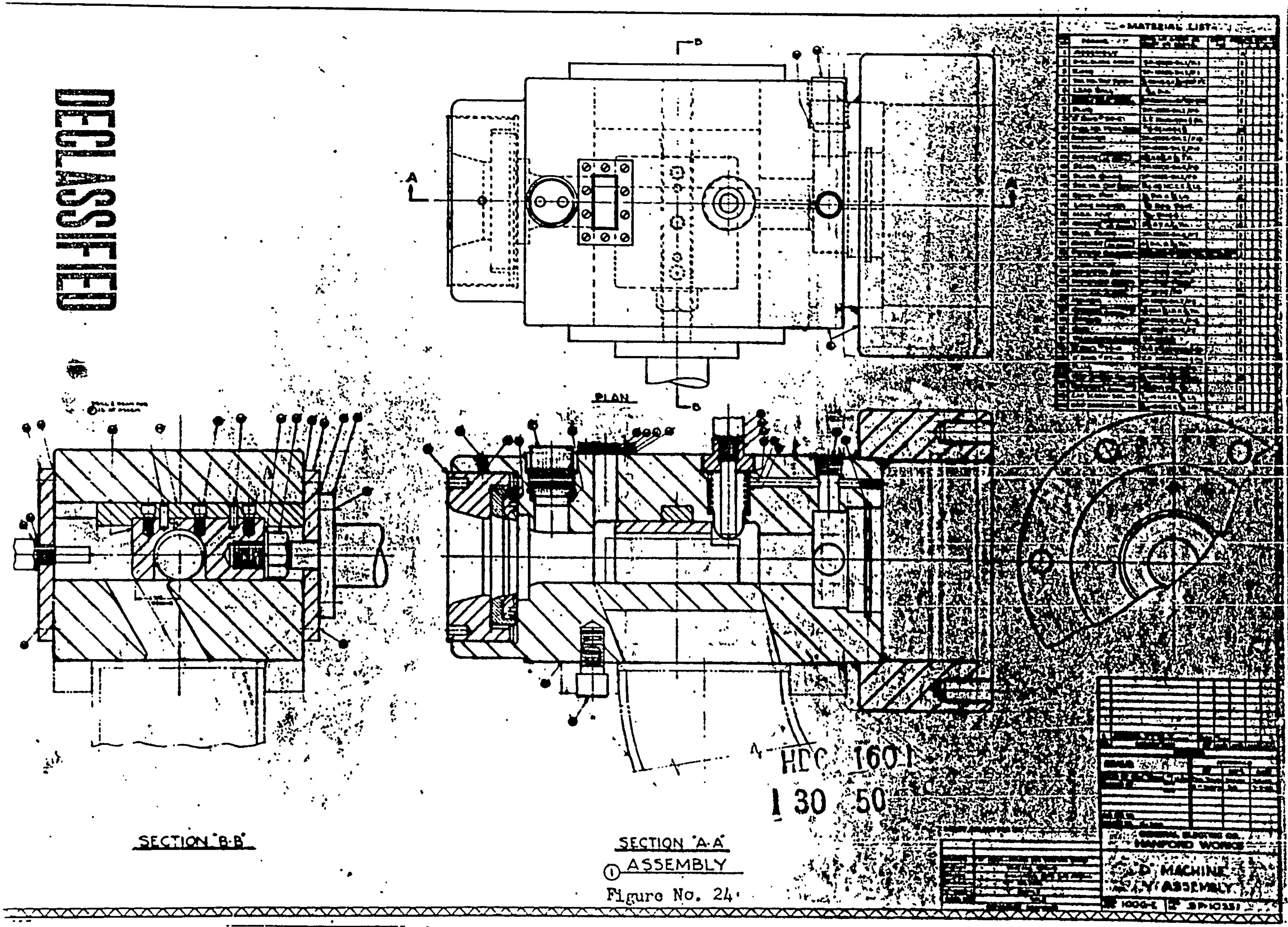

MATERIAL LIST
REAR ELEVATION
SECTION AT "A-A"
① ASSEMBLY
BLIND FLANGE
GENERAL ELECTRIC CO.
HANFORD WORKS
ASSEMBLY
TESTING STAND
PRELIMINARY-UNAPPROVED
HDC 1601
1 30 50

FIGURE NO. 23



① ASSEMBLY

Figure No. 24

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Reactor Division Production Test Request (DCR-1-105-P) has been prepared to cover this phase of the work. The slug bucket exposure will greatly accelerate the irradiation intensity, as compared to Part II.

For Part II, two Vernatherm units will be installed in special T fittings which will be mounted between the outlet nozzle and the pigtail. The units will not be in actual contact with the process water, but will be separated from it by a metal diaphragm. A drawing of the special fitting with the Vernatherm unit installed is given in Figure 25. The Production Test Request for Part II, DCR-2-105-P, is currently awaiting approvals.

A picture of the water bath with which thermal calibrations have been made is seen in Figure 26. The dial gauge bears upon an extension rod and is actuated by the Vernatherm unit which is enclosed by the special "slug" and hidden from sight.

C. Status

All of the equipment has been fabricated and assembled for the tests, the initial unexposed thermal calibration data have been taken, and the irradiation exposure will begin as soon as the Production Test Requests are approved.

XIII TEST FOR EFFECT OF RADIATION ON TELEVISION EQUIPMENT (TEST PROJECT #15)

A. Object

This test was conducted to determine the effect of relatively high level radiation on image characteristics and upon the television apparatus itself. A wired television system is under consideration for the remote alignment and manipulation of continuous discharging equipment.

Specifically, it was desired to test the "Utiliscope" camera of the Diamond Power Specialties Corporation. Further details are to be found in the Test Project Authorization, HDC-1338.

B. Method

Tests consisted of two parts. In the first, the camera was exposed to hot slugs during a normal discharge operation with the pile shut down. The actual television camera lens was located approximately 10' from the tip-off. In the second, the camera was placed within approximately 3' of an outlet nozzle caps for approximately two weeks during normal pile operation.

[redacted]

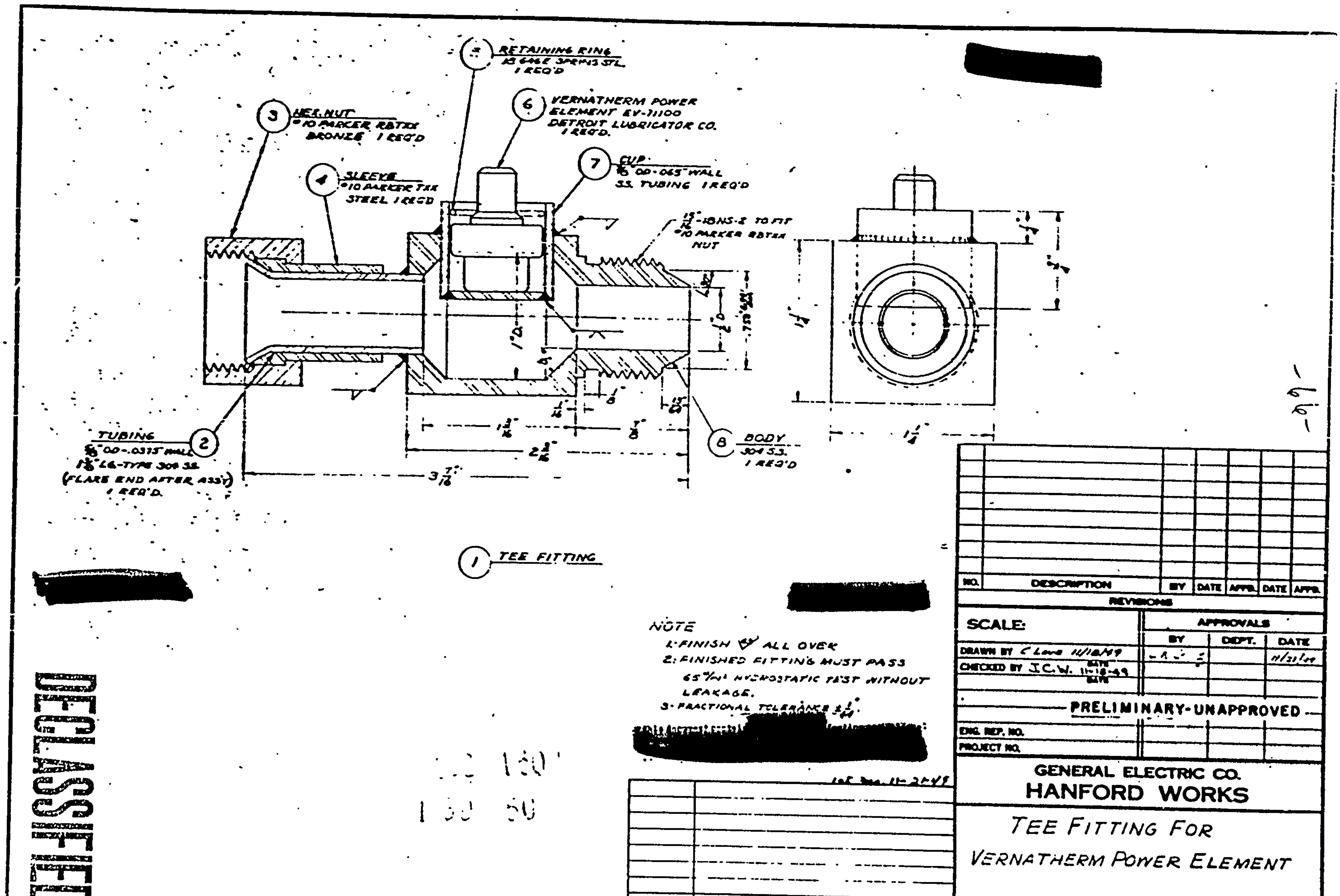

[redacted]
3 HEX.NUT #10 PARKER RBTXX BRONZE 1 REQ'D
4 SLEEVE #10 PARKER TXX STEEL 1 REQ'D
RETAINING RING 13 GAGE SPRING STL. 1 REQ'D
6 VERNATHERM POWER ELEMENT EV-71100 DETROIT LUBRICATOR CO. 1 REQ'D.
7 CUP 15/16 OD-.065 WALL SS TUBING 1 REQ'D
15/16-18NS-2 TO FIT #10 PARKER RBTXX NUT
2 TUBING 5/8 OD-.0375 WALL 1 5/8 LG-TYPE 304 SS (FLARE END AFTER ASSY) 1 REQ'D.
8 BODY 304 S.S. 1 REQ'D
1 TEE FITTING
[redacted]
[redacted]
NOTE
1. FINISH ALL OVER
2. FINISHED FITTING MUST PASS 65#/in² HYDROSTATIC TEST WITHOUT LEAKAGE.
3. FRACTIONAL TOLERANCE ±1/64
[redacted]
DWG. NO.
TITLE
REFERENCE DRAWINGS
NO.
DESCRIPTION
BY
DATE
APPR.
REVISIONS
SCALE:
APPROVALS
DEPT.
DRAWN BY C Love 11/18/49
CHECKED BY J.C.W. 11-18-49
PRELIMINARY-UNAPPROVED
ENG. REP. NO.
PROJECT NO.
GENERAL ELECTRIC CO.
HANFORD WORKS
TEE FITTING FOR
VERNATHERM POWER ELEMENT
BLDG. NO'S 100G-2
DWG. NO. SP-10584

Figure No. 25

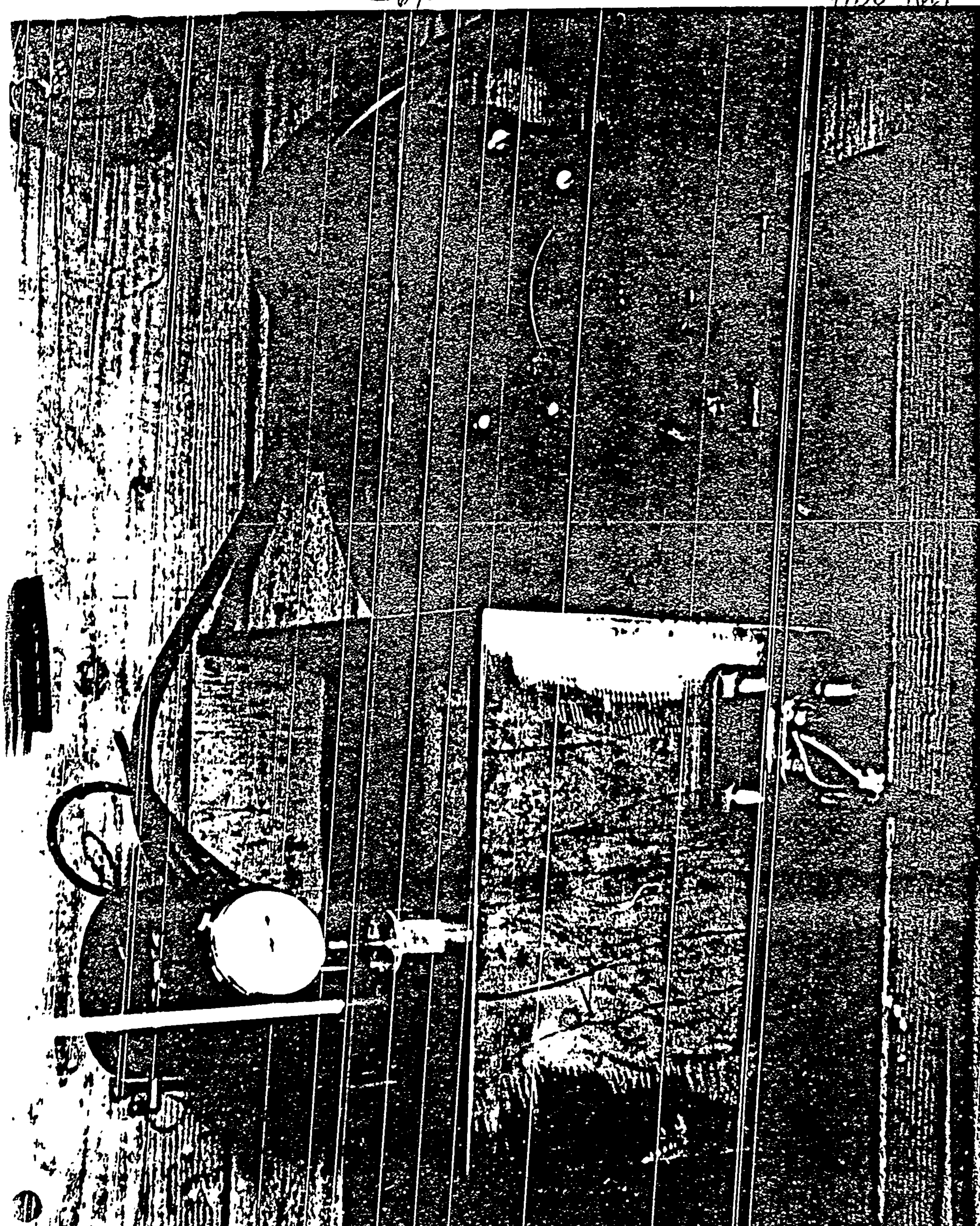


Figure No. 26

Section III - Test for Effect of Radiation on Television Equipment (Cont.)

The television monitor was located where periodic inspections of the quality of the image could be made. During Part I, continual visual observation and frequent photographic records of the image were made. These data were taken at daily intervals during the two weeks of Part II.

The television camera was completely enclosed in a sealed wooden box with a window, and all power leads were encased in a rubber hose to guard against contamination. The power pack unit was outside the "hot" area and was separated from the camera by 50' of cable. A sketch showing the approximate arrangement of the test apparatus at the rear face of 105-F is presented in Figure 27.

C. Results

For the extent of the exposure in these tests, the "Utiliscope" camera performed entirely satisfactorily. The only difficulties experienced were minor, being those which would normally arise with unskilled operators, and were routine adjustments and corrections. An excellent view was had of the discharging operation, wherein it was possible to identify the various types of dummy slugs as they passed over the tip-off.

XIV SHORT-LENGTH HEAT TRANSFER TESTS (TEST PROJECT #17)

NOTE: The Short-length Tests are an integral and complementary part of the Full-scale Heat Transfer Tests (Test Project #18), a description of which follows in the section below. The ultimate objective of both tests is the same and the greater portion of the apparatus is common to both.

A. Object

To provide means for studying heat transfer and coolant flow characteristics in process tubes. Further, to assess the feasibility of operating "maximum performance tubes" at an overall pile output in the range of 800 MW by establishing the limiting safe heat load conditions in pile process tubes.

Specifically, the Short-length Tests are intended to study these variables step-wise (in short sections) throughout the length of a process tube. They will permit investigation of a great number of variables, such as annulus size, burn-out conditions, heater construction, and critical flow, more rapidly and over a wider range than would be practical with the full-scale apparatus. In a sense, these tests will also serve a "pilot run" function to the full-scale tests in that critical experiments will first be performed with the Short-length equipment.

Test objectives and plans are elaborated in the Test Project Authorization, HDC-1508.

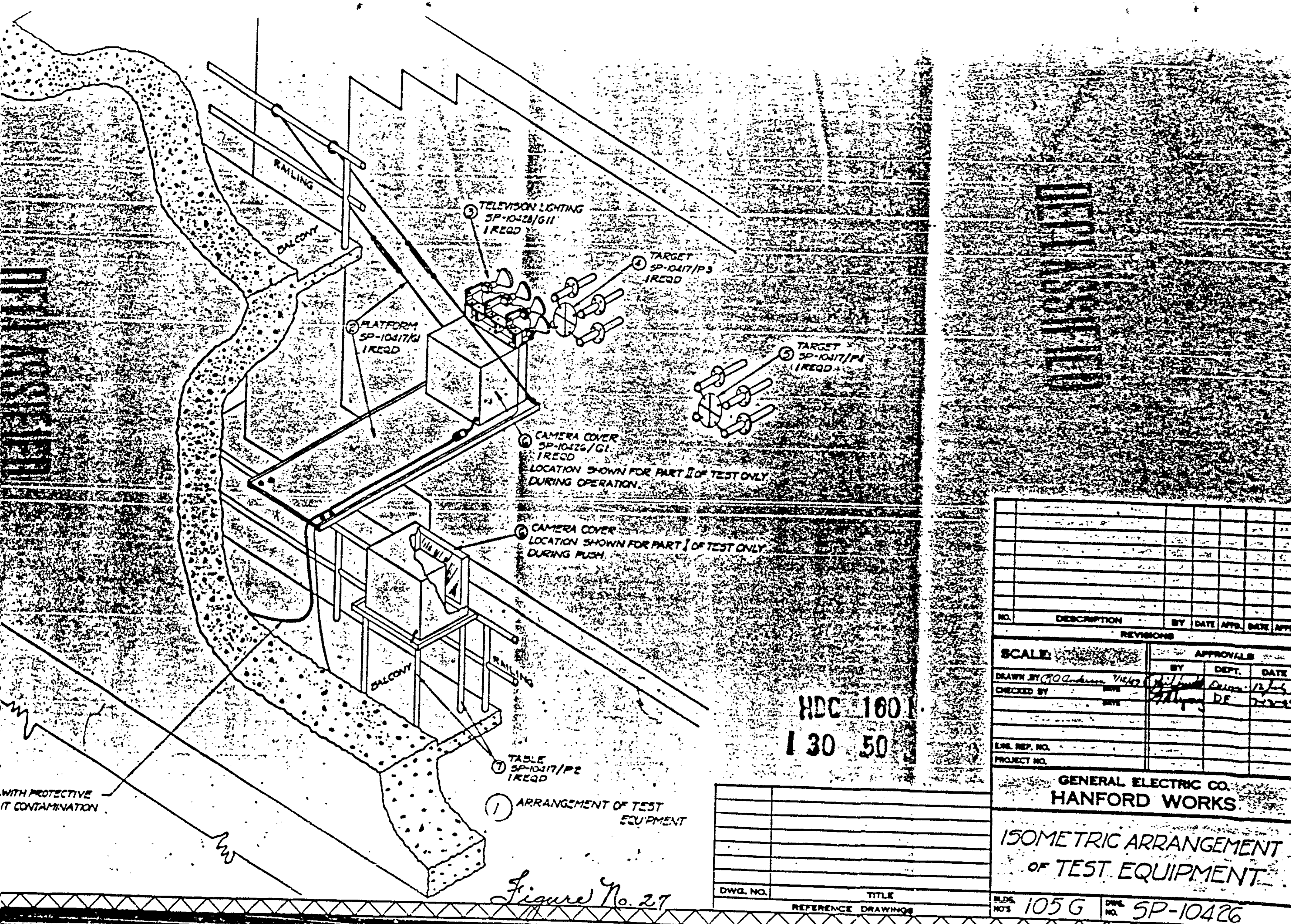
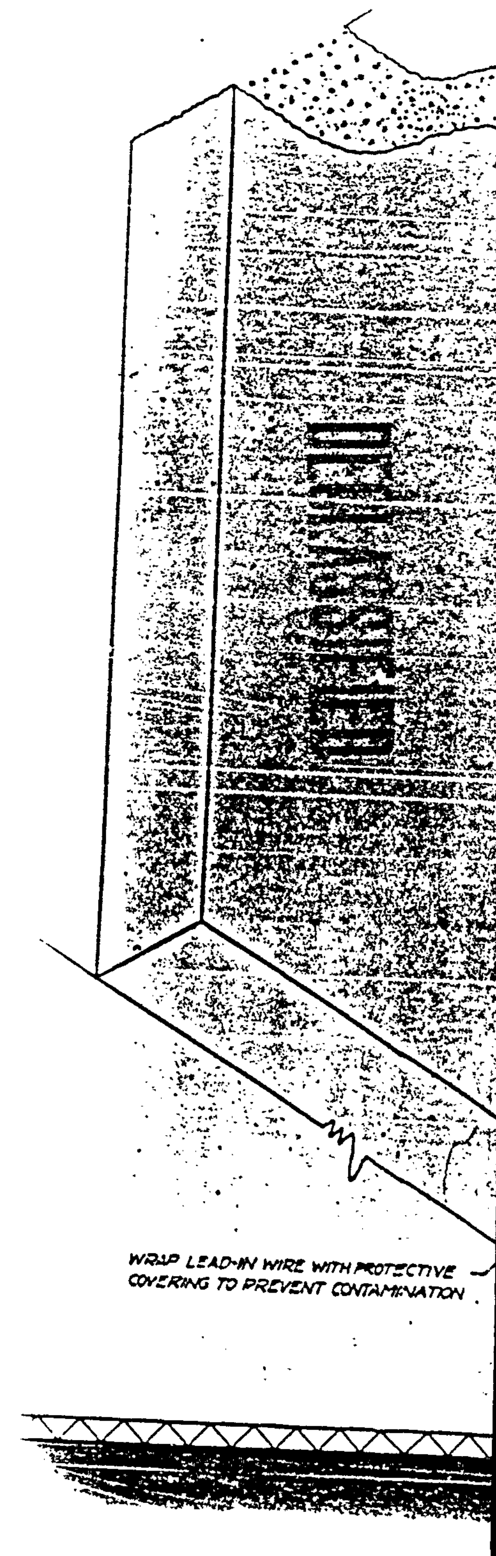

RAILING
BALCONY
③ TELEVISION LIGHTING SP-10428/G11 1 REQD
④ TARGET SP-10417/P3 1 REQD
② PLATFORM SP-10417/G1 1 REQD
⑤ TARGET SP-10417/P4 1 REQD
⑥ CAMERA COVER SP-10426/G1 1 REQD LOCATION SHOWN FOR PART II OF TEST ONLY DURING OPERATION.
⑥ CAMERA COVER LOCATION SHOWN FOR PART I OF TEST ONLY DURING PUSH.
⑦ TABLE SP-10417/P2 1 REQD
WITH PROTECTIVE
IT CONTAMINATION
① ARRANGEMENT OF TEST EQUIPMENT
DECLASSIFIED
HDC 160
I 30 50
NO. | DESCRIPTION | BY | DATE | APPD. | DATE | APPD.
REVISIONS
SCALE:
APPROVALS
BY | DEPT. | DATE
DRAWN BY
CHECKED BY
DF
ENG. REP. NO.
PROJECT NO.
GENERAL ELECTRIC CO.
HANFORD WORKS
ISOMETRIC ARRANGEMENT OF TEST EQUIPMENT
DWG. NO. | TITLE
REFERENCE DRAWINGS
BLDG. NO'S 105 G
DWG. NO. SP-10426

Figure No. 27


DECLASSIFIED
WRAP LEAD-IN WIRE WITH PROTECTIVE
COVERING TO PREVENT CONTAMINATION

Section III - Short-Length Heat Transfer Tests (Continued)

B. Method

The Short-Length Test Section will be approximately 3 1/2' in length and will consist of a length of aluminum process tube enclosing an electrically-heated, thin-walled tube. The heater tube which simulates the heating of a short column of slugs will, at maximum conditions, be supplied with approximately 126 KW of electrical energy, direct current.

"Process water" will be circulated through a closed flow system with provision for continual de-aeration of the water. A multi-stage centrifugal pump will provide pressures up to 400 p.s.i.a. at the inlet of the test section for a maximum flow rate of 35 g.p.m. A condenser will cool the fluid between the outlet of the test section and the inlet of the pump to avoid cavitation. Any additional heating, before reentry at the test section, will be supplied by a steam preheater. Provision has been made for maintaining either constant flow or constant inlet pressure conditions. A schematic flow diagram is given in Figure 28 which shows the mechanical components of the system and the major instrumentation. Direction of flow is indicated by arrows on this sketch. The actual process piping layout is contained in Figure 29. The upper view is a plan; the lower, a side elevation.

The supply of electrical energy is discussed under Test Project #18, (Method), below.

C. Status

Orders have been placed for the major portion of the apparatus and instrumentation required for both tests. Procurement schedules should permit the initiation of preliminary testing by approximately April 1, 1950.

Power Division approval has been received to use space and facilities at the 189 (Refrigeration) Bldg. at 100-D. Work Orders have been initiated for preparation of the test site.

XV FULL-SCALE HEAT TRANSFER TESTS (TEST PROJECT #18)

NOTE: See explanatory statement in preceding section.

A. Object

The Full-Scale test will serve to amplify and confirm the results obtained both in Test Project #5 and #17. The subject program will provide specific data on the following:

1. Pressure-drops corresponding to required flow rates.
2. Consistency of outlet water temperature and flow.
3. Stability of flow conditions with the occurrence of boiling.
4. The relationship of all of the above, plus heat load, upon header pressure and orificing requirements.

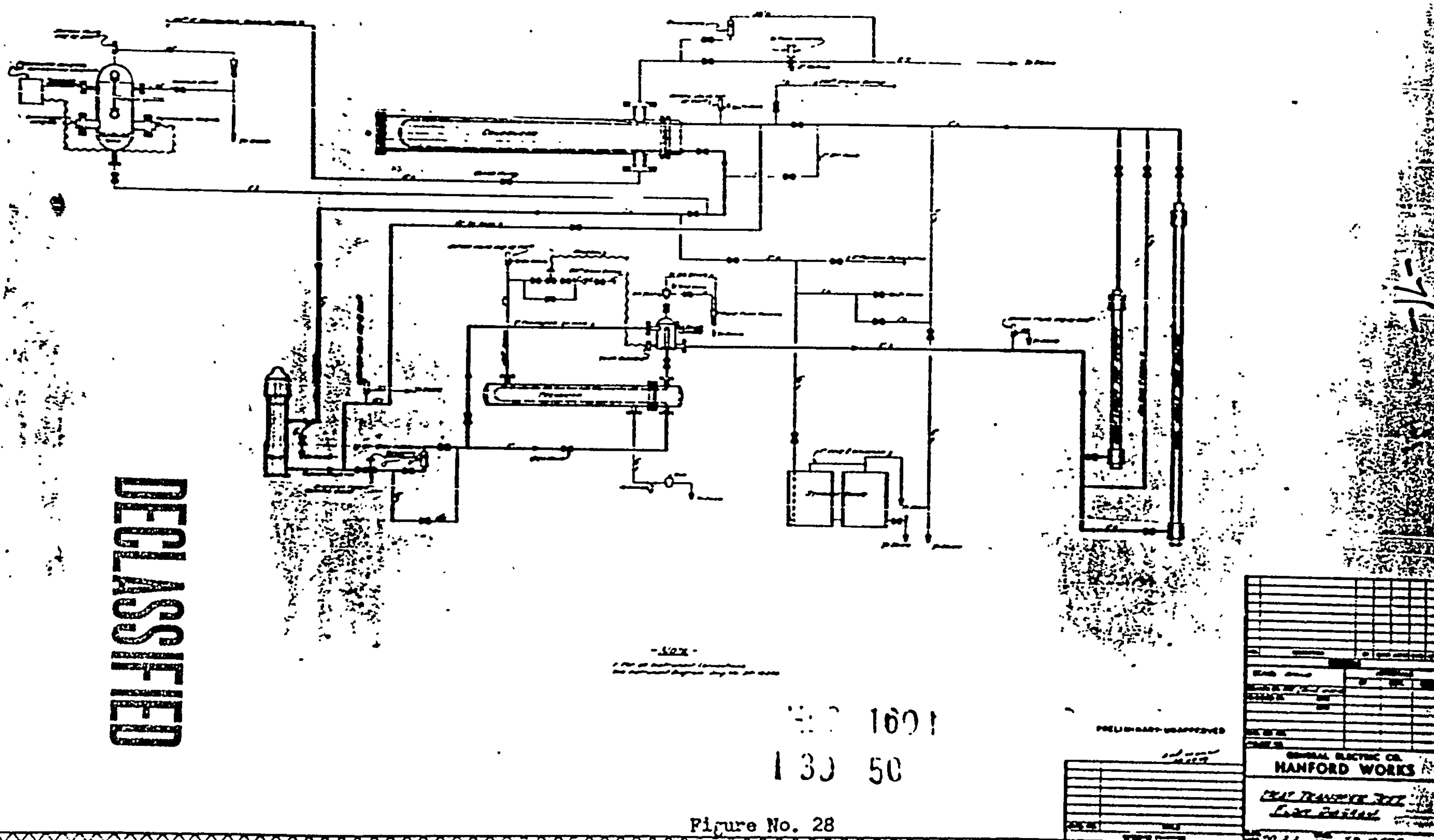


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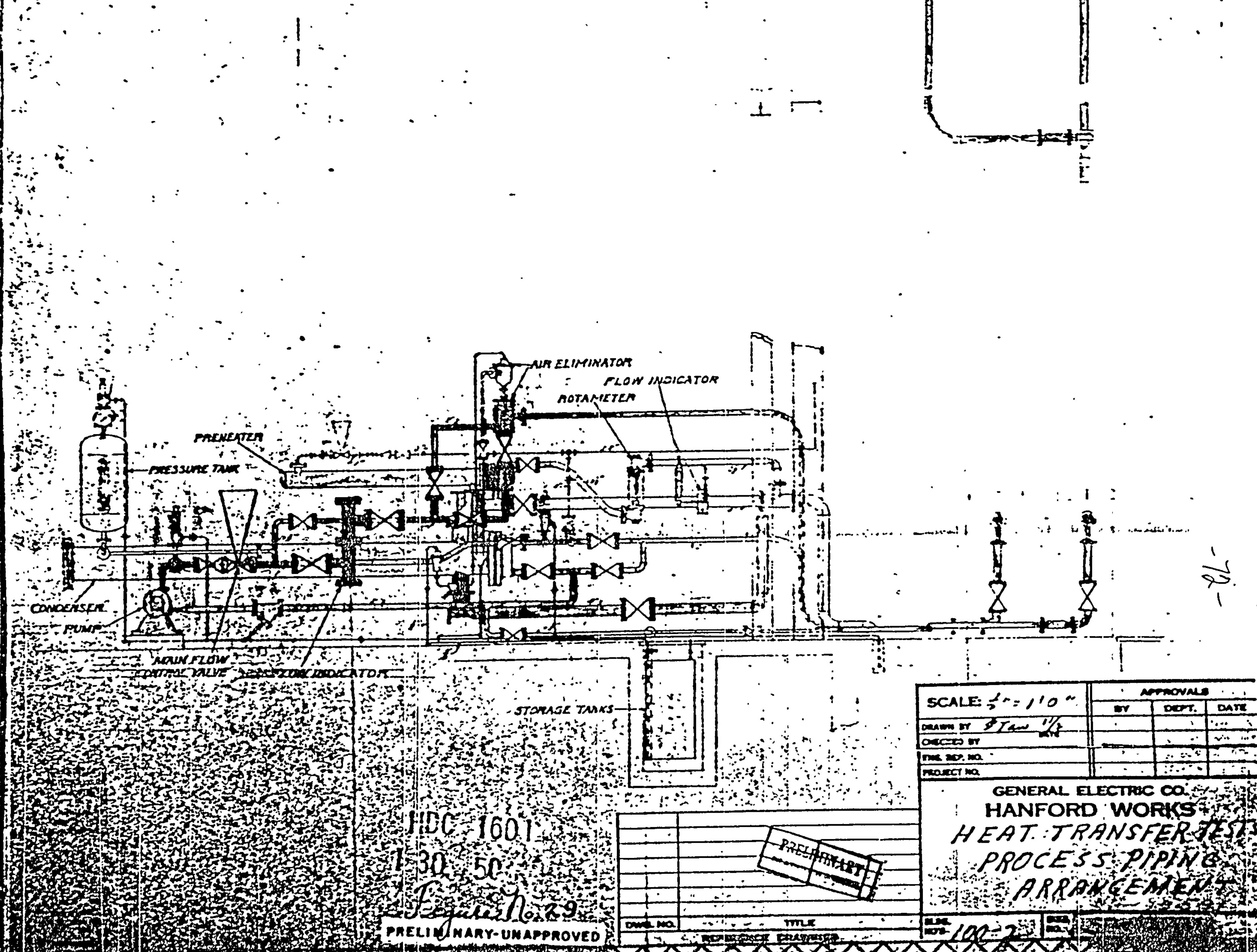
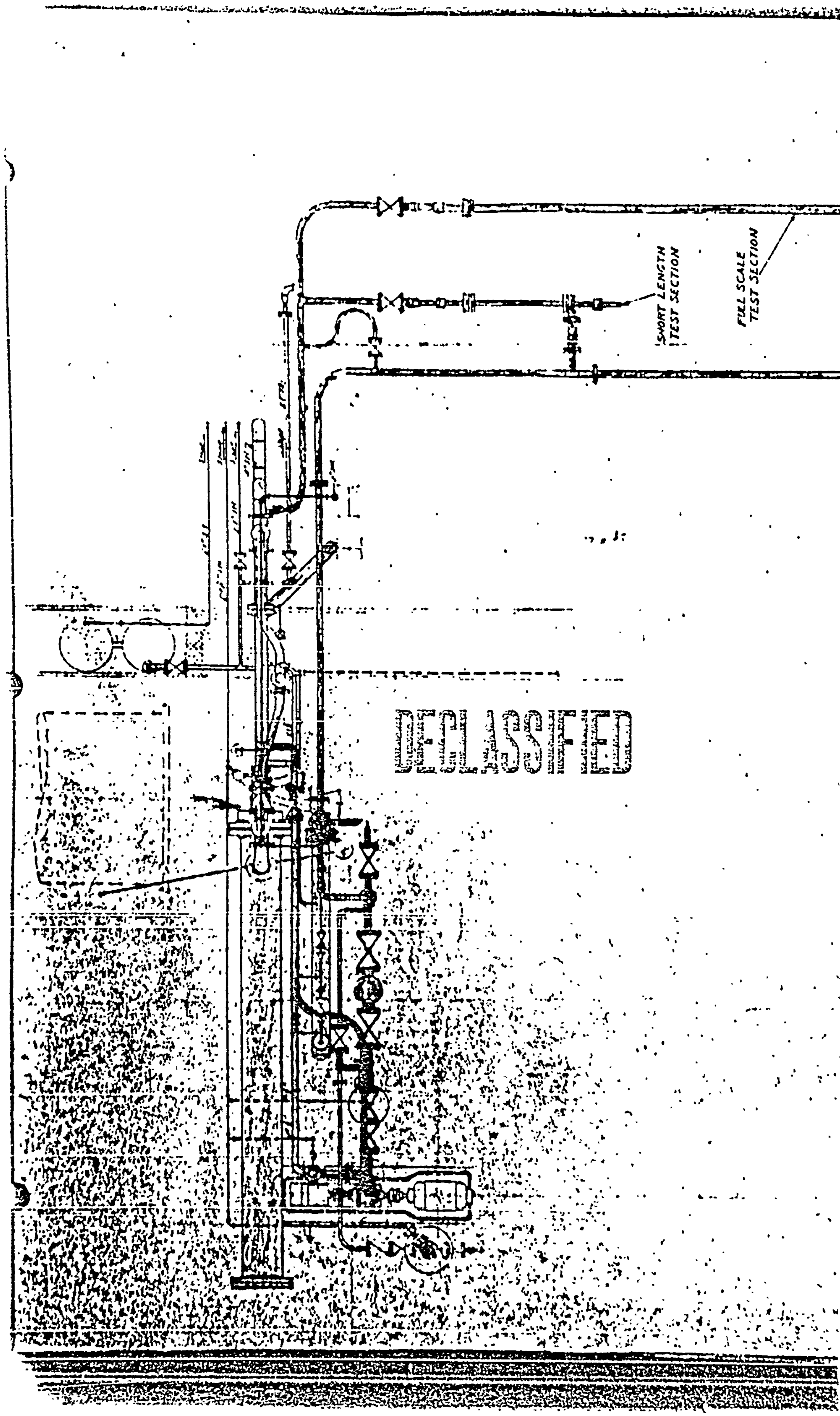
Figure No. 28



HDC 1601
1 30 50
Figure No. 29


SHORT LENGTH TEST SECTION
FULL SCALE TEST SECTION

[redacted]

Section III - Full-Scale Heat Transfer Tests (Continued)

Confirmation of new design criteria for an 800 MW pile: heat load, flow rates, annulus size, etc., will be attempted with the full-scale tests.

B. Method

The general flow diagram and instrumentation required for Project #17 will be used for the subject tests. The chief differences lie in the length of test section: 23' instead of 3 1/2'; the power required: 750 KW instead of 126 KW; and in the omission of the preheater in the process water flow diagram (Figure 28).

A high-capacity motor-generator set has been ordered, capable of delivering 15,000 amps maximum, over a range 3 to 50 volts. A single 1200 h.p. motor will be used to drive two 7500-amp generators with suitable provisions for load balancing, and for current and voltage control. A 2000 KVA transformer, 3-phase, 13,800 - 2300 volts, which is located outside the 186-D Bldg., will be used for the power supply. Circuit breakers will be located both at the 2000 KVA transformer and in the DC feeders from the generator to the test section. These will "suicide" the circuits for any of the following conditions: high overload (short circuit), open circuit, excessive pressure drop in the water across the test sections, and abnormal pressures in the liquid contained in the heater tube (indicating excessive temperature-rise).

Assistance Request DCR-1. has been issued to GECL at Schenectady for the development and fabrication of a full-scale heater section. This unit is described in considerable detail on Page 1 of this Request.

C. Status

The status of these tests is essentially that given for Project #17. All major components of the electrical system have been ordered. Present delivery dates should permit initial testing with the full-scale section to begin approximately July 1, 1950.

XVI GRAPHITE KEY TESTS (TEST PROJECT #19)

A. Object

These tests are to determine relative strengths of round and rectangular keys and keyways in graphite. Further, the "wedge" or lifting effect of round keys and the effective shear or crushing strength in keys and keyways of both types will be investigated.

These tests are necessary to evaluate measures designed to counteract effects of graphite growth. The method of keying between adjacent blocks or layers is of prime importance in the stability and life of the pile under conditions of graphite growth. Further information is to be found in the Test Project Authorization, HDC-1512.

[redacted]

Section III - Graphite Key Tests (Continued)

B. Method

These tests will be carried out in the 60,000# testing machine at the 300 Area. A jig has been fabricated according to the drawing shown in Figure 30 and will permit, by the substitution of various types of graphite blocks, investigation of either type of keys: round or rectangular.

Tests will be made both of GBF and CSF grades of graphite. Shear (or crushing) strength of keys will be determined by loading the test assembly in compression; keyway "tear out" strength will be measured under tensile loading conditions. The latter will, in a sense, be an investigation of stress concentration at the keyway due to "notch" form. The wedge or lifting effect of round keys will be evaluated with the aid of resistance-type strain gages attached to transverse tie-bolts (Part 8 in Figure 30).

It is anticipated that further tests may be required besides the primary investigations which specify 1 1/2" square keys and 1 5/8" diameter round keys. Other variables such as additional key shapes or sizes, edge distance, etc., may require investigation.

C. Status

The major portion of the apparatus and test samples have been fabricated or procured. Tests will commence when the electric strain gages are received from an eastern vendor.

XVII BALL 3X SYSTEM FUNCTIONAL TEST (TEST PROJECT 4-1)

A. Object

This test is planned to obtain specific operational characteristics of a proposed Ball 3X System. A 3X System which embodies a neo-fluid (1/4" diameter low density balls) would permit a rapid poisoning of the pile reaction by filling the rod openings. Yet such a "fluid" could be readily recovered and drained off at the bottom, prior to start-up. The following is a partial survey of the information sought from these tests:

1. Period and flow rate of the dropping cycle.

2. "Hydrostatic" and impact forces imposed on the graphite stack by the balls.

3. Reliability of the release mechanism and of the exit gate apparatus (at the base of the slot).

4. The effect of dropping the rod at various phases of the ball release cycle.

Further particulars are contained in the Test Project Authorization, HDC-1526.

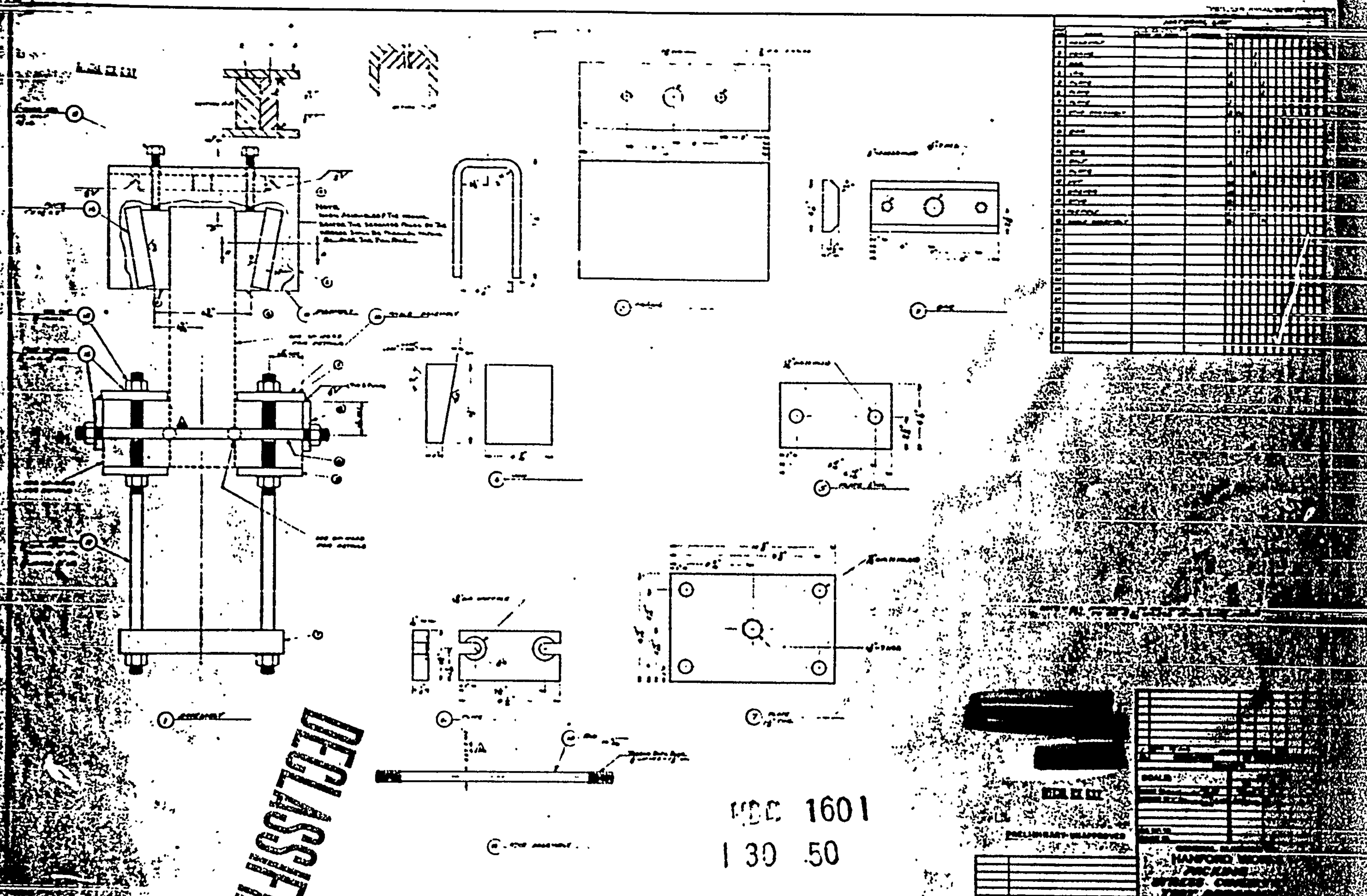


Figure 30

B. Method

The major portion of these tests will be carried out in a new bay which is to be constructed at the White Bluffs Test Tower, described and shown pictorially in the discussion under Test Project #11, above. A full-scale mock-up of the rod opening in the graphite is being fabricated. The shape of the opening in the new stack differs from the present rod mock-up in that additional space is provided for the balls.

A schematic sketch of the test equipment and instrumentation is presented in Figure 31. The dropping rate of the balls will be measured by means of the load cell from which the entrance hopper is suspended. Impact and hydrostatic forces on the graphite will be determined by movable graphite blocks which bear upon load cells; one at 1/3 and one at 2/3 the height of the stack. Timing switches at top and bottom of the slot will measure the interval required for the first balls to fall from top to bottom.

The first phases of testing will be carried out in the new bay of the tower. Subsequent bowing tests and those investigations which involve dropping the sheet rod simultaneously with the release of balls will be conducted in the 90' section of the tower within which sheet rod tests are currently under way.

C. Status

Drawings of all components of the apparatus are virtually completed. Fabrication of the release gate and hopper will commence in the near future. Procurement of various items of instrumentation is under way and work orders have been written for machining the graphite and for the fabrication of the wooden supporting structure for the graphite.

It is expected that preliminary tests will begin approximately February 27, 1950, contingent upon the rigors of the Hanford winter.

XVIII WATER SYSTEM STUDIES (TEST PROJECT #20) - F. H. Ames (Reactor Div.)

A. Object

Test operation is planned to obtain experimental data with which to establish basic criteria for the design of a Process Water Recirculation System for a Hanford-type Reactor. The test program is described in Test Project Authorization #20, HDC-1551.

It is expected that this experiment will supply the necessary data to permit economic and operational feasibility evaluation of a process water recirculation system. This system will be compared with a simplified conventional process water plant to arrive at final design for the "G" Water Plant.

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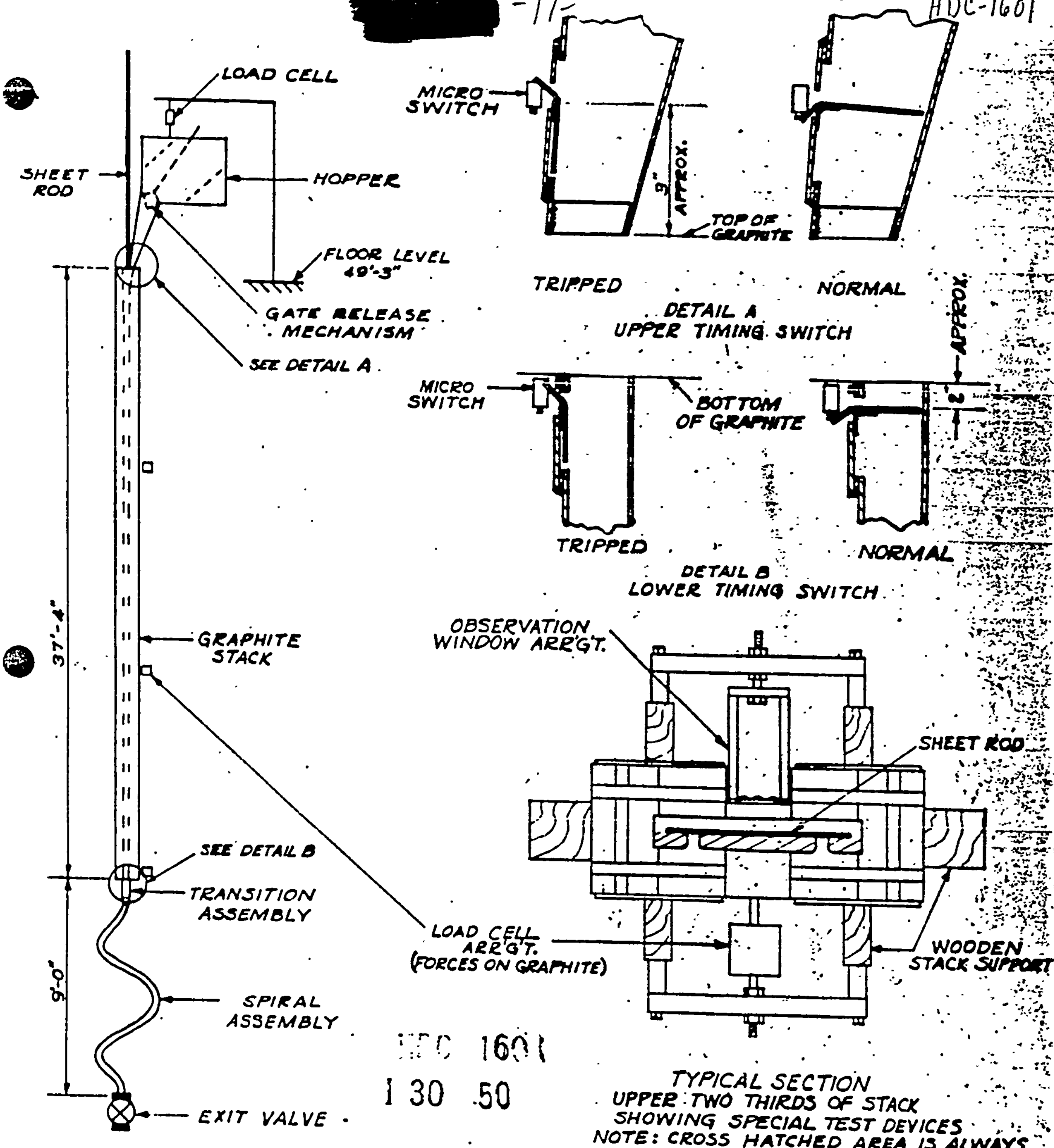

HDC 1601
1 30 50

FIGURE NO. 31

GENERAL ELECTRIC CO. HANFORD WORKS	SCALE —	[redacted]
TEST 21 BALL 3X FUNCTIONAL TEST SCHEMATIC	APPROVED [signature] 1/?/50	DATE 1-3-50 DRAWN BY J. L. Smith CHECKED J. L. Smith PROJ. NO. E. R. NO. BLDG. NO. 100-G-2
	PRELIMINARY-UNAPPROVED	DWG. NO. SP-10,691

Section XII - Water System Studies (Continued)

B. Method

This test program will consist of two phases. The first will utilize the H-pile experimental "V" hole loaded with dummy slugs. The second will use production tube 0961 loaded with metal slugs. In each case, the cooling water will be recirculated at normal flow rates through a stainless steel system of retention tanks and heat exchangers while measurements are made of corrosion rates, film formation, and chemical composition and radioactivity level of the water. The cooling water is to be obtained from steam condensate in the area. Sufficient "back-up" is being provided to preclude loss of coolant to the single tube being used.

C. Status

The basic drawings for the test system have been prepared and vendors are being contacted for bids. Selection of the equipment will permit completion of the detailed drawings and selection of the construction personnel necessary to do the work. It is anticipated that actual installation will start in February, 1950.

XIX CORROSION TESTS - PROCESS WATER - R. J. Schier (Reactor Division)

A. Object

These tests are intended to evaluate aluminum alloys and zirconium as possible substitutes for the present 2S aluminum construction material.

B. Method

The corrosion tests are being run by the Technical Divisions in the 105-D Flow Laboratory, using standard process water. Temperatures of about 17°C, 30°C, 45°C, 65°C, and 90°C are being investigated.

The following standard commercial aluminum alloys are in test:

3S	56S
52S	61S
53S	63S

Several promising new alloys are being prepared by Battelle and will be tested also. Evaluation of Bureau of Mines Zirconium (magnesium reduced) has been started, and samples of low hafnium zirconium produced by a variety of methods in an AEC sponsored program have been requested for evaluation.

[redacted]

Section III - Corrosion Tests - Process Water (Continued)

C. Status:

It is not anticipated that meaningful data will be available from this corrosion test program until April.

XX CORROSION TESTS - PILE ATMOSPHERE - R. J. Schier (Reactor Division)

A. Object

These tests are designed to evaluate pile constructional materials, particularly control rod materials such as stainless steel and titanium, in simulated pile atmospheres.

B. Method

These tests will be performed by the Technical Divisions in the 300 Area. To start, materials will be evaluated in a CO_2-CO equilibrium atmosphere at 800°F. to 1300°F. However, the equipment is suited for testing with other atmospheres at temperatures up to 1800°F.

C. Status

Design of the test equipment has been completed. It is hoped that installation of this equipment can be completed during March, after which about six months will be required to obtain useful corrosion data.

[redacted]

SECTION IV

REFERENCE DOCUMENTS

I N D E X

SECTION IV

REFERENCE DOCUMENTS

The following documents have been issued since the previous progress report (HDC-1176, dated May 24, 1949) and are listed for reference purposes.

A. WATER SYSTEM

HDC-3224	A Modification of the Present Design of Water Areas.
HDC-3150	Process Water Provided by Gravity Flow.
HDC-3149	Process Water Recirculation.
HDC-1551	Test Project Auth. #20 - Recirculation Test System.
HDC-1562	Minutes of Meeting - Water Requirements for Reactor "G" - G. H. Syrovy to File, 12/14/49.

B. HEAT TRANSFER

HDC-1461	Simulation of Thermal Conditions in Aluminum End Cap.
HDC-1513	Requirements for Heater Test Element.
HDC-1424	Progress Report on Gas Cooling of Control Rods.
HDC-1521	Results of Calculations to Determine Effectiveness of Increasing Area of Heater Tube to Simulate Heating Distribution in Aluminum End Cap.

C. PILE PHYSICS

HDC-3957	"G" Pile Control System - P. F. Gast to P. E. Lowe, 1/3/50.
HW-14988	Flattening Curves and Inhour Absorption by Water - P. F. Gast, 11/23/49.
HW-15208	Shielding Calculations on Taper Bore Gun Barrel Assembly - R. L. Dickeman to P. E. Lowe, 11/25/49.
HW-14031	Exponentail Facilities for Exponential Experiments, 8/1/49.

D. MATERIALS

HDC-1334	Request for Data on Zirconium and Titanium, 6/8/49.
HDC-1390	Corrosion Testing Stainless Steel - Boron Alloys, 8/11/49.
HDC-1392	Discussion of Titanium Metallurgy at the Bureau of Mines Station in Albany, Oregon, 8/9/49.
HDC-1438	Minutes of Meeting on Sheet Rod Materials, 9/23/49.
HDC-1490	Trip Report - Review of Reactor Development Programs, 10/19/49
HDC-1523	Trip Report - Visit to Battelle and ALCOA, 11/23/49.
HDC-1555	Conference on Beryllium in New York City, 11/21/49.

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Section IV - Reference Documents (Continued)

E. DESIGN

HDC-1192 Metal Handling Procedures & Equipment Report - C. M. Burns to W. E. Johnson, 5/4/49.

HDC-1269 Minutes of Meeting - Sheet Rod Test Program - G. H. Syrovy to File, 6/7/49.

HDC-1322 Development of a Gadolinium-Titanium Alloy for Control Rods - G. H. Syrovy to W. E. Johnson, 7/5/49.

HDC-1406 Materials Handling Recommendations - P. P. Smith to File (undated)

HDC-1430 Trip Report - Visit to Reactor Development Sites - J. R. Wolcott, H. S. Isbin, G. H. Syrovy to W. E. Johnson, 9/14/49.

HDC-1431 Minutes of Meeting - 3X System Design - A. T. Strand to File, 9/20/49.

HDC-1437 Minutes of Meeting - Pile Shielding - R. T. Jaske to File, 9/21/49.

HDC-1440 Asphalt as Shielding Medium, C-300 - R. T. Jaske to File, 9/26/49.

HDC-1443 Minutes of Meeting - Sheet Rod Assembly - R. F. Klein to File, 9/27/49.

HDC-1447 Minutes of Meeting - Graphite Stack - A. T. Strand to File, 10/3/49.

HDC-1466 Minutes of Meeting - Pile Gas System - R. T. Jaske to File, 10/7/49.

HDC-1468 Minutes of Meeting - Process Tube Assembly - A. T. Strand to File, 10/7/49.

HDC-1484 Shielding - Pile Area "G" - C-300 R. T. Jaske to J. E. Maider, 10/21/49.

HDC-1485 Reactor "G" Design - Specifications for Drafting Room Use - G. H. Syrovy to File, 10/21/49.

HDC-1493 Minutes of Meeting - Fabrication and Testing of "D" Machine Ejector Counter - P. P. Smith to File, 10/28/49.

HDC-1494 Minutes of Meeting - Pile Charging Machines - P. P. Smith to File, 10/28/49

HDC-1500 Design Basis for Ball 3X System - R. R. Wall to File, 11/3/49.

HDC-1506 Report on Rear Face Loading Machine for Segmented Discharge - R. F. Klein to File, 11/10/49.

HDC-1517 Minutes of Meeting - Continuous Charge Program - P. P. Smith to H. E. Grantz, 11/14/49.

F. DEVELOPMENT TESTS

HDC-1108 Test Request - Water Impelled Slugs.

HDC-1132 Preliminary Slug Discharge Tests.

HDC-1255 Test Report - Water Impelled Slugs.

HDC-1318 Test Data on Various Bar-Plugs.

HDC-1338 Effect of Radiation on Television.

HDC-1417 Report on Test #6, Bar-Plugs.

HDC-1510 Function Test - Slug Ejector-Counter, Authorization

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Section IV - Reference Documents on Development Tests (Continued)

HDC-1219	Test Request No. 12 - Coefficient of Friction of Graphite - L. H. Hildebrandt to H. J. White, 5/19/49.
HDC-1243	Test Request No. 11 - Sheet Rod Test - C. M. Burns to H. J. White, 5/27/49.
MEMO	Test Request No. 13 - Slug Ejector-Counter Mechanism and Nozzle Seal - G. H. Syrovy/P. P. Smith to H. J. White, 7/5/49.
HDC-1324	Test Request No. 14 - Vernatherm Functional Test A. T. Strand to H. J. White, 7/5/49.
MEMO	Test Request No. 15 - Effect of Radiation on Television - G. H. Syrovy/P. P. Smith to H. J. White, 7/6/49.
MEMO	Test Request No. 16 - Test Data on Tubular Flexible Bar-Plug - G. H. Syrovy/P. P. Smith to H. J. White, 7/11/49.
HDC-1425	Test Request No. 19 - Stress Concentration in Graphite - A. T. Strand to H. J. White, 9/6/49.
HDC-1474	Test Request No. 21 - Ball 3X Functional Test - A. T. Strand to H. J. White, 10/10/49.
HDC-1514	Test Request No. 24 - Pressure Losses in the Pigtail and Nozzle Assemblies - A. T. Strand to H. J. White, 11/10/49.
MEMO	Test Request No. 25 - Measurement of Radiation Attenuation of a Taper Bore Process Tube Entry - R. T. Jaske to H. J. White, 12/8/49.
MEMO	Test Request No. 22 - Functional Test of Hansen Bar-Plug Lock - G. H. Syrovy/P. P. Smith to H. J. White, 11/8/49.
HDC-1565	Test Report - Two-phase Flow and Pressure Drop Tests
HDC-1417	Test Report - Various Types of Bar-Plugs.
HDC-1398	Test Report - Coefficient of Friction of Graphite.
HDC-1259	Test Authorization - Two-phase Flow and Pressure Drop.
HDC-1332	Test Authorization - Vertical Sheet Rod Assembly.
HDC-1280	Test Authorization - Coefficient of Friction of Graphite.
HDC-1507	Test Authorization - Vernatherm Unit
HDC-1508	Test Authorization - Short-length Heat Transfer Tests.
HDC-1509	Test Authorization - Full-scale Heat Transfer Tests.
HDC-1512	Test Authorization - Graphite Key Tests.
HDC-1526	Test Authorization - Ball Third Safety Functional Tests.

G. INVENTION REPORTS

HDC-1328	Report of Invention - R. F. Klein to W. I. Patnode, 7/7/49.
HDC-1401	Report of Invention - R. F. Klein and G. H. Syrovy to W. I. Patnode, 8/6/49.
HDC-1403	Report of Invention - G. H. Syrovy and C. G. McIntosh to W. I. Patnode, 8/9/49.
HDC-1459	Report of Invention - R. M. McCugh to W. I. Patnode, 10/7/49.
HDC-1488	Report of Invention - A. T. Strand to W. I. Patnode, 10/24/49.
HDC-1571	Report of Invention - C. G. McIntosh to W. I. Patnode, 12/22/49.
HDC-1134	Report of Invention - R. M. McCugh to W. I. Patnode, 3/31/49.
HDC-1156	Report of Invention - L. H. Hildebrandt to W. I. Patnode, 4/12/49.