COMPLETION REPORT

MASTER

Project Cowboy

U. S. ATOMIC ENERGY COMMISSION
CONTRACT AT(29-2)-20

AC08-16NV00020

November 1960

[redacted]

ENGINEERS
HOLMES & NARVER INC
CONSTRUCTORS
Los Angeles, Calif.

[redacted]

DOE/NV/00020--T1

DE82 019641

COMPLETION REPORT

Project Cowboy

U. S. ATOMIC ENERGY COMMISSION
CONTRACT AT(29-2)-20

AC08-76NV00020

November 1960
S/P-3-60

SPECIAL PROJECTS DIVISION
HOLMES & NARVER INC

ENGINEERS
CONSTRUCTORS

MILITARY RESEARCH & APPL. 70 to 35

[redacted]

JHSW

DISTRIBUTION

Major Gen. A. D. Starbird, Director
Division of Military Applications
U. S. Atomic Energy Commission
1717 H Street, NW
Washington 25, D. C. 5

Mr. Kenner F. Hertford
Albuquerque Operations Office
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 1

Mr. Ellison C. Shute, Manager
San Francisco Operations Office
U. S. Atomic Energy Commission
2111 Bancroft Way
Berkeley, California
Att: Mr. Russell H. Ball 1

Mr. James R. Reeves
Assistant Manager for Test Operations
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 1

Col. E. H. Lang, Director
Waterways Experiment Station
Corps of Engineers
Vicksburg, Mississippi 1

Dr. A. Vay Shelton
Lawrence Radiation Laboratory
Post Office Box 808
Livermore, California 5

Mr. Julian T. Lefler, Director
Engineering & Construction Division
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 1

Mr. George Udell, Director
Supply Division
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 1

Mr. Frank D. Peel, Director
Finance Division
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 1

Mr. L. W. Otoski, Director
Budget Division
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 1

Mr. Sherman H. Sullivan
Los Angeles Branch
U. S. Atomic Energy Commission
Post Office Box 5450
Los Angeles 55, California 1

Mr. Edwin G. Bowen, Director
Holmes & Narver, Inc.
Special Projects Division
849 South Broadway
Los Angeles 14, California 1

Test Division Files
Office of Test Operations
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 2

Mail and Records Branch
Office of Test Operations
U. S. Atomic Energy Commission
Post Office Box 5400
Albuquerque, New Mexico 2

TABLE OF CONTENTS

V CONSTRUCTION SUPPORT

VI ADMINISTRATION

FIGURES

EXHIBITS

FIGURE 1. A general view of the tipple house and conveyor at Carey Salt Company Mine near Winnfield, Louisiana, site of Project Cowboy.

I GENERAL

A. BACKGROUND

Objective

Project Cowboy was approved as a Special Project by the Division of Military Application, USAEC, to establish the validity of a seismic decoupling theory. Technical Administration was assigned to the Office of Test Operations, ALO.

Details of the project were developed in a document entitled *Technical Director's Operational Concept,* issued by Lawrence Radiation Laboratory under date of 26 May 1959. This theory indicated the possibility of greatly reducing the seismic effects of any explosive energy release by detonation in a cavity (decoupled) instead of in a packed and tamped (coupled) cavity.

Technical requirements included a homogeneous medium of sufficient mass to contain the detonations at a stipulated depth below the surface. The project was conducted in a salt dome because salt is relatively homogeneous, geologically competent, and provides the required stability with the lowest excavation costs.

The scientific program consisted of detonating a series of chemical high explosives, and of measuring the horizontal and vertical particle movements at distances from the detonation center varying from a few feet to 60 miles. For comparison between decoupled and coupled shots, charges detonated in a sphere were paired with identical charges packed into drill holes which were closely tamped before detonation.

Participating Organizations

The AEC made contractual arrangements 29 July 1959 with the Carey Salt Company for activities at the Carey salt mine (Figure 1) near Winnfield, Louisiana. The following organizations participated in Project Cowboy:

U.S. Atomic Energy Commission, Albuquerque Operations (AEC/ALO)
U.S. Corps of Engineers, Waterways Experiment Station (WES)
U.S. Bureau of Mines (USBM)
University of California Lawrence Radiation Laboratory (UCLRL)
Sandia Corporation (Sandia)
Edgerton, Germeshausen & Grier (EG&G)
Atomic Weapons Research Establishment, United Kingdom
Holmes & Narver, Inc. (H&N)
Stanford Research Institute (SRI)
University of Michigan (UM)
Carey Salt Company
U.S. Coast & Geodetic Survey (USC&GS)

In addition, major items of construction and support were procured by competitive bidding on H&N purchase order contract as follows:

Vacuum and Gas System	Barnet Brezner
Plugs and Liners	Farnsworth & Chambers, Inc.
Seismic Stations	Louisiana Industrial Services, Inc.
36-inch diameter Vent Hole	Modern Foundation Company
Cementing 36-inch diameter Vent Hole	Halliburton Oil Well Cementing Co.
Support to Scientific Users	Barnet Brezner and Louisiana Industrial Services, Inc.

Organizational Control

Albuquerque Operations was authorized by the Division of Military Application to proceed with the engineering and construction of Project Cowboy. The organization established by the Office of Test Operations and concurred in by the Lawrence Radiation Laboratory included an AEC Project Manager with an AEC Project Officer representing the Project Manager at the site. Responsibility for the coordination and execution of required engineering, logistical support functions, construction, and drilling was assigned to the AEC Support Director, and to the AEC Deputy Support Director.

The LRL Technical Director was responsible for the planning and execution of the technical programs essential to the acquisition of the required data and the LRL Support Coordinator was responsible for the coordination of logistical support requirements and scientific and technical operations.

By AEC contractual authorization, Holmes & Narver, Inc., provided architect-engineer service, procurement service in certain categories, and overall logistical and field support. Under the direction of the Manager, Engineering & Construction, the Senior H&N representative (Project Engineer) at Jobsite was responsible for the administration, management, and coordination of these services and support functions.

Technical Programs

The Technical Director, LRL, planned the experiments, coordinated the criteria from all scientific participants, and supervised the technical measurements.

LRL measured the shock pressures on some of the tamped shots, and surveyed the permanent cavity deformations.

Sandia Corporation conducted close-in earth motion measurements by means of accelerometers and velocity gauges, and was also responsible for the procurement, storage, handling, emplacement, and arming of the high explosives.

Stanford Research Institute developed geological deformation inspection techniques.

The U.S. Coast Guard and Geodetic Survey conducted measurements of the seismic signals at a series of instrument stations extending 60 miles from the mine. USC&GS also installed instrumentation within the mine shaft and monitored the blasting effects on the shaft.

Edgerton, Germeshausen & Grier, Inc., were responsible for the timing and firing function.

Seismic measurements were recorded by the University of Michigan.

The U.S. Bureau of Mines provided advisory support on mine safety and the effects of the experimental program on the existing mine facilities. Late in the program this group conducted a series of rock dynamics investigations with small charges in shallow holes. (15 March to 15 April 1960)

A group from the United Kingdom conducted a program of earth motion and pressure/time velocity measurements.

Technical Effect

The LRL *Preliminary Report on Cowboy*, dated 11 March 1960, inferred from the results that, by calculation, the cavity size could be predetermined which would result in elastic reflection of the shock wave from the cavity walls, thereby reducing the conversion factor of released energy into a seismic wave to less than 1% of the similar factor applied to coupled shots.

Authorization

Authority for H&N to prepare an Engineering, Construction, and Support Plan was established in a teletype from ALO, Reference MHT–5481, 22 June 1959.

Authorization establishing H&N responsibility in certain phases of construction, Operation and Management of Facilities, Maintenance of Facilities, and Procurement, was included in Modifications No. 74 and 80 to Contract AT(29-2)-20.

The authority for the preparation of this Completion Report was contained in a teletype from ALO, Reference MHT-1588, 25 April 1960.

Site Description

Project Cowboy was conducted in and around the salt mine of the Carey Salt Company, about 5 miles west of Winnfield, Louisiana, on U.S. Highway 84. (Exhibit I) The surface level was 200 feet above sea level and the mining level was 811 feet below the surface.

The only access to the mine floor was through the mine shaft equipped with an electrically operated hoist and 4 x 5-foot personnel platform of 2-ton capacity which was counter-balanced by the salt skip. The shaft was equipped with neither ladder nor illumination.

The Cowboy experimental area was well removed from the Carey production area, and about 1600 feet from the bottom of the mine shaft. A major portion of the mined area was surmounted by a hard rock quarry operated by the Anderson-Dunham Company of Baton Rouge under leasing arrangements with Carey (Exhibit III).

The main administration office (Figure 2) was a large frame house rented by H&N in Winnfield. Another building (Figure 3) in Winnfield, also rented by H&N, provided warehouse and supplemental office space.

Project Description

The original design and construction features for Project Cowboy were as follows:

a. Excavation of two spherical chambers, one 12 feet in diameter (Phase I) and one 30 feet in diameter (Phase II), and separate access tunnels connecting the spheres with an unused section of the mine production area. (Exhibit V)

b. Tunnel lining, floor plate, and plug array involving the fabrication and installation of 38 tons of steel.

c. A 36-inch diameter (ID) steel lined vent shaft extending from ground surface to the mining level (approx. 800 feet). As planned, the shaft would provide supplemental ventilation, conduct gas, vent and purge lines, and conduct scientific and communication cables. (Exhibit VI)

FIGURE 2. Looking west at front of main office, located at 109 N. Jones Street, Winnfield, Louisiana.

d. A system for evacuating the spherical chambers to about 0.10 atmosphere and introducing an explosive gas mixture of hydrogen-oxygen. This system was to extend from ground surface to the mining level through a 36-inch ID shaft. The work to implement the system included above ground installation of piping, valves, meters, gauges, and vane axial ventilating fan; extending the gas, vent and purge lines down the shaft; completing the underground installation of piping, valves, meters, gauges, vacuum pumps, condensate system poppet valves with hydraulic actuators; installation of secondary equipment and wiring from a 45 kva transformer in the mine; and the installation of equipment and wiring for the control of the vacuum and gas system.
e. Field drilling consisting of vertical, horizontal, and sloping holes of various lengths and diameters.
f. Construction of seismic stations at eleven locations extending out from surface zero to a distance of approximately 60 miles. (Exhibit II)

B. NARRATIVE SUMMARY

Progression of Events

From a USGS survey of six salt mines in Louisiana and Texas, the Carey site was selected as the only mine that fulfilled the geologic and seismic requirements, and offered satisfactory operating conditions. During July 1959, H&N commenced construction drawings and the Operational Plan for Engineering, Construction, and Support. Also in July H&N began all phases of Jobsite mobilization. Work orders were issued to Carey for extensions into the project area of the underground mine utilities, for equipment assembly, and for general support.

In the original concept, Carey was scheduled to perform all mining and excavation, install the compressed air system, vacuum piping, power and

coaxial cable, provide labor support to mix and place the saltcrete, and furnish other surface and underground labor support as directed. WES was to be responsible for underground drilling of instrument and shot holes, and was to provide equipment and technical assistance for all saltcrete grouting, cementing the vent shaft casing, and cementing to regain circulation during the vent shaft drilling. H&N would initiate by purchase order the vent shaft, seismic stations, and trailer park facilities.

Many changes became necessary as the project developed, which in total, caused significant realignments of responsibility and attendant increases in cost. Carey was relieved of the installation of the plugs and liners, the vacuum and gas system, and the scientific power system. These installations were subsequently acquired through H&N purchase order. When the WES grout-mixing equipment proved inadequate, Halliburton Oil Well Cementing Co. was engaged under the provisions of an H&N purchase order to place the cement in required volume. Problems attending the drilling of the vent shaft resulted in increased cost and failure to complete on schedule, and because of the time lost, it was necessary to abandon the plans for gaseous explosive and to substitute facilities for a solid explosive.

Construction was originally scheduled to end 20 October and the scientific program to end 1 December 1959. Actual construction was geared to a revised shot schedule beginning 17 December 1959 and ending 4 March 1960 (not including the USBM series), and was completed in April.

During August 1959, Jobsite mobilization was completed, a primary survey was made, and awards were issued for the vent shaft and the seismic stations. In September, the mine utilities were extended to the working areas and salt excavation commenced. Since most of the Carey workmen were inexperienced, they had to learn the usual mining techniques and then adapt themselves to limitations on the use of excavation explosives imposed by the scientific agencies to minimize fracture in the salt. It was necessary to institute a training program in an experimental adit to develop equipment techniques and shot hole patterns.

Construction of the eleven seismic stations was completed in September.

During October all excavation was complete except in the 30-foot sphere. The low rate of excavation was improved late in October when the explosive limitations were relaxed. Certain work originally assigned to Carey was redelegated to H&N and was accomplished under one purchase order issued 28 October for the plugs and liners, and another issued 12 November for the vacuum and gas charging system and the scientific electrical systems. During the October-November period WES proceeded with the drilling of shot and instrument holes, and with assistance from Halliburton in the vent shaft, WES also handled the grouting and cementing. The problems and delays encountered in drilling the vent shaft are detailed elsewhere in this report.

Scientific testing began early in December, and the Technical Director advanced the shot schedule to provide for small experiments in Phase I and Phase II facilities by 4 January 1960. Concurrently, it became evident that the vent shaft could not be finished in time to provide passageway for the signal cable and gas piping. This combination of circumstances created major changes: (1) the recording instruments were moved from the surface into a bunker built at the mine level and were connected with signal cables brought down the mine shaft, (2) the plan to use hydrogen and oxygen gas was abandoned in favor of a solid explosive; (3) the vacuum and gas system was constructed but used only as a vacuum system. The design and procurement required for these changes were extensive and demanded immediate attention.

By intensified efforts and the use of temporary and substitute facilities, the supporting construction activities met the revised deadlines and the technical program was conducted within the revised schedule. The last detonation occurred on 4 March and the vent shaft was complete on 4 April. Post-shot activities included the recording of scientific data, preparation of as-built drawings, and roll-up of the project which ended officially on 27 April 1960. (See Construction Schedule – Exhibit VII) Roll-up planning underwent a number of late changes due to a decision to retain an experimental capability in the mine for a period of from two to three years, and to mothball certain facilities. Also, a late decision (4 April) to undertake a post-shot investigation (Project Plowboy) had some delaying effects on the Cowboy roll-up work.

Cost Recapitulation

Costs incurred from project inception through 30 June 1960 were as follows:

Sub-category 3843.102	$2,047,722.84
Sub-category 3910	80,757.83
Total	$2,128,480.67

C. CONCLUSIONS AND RECOMMENDATIONS

Areas of Interest

Government work was performed on private property by a number of contractors, one of whom was the property owner. This situation fostered the development of conflicts of interest despite the efforts made by AEC and H&N site representative in areas of diplomacy, coordination, and arbitration. Relations between the parties involved deteriorated at times to the point of seriousness. In any case of Government work on private property extreme care should be exercised in depicting all-inclusive working conditions, and all participants should be prepared to cooperate fully in settling any disputes. Preferably the property owner should not be committed contractually beyond his status as lessor.

Selection of Potential Bidders

Experience in the construction of the vent shaft served to emphasize the necessity for thorough prequalification of all potential bidders, not only before award of contract, but prior to distribution of the Invitations to Bid. It is essential, particularly with a construction project which is unique, specialized, or particularly difficult and exacting, that Invitations to Bid are clear and specific in admitting to participation only contractors with thoroughly demonstrated capabilities in the particular field, complete adequacy of equipment, experienced personnel, and sound financial standing. Advance notices should be sent only to a selected list of qualified contractors.

Stabilization of Construction Schedules

The frequent extensions of the construction period resulted from criteria changes and original lack of comprehensive analysis of all requirements. Evaluations of capability were occasionally inaccurate, and controlling decisions were made without concurrence of associates. The integrated dependence on completion of the vent shaft eventually delayed other construction. Revisions to the test firing schedule also affected construction operations.

Construction schedules should be endorsed and accepted as regulation by all participants. Procurement, labor, and contractual difficulties should be anticipated and allowances should be made for them. Further improvement will be realized by better definition of responsibilities and by increased coordination among all participating organizations.

Procurement Coordination

Control of procurement activities assigned to H&N was lost on several occasions through injection of other agencies into the procurement picture, insufficient coordination with architect-engineer's procurement representative, and failure to follow prescribed channels of approval and purchasing.

Continuity of Policy and Action

Problems arose through the construction phase of the project as a result of frequent changes in the key staffs of AEC, LRL, and H&N. Continuity of policies and actions should be maintained with stable assignments of key personnel qualified to function with a minimum of home office guidance.

FIGURE 3. Looking S.W. at H&N warehouse, located at 200 Court St., Winnfield, La. This section was walled up by H&N.

II ENGINEERING—LOS ANGELES OFFICE

A ADVANCE PLANNING AND CRITERIA DEVELOPMENT

Program Development

Criteria for engineering design and construction was forwarded by the Technical Director, LRL, to H&N through the Chief, Los Angeles Branch, AEC. Preliminary criteria received late in June and early in July 1959, served as the basis for preparation of a preliminary cost estimate and outline material for the *Operational Plan for Engineering, Construction, and Support*. A draft submitted to AEC/ALO in mid-July was returned with comments early in August.

Criteria Changes

During August the refinement and elaboration of criteria was further developed by H&N through consultations involving extensive travel to Jobsite, ALO, and LRL; a revised preliminary cost estimate was prepared, and preparation of the engineering drawings commenced.

Formal issuance of the *Operational Plan for Engineering, Construction, and Support,* initially scheduled for September, was delayed when criteria and operational concept changes required preparation of a revised estimate and schedule.

Rescheduled for issue in October, further delay of the Operational Plan was necessary when Jobsite developments created many changes in planned facilities and assigned responsibilities. Since the changes were basic, and the effects far-reaching, an earlier publication would have served no useful purpose. When it was issued 3 December, with revised estimates and schedules, the Operational Plan still did not depict project concepts and responsibilities as finally established, because of the late completion of the vent shaft.

Coordination

Criteria development, engineering and construction were carried on concurrently, incorporating frequent, and sometimes major changes as the work progressed. From LRL criteria H&N developed final design, working drawings and specifications for contract documents. When expedient, preliminary drawing submittals for User review were were made directly to Jobsite; and in many cases construction and procurement were initiated on the basis of preliminary plans.

B. DESIGN PROGRESS

Vent Shaft

Contract documents for construction of the 36-inch vent shaft by H&N purchase order were prepared by the Los Angeles Office. Bids were opened 12 August 1959, and award was made to Modern Foundation Company, Shreveport. Difficulties in the prosecution of this work required several visits to the Jobsite by Los Angeles Office personnel in matters requiring engineering consideration and decision.

Major Revisions

Original project planning contemplated detonations of gas mixtures in the experimental cavities. Initial design criteria for a vacuum and gas system to implement this program were developed in a meeting in the Los Angeles Office with LRL personnel on 13 August 1959. Design of this system was completed, and authorization was obtained for procurement of long-lead items. Although underground installations originally had been assigned to Carey Salt Company in its capacity as support contractor, Carey declined after consideration of the techniques required. The Los Angeles Office immediately prepared contract documents for two H&N purchase orders, one for the vacuum and gas system, and another for the fabrication and installation of the plugs and liners for the detonation cavities. Bids for both were opened 16 October 1959. Award for the vacuum and gas system was made to Barnet Brezner, Alexandria, Louisiana; and award for the plugs and liners was made to Farnsworth & Chambers, Houston, Texas.

Early in December 1959, the schedule for experimental detonations was greatly advanced and the plan to use a gas mixture as explosive was abandoned in favor of the use of solid explosive contained in plastic spheres supported in the center of the cavity. As a matter of program necessity, the spheres for the first series of shots were fabricated and furnished by LRL. Design of the spheres and supports for the Phase II series were executed, and procurement expedited, by the H&N Los Angeles Office. (Figure 4)

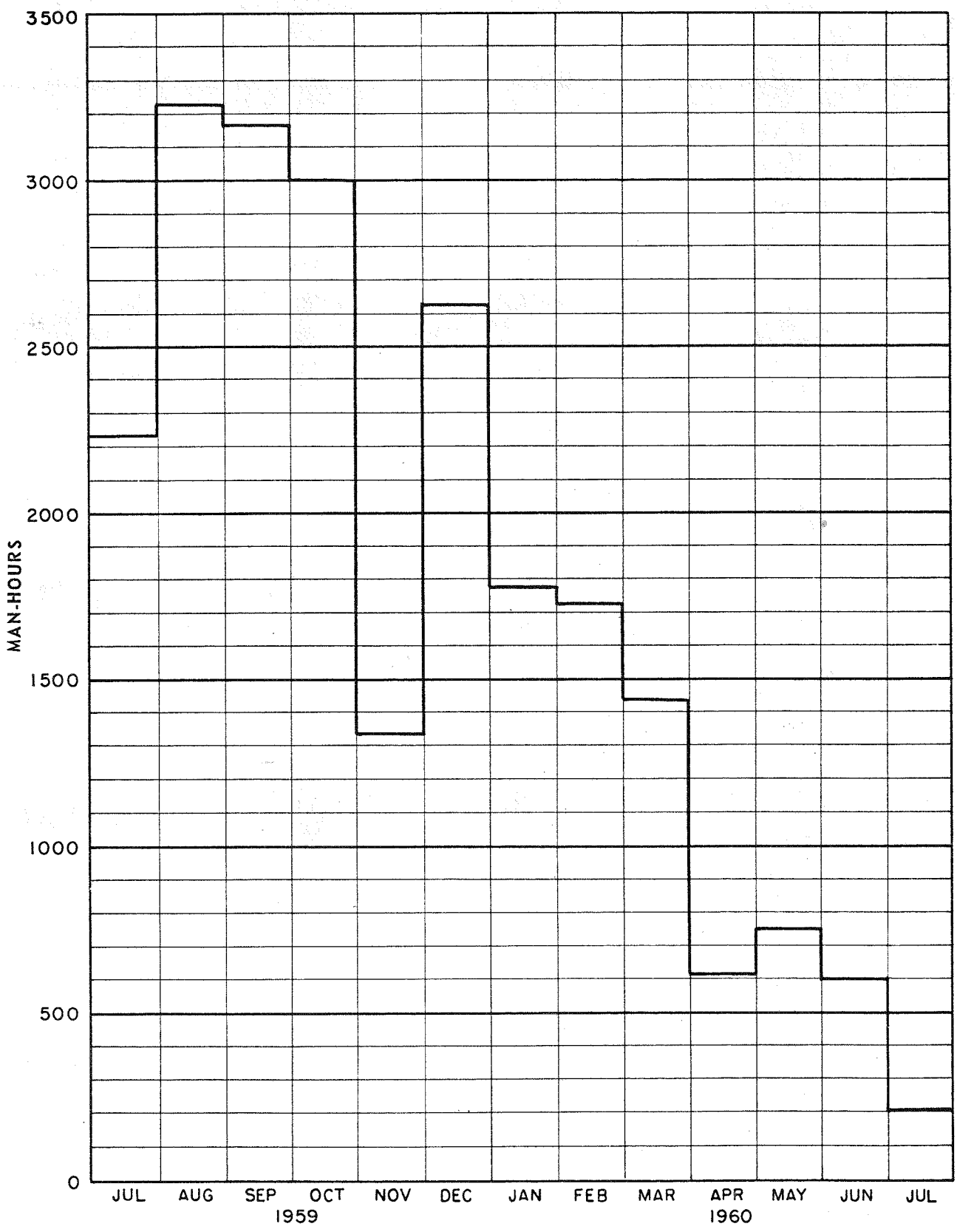


FIGURE 4. **LOS ANGELES OFFICE ENGINEERING MAN-HOURS – PROJECT COWBOY**

Volume

Between initial concept and ultimate planning, Project Cowboy experienced an extensive increase in scope. This is evidenced by the fact that early estimates contemplated a requirement for approximately 20 engineering drawings whereas a total of 99 drawings were actually issued. A summary of the drawings issued for Cowboy is tabulated as follows:

Civil	13	Revisions	26
Mechanical	14	Revisions	12
Structural	30	Revisions	23
Electrical	36	Revisions	35
Communication	6	Revisions	8
Total	99		104

III ENGINEERING—JOBSITE

A. JOBSITE STAFF

Organization

The Holmes & Narver organization was directed by a Project Engineer who was assisted in all phases of the work by an Assistant Project Engineer.

As indicated in Figure 5 (Jobsite Organization Chart), three major subdivisions existed:

a. Support Services
b. Engineering
c. Construction

Support Services were provided through the office at Winnfield and consisted of the following functions:

a. Office management
b. Stenographic and clerical assistance
c. Communications
d. Warehousing
e. Procurement
f. Reproduction
g. Transportation

Responsibilities

The Project Engineer supervised all engineering work performed by the Field Engineers and by engineers, draftsmen, and estimators transferred from the Los Angeles Office as the work load required.

Construction inspection and support at the vent shaft was performed by a Field Engineer. Technical drilling consultants were engaged to evaluate the large diameter drilling work at various stages, and to analyze specific problems.

Other construction inspection above ground and in the mine was under the direction of the Assistant Project Engineer with assistance by the shift Field Engineers and survey crews.

B. WORK AUTHORIZATION

Major

Work or service required by the Technical Director's organization to be performed by Carey was authorized by H&N on a work authorization form. Twenty-five authorizations, with 20 revisions were issued and are summarized in Exhibit VIII. These work authorizations were approved by AEC and LRL.

Minor

A form of buckslip was utilized to authorize minor field changes and to supplement the work authorizations. Buckslips were approved by LRL and H&N, and were limited to work estimated to cost no more than $300.00. During the project 105 buckslips were issued.

Estimates

To save time, initial work authorizations required to expedite the opening phases of the project were issued without cost estimates and the estimates were prepared as soon as possible thereafter by the Los Angeles Office. When an estimate was received at Jobsite the work authorization was revised to include the estimated cost. Thereafter, minor estimates were prepared at Jobsite, and complex estimates were made by the Los Angeles Office utilizing information furnished by Jobsite.

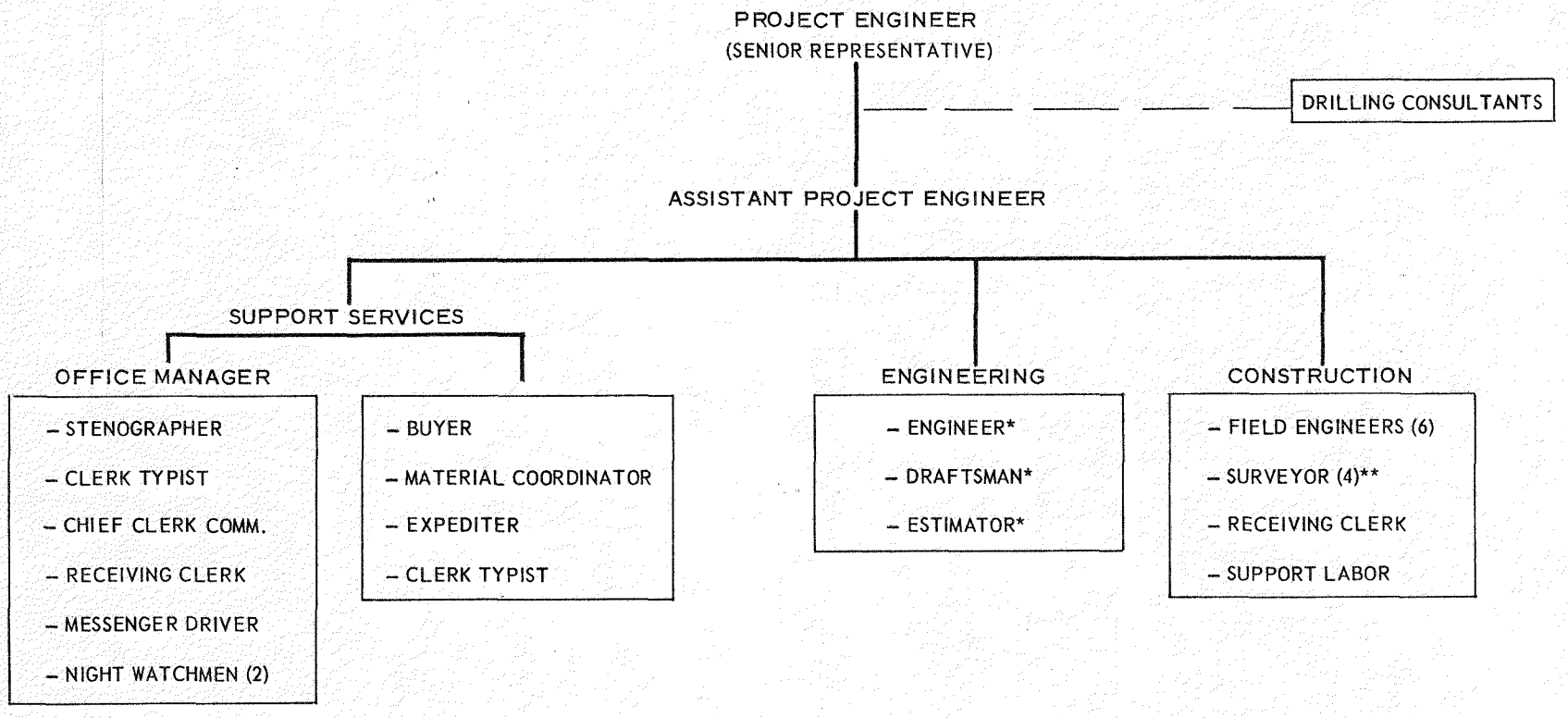
C. JOBSITE DESIGN

Adapting to Program Changes

When the shot schedule was accelerated early in December, it was evident that major changes would be required in planned facilities because the vent shaft could not be completed in time to provide a passageway for the signal cable and piping system. Design had to be revised to adapt existing materials and facilities into a workable system. At this time mechanical, electrical, and structural engineers were transferred from the Los Angeles Office to supplement the field design staff. Jobsite activities included design of the temporary electrical control panels for the Phase I facility, redesign of portions of the vacuum and ventilation system to provide for the underground release of the detonation gases, a complete design of the power and lighting required for the two new trailer parks, the instrument bunker structures, and the transformer protective structures. Drawings were approved by AEC and LRL-(Figure 6)

HOLMES & NARVER, INC.
PROJECT COWBOY

ORGANIZATION CHART
JOBSITE



* Provided on an as-required basis from the Los Angeles Office.
**Supplemented by three 4-man survey crews obtained on an H&N purchase order.

FIGURE 5

OFFICIAL USE ONLY

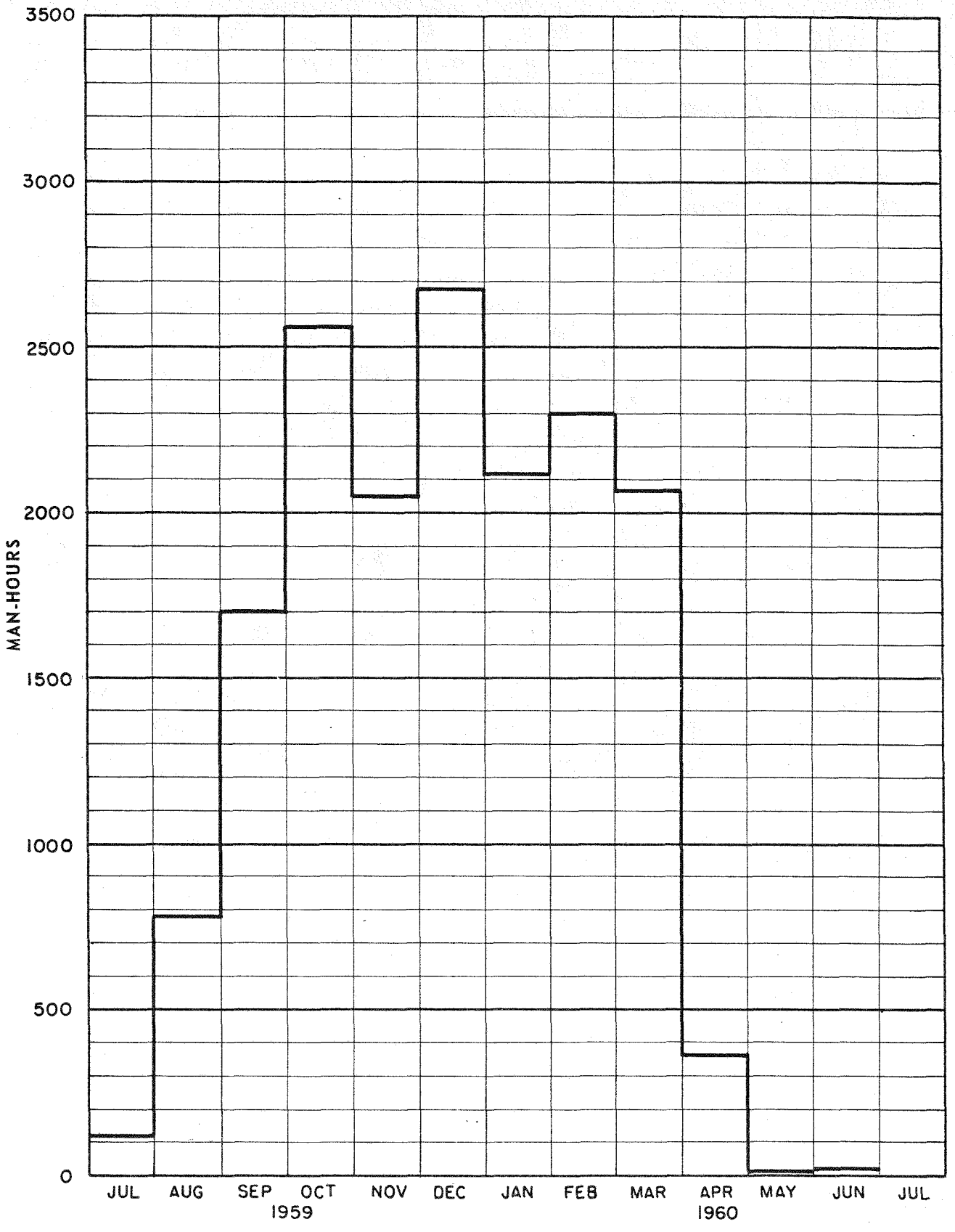


FIGURE 6. **FIELD ENGINEERING MAN-HOURS – PROJECT COWBOY**

D SURVEYS

Control

Primary survey control included a third-order system which reconstructed portions of the existing Carey monuments and provided for complete underground and surface traverse tied together by plumbing the shaft. This work was performed by an experienced mine survey firm, whose services were obtained by H&N purchase order. The work was completed 25 August.

Construction

Surveys for construction were provided by three complete four-man crews obtained by H&N purchase order to Louis T. Daigre Associates. One crew was assigned to each of the operating mine shifts. Conventional survey techniques were employed to establish line-of-sight drill holes, whereas oil well bore hole techniques were used in surveying all other drill holes. Diametrical measurements of the spheres and deformation measurement of the steel liners were made pre and postshot to detect any possible changes in shape. Field survey computation, including staking diagrams and as-built locations of drill holes and structures were made at the field office by a computer obtained from this same firm.

The entire construction survey work was supervised and monitored by a H&N four-man survey crew which included a party chief and instrument man with extensive experience in test facility type survey control.

E. CONSTRUCTION INSPECTION

Underground

One field engineer was on duty during each shift to inspect underground mine work. This inspection was supplemented by mechanical, electrical and welding specialists during the installation of the plugs and liners, the vacuum and gas system and the scientific power system.

Surface

The Project Engineer and the Assistant Project Engineer inspected the facilities on the surface at the mine site, underground, and off-site at the seismic stations. Field engineers inspected the work at the vent shaft.

F. AS-BUILT DRAWINGS

Jobsite

As a consequence of the accelerated schedule of work instituted in December, it became evident at Jobsite that complete design and construction drawings could not be prepared prior to the commencement of the work. The engineers assigned to the field work prepared Jobsite drawings as construction progressed, and completed most of these drawings to as-built status.

In February a draftsman was transferred from the Los Angeles Office for the specific purpose of detailing the more complex as-built electrical drawings.

Los Angeles Office

Drawings which were not revised to as-built status at Jobsite were so revised at the Los Angeles Office. Marked-up prints from the field were sent to Los Angeles with information required to complete these drawings.

G. PROGRESS REPORTS

Daily reports of operations were transmitted via teletype to the Los Angeles Office, and semimonthly and monthly summary reports were produced as contributions to the general Special Projects report. A weekly summary of action by Work Authorization was prepared at the site and forwarded to AEC, User participants, and to the H&N Los Angeles Office.

H. ESTIMATING

Estimates required for Jobsite were usually prepared by the Los Angeles Office after consultation with the Project Engineer. When estimating activity increased during the period of the major contract revisions to the vacuum and gas system, the plug and liner installation and the drilling activities, a Los Angeles Office estimator was transferred to the site.

IV CONSTRUCTION

A CONCEPT CHANGE

Carey Labor Problems

After a comprehensive review of the local labor market and a study of the Carey Salt Company's contract with the United Mine Workers, it was recognized as impractical to require Carey to perform any work other than underground labor support and salt excavation. Carey had been operating on a 40-hour week or less since first commencing operation in 1931. There was no depth of experience in the organization enabling men to shift quickly from one position to another and operations were based on absolute minimum personnel. Their salary structure, based on a UMW contract, was adequate only for the immediate area.

Skilled craftsmen required to assemble the heavy steel plugs and liners, and install the vacuum piping and the signal, power, and coaxial cable system were available only from towns 30 to 50 miles from the site, and at prevailing union construction pay scales that were considerably higher than Carey's prevailing rates. Under the requirements of the UMW contract, these craftsmen would be put on the payroll as common laborers and advanced to higher positions on a plant-wide seniority basis; however, at no time could the maximum rate paid be in excess of UMW contract scales. Therefore, it was obvious that construction workers would be extremely reluctant to accept employment on these terms.

Reduction in Scope

On 31 August it was determined that the Carey scope of work would be reduced to installing construction utilities, performing the salt excavation and providing underground labor support. H&N was directed to procure and install the plugs, the vacuum and gas system, and the scientific power layout.

Cost Increase

Cost increases due to the award of separate purchase orders are estimated as follows:

Plugs and Liners

Procurement of fabricated sections, H&N	$18,500
Installation of fabricated sections, Carey	61,300
Total H&N Estimate - 14 July 1959	$79,800
Farnsworth & Chambers (H&N P.O. 70047 - 20 October 1959)	
Furnish and install plugs and plug casing	$111,973*

The above figures indicate a 40% increase between the July estimate and the October award of the purchase order.

A portion of this increase was the Contractor's mobilization cost and is directly attributable to doing business with an outside contractor. The remaining portion of the increase, approximately 23%, is due to criteria and design modifications.

Vacuum, Gas, & Scientific Power

H&N estimate – 14 July 1959	$44,138
Barnet Brezner (H&N P.O. 71480 – 16 Nov. 1959	93,800*
Increase	$49,662

The indicated increase of approximately 120% between the July estimate and the November award date is primarily due to a change in criteria. As with the plug and liner purchase order, a portion of this increase is due to the contractor's mobilization cost, although this portion cannot be determined.

B. SCHEDULE

Original

In July 1959, H&N estimated that the completion dates for the salt excavation would be 27 September for Phase II and 7 October for Phase I. However, when the work had progressed sufficiently to determine the actual rate of salt excavation, these dates were revised to 4 November for Phase I and 24 December for Phase II. At this same time, it was estimated that the vent shaft would be completed on 1 December 1959.

On 23 September, Carey presented their first official estimate for completion of the excavation which was as follows:

Phase II Tunnel and Alcoves	10 October
Access Tunnel to Phase II Sphere	21 October
Phase II Sphere	2 February
Access Tunnel to Phase I Sphere	7 October

* Estimated allowances for standby time are not included in this figure.

Phase I Sphere	7 December
Access Tunnel to Vent Hole	3 days after successful grouting and testing of casing on vent hole.

Technical Acceleration

Early in December the shot schedule was advanced to provide for small experiments in Phase I on 15 December and for final completion of all Phase I and II facilities on 4 January. For these shots, the basic concept of the experiment was altered from gas to conventional explosive, and from venting through the 36-inch shaft to discharging into the mine atmosphere.

Facility Changes

The schedule for construction of the vent shaft indicated that its completion would not be in time for its use in the series of experiments; therefore, plans to locate scientific instrumentation at a surface trailer park were abandoned in favor of a location at an underground facility near the existing mine shaft.

Advancement of the completion date for the plugs and liners, and for the vacuum and gas system required overtime which increased the costs as follows:

	Station 1.1	Station 2.1
Plugs and Liners	$ 3,986	$ 8,725
Vacuum and Gas*	20,000	31,000

C. SEISMIC STATIONS

Award

Bids were opened 20 August for construction of eleven seismic stations to be located at various distances from the mine site. See Exhibit II. (Seismic Station Map). Maximum distance was approximately 60 miles. A purchase order to the low bidder, Louisiana Industrial Services, was awarded on 31 August, which called for completion of Stations 5 through 11 by 7 September 1959, and Stations 1 through 4 by 25 September.

Construction

H&N survey crews began construction layout of the stations on 18 August. Reference monuments and basic orientation were provided by the User. Concrete foundation work was obtained by lowertier award to H. E. Gorham of Winnfield, and was completed 1 September. All stations were completed on schedule.

An addition to Station 5 was completed 1 January 1960 by Barnet Brezner. This structure included a recording station and an instrument pit.

Just prior to Shots No. 2 and 16, a series of geophones were installed over Ground Zero at the quarry site. This work consisted of 12 instrument holes with steel cable conduit under the quarry entrance road. The work for Shot No. 2 was completed 17 December and was included in this experiment. The work for Shot No. 16 was completed 29 February, but was not instrumented.

D EXPERIMENTAL ADIT

Function

Work Authorization No. 15, "Experimental Adit – Special Methods Excavation Study," was issued 30 September 1959 to develop mechanical and low yield explosive excavation methods.

Field work was performed in an experimental adit (Figure 7) in Carey Drift A approximately 250 feet west of Station 2.1 on the swing shift during the last half of September and the first half of October 1959 by two of the project miners under the direction of an H&N field engineer.

Techniques

Employees were instructed in the use of two-pound charges and four-ounce charges of blasting powder, and in the use of hand and power tools. The production rates obtainable by the various methods of excavation in the experimental adit were noted by Carey as standards for use in the actual project excavations.

E. CAREY MINING OPERATIONS

Extension of Utilities

Carey Operations began 27 July on a one-shift basis. Initial efforts were directed toward extending the underground railway into the project area, (Exhibit IV), installing a compressed air and construction power system, and in removing salt debris and accumulated water from the area designated for coupled shots. The swing shift began operations on 6 August, and the graveyard shift began 25 September.

The rail line extension was completed 19 August, and the compressed air system and primary

* The figures for the Vacuum and Gas purchase order are estimated from available contractor payroll records.

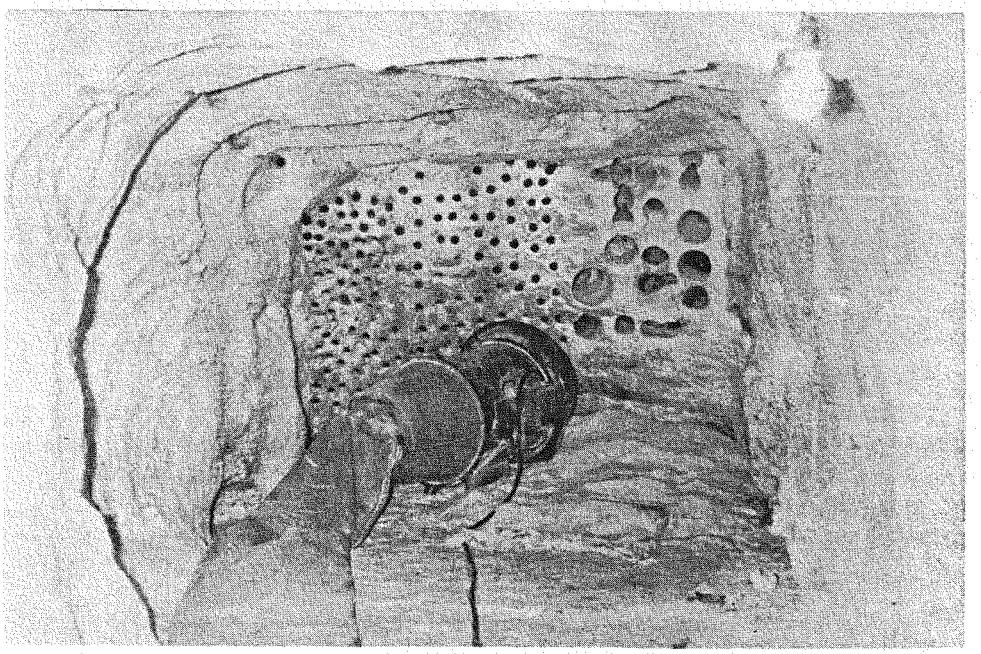


FIGURE 7.
Experimental Adit

power on 5 September. New mining crews were trained during the period from 27 July until the first salt excavation on 15 September.

Dimension Limits

The most exacting portions of the Carey work were the excavation of two spherical chambers, the smaller (Figures 8 and 9) having a diameter of 12 feet (Phase I) and the larger having a diameter of 30 feet (Phase II). The work was further complicated by the fact that, in each case, it had to be accomplished through a 4-foot diameter opening at the spring line. Excavation tolerances were as follows:

12-Foot Diameter Sphere

Mean radius of 6 feet $\pm$ 1 foot
Ratio of as-built radius to the mean as-built radius shall be 1.00 $\pm$ 0.10
Irregularities not to exceed $\pm$ 2 inches from true surface.

30-Foot Diameter Sphere

Mean radius of 15 feet $\pm$ 2.5 feet
Ratio of as-built radius to the mean as-built radius shall be 1.00 $\pm$ 0.10
Irregularities not to exceed $\pm$ 2 inches from true surface.

Engineering control was provided by H&N and both spheres were completed well within the above tolerances.

Blasting Restrictions

In an effort to preserve the undisturbed characteristics of the salt, LRL imposed certain blasting criteria for the excavation of the tunnels and spheres. However, as more experience was gained working in a salt medium, the criteria was relaxed somewhat on several occasions. The original blasting criteria and modifications thereto were as follows:

Initial Blasting Criteria

30-foot Diameter Sphere (Phase II):

a. Within 46 feet of center of sphere—no explosives
b. 46 feet—56 feet of center of sphere—2 lb
c. Remainder of entrance drift—20 lb
d. Main access tunnel—40 lb

12-foot Diameter Sphere (Phase I):

Same as for a, b, and c, above. Item d was not applicable.

Revised Explosive Units – 3 September 1959

a. Within 6 feet of any sphere surface—no explosives
b. 6 feet—12 feet of any sphere surface—¼ lb
c. 12—25 feet of any sphere surface—2 lb
d. 25—75 feet of any sphere surface—20 lb
e. Beyond 75 feet of any sphere surface—40 lb.

These limits applied as the maximum sizes to be fired within a 10-millisecond period, and multiple charges with appropriate delays were acceptable.

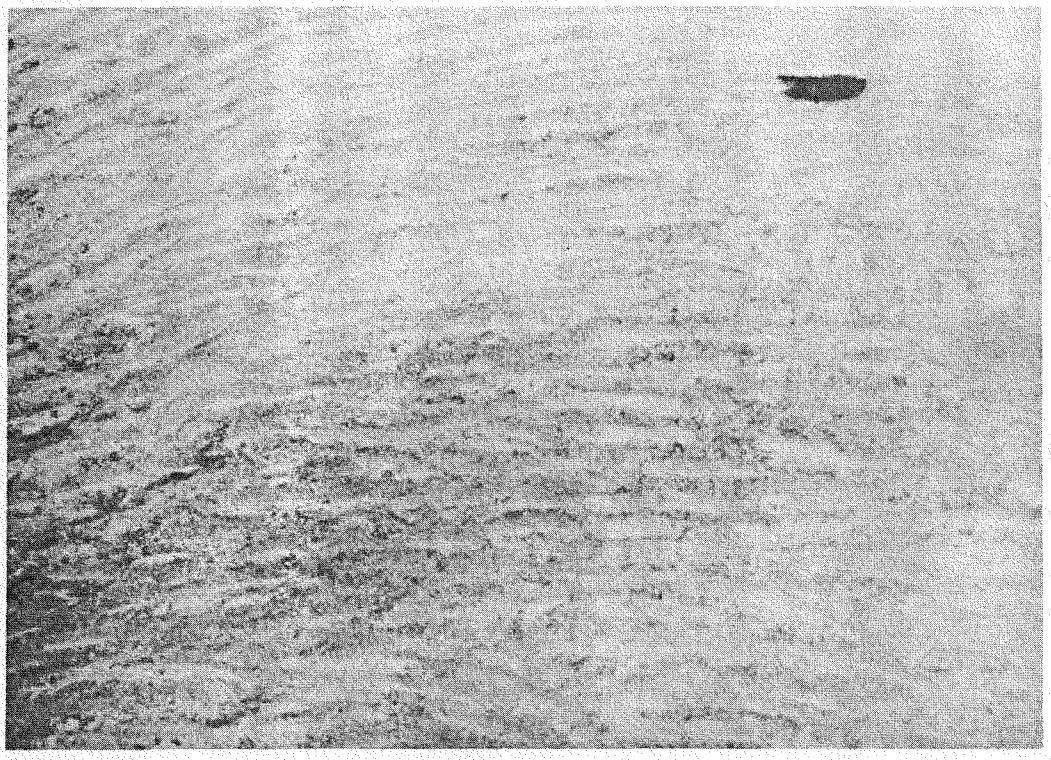


FIGURE 8. Interior of Station 1.1

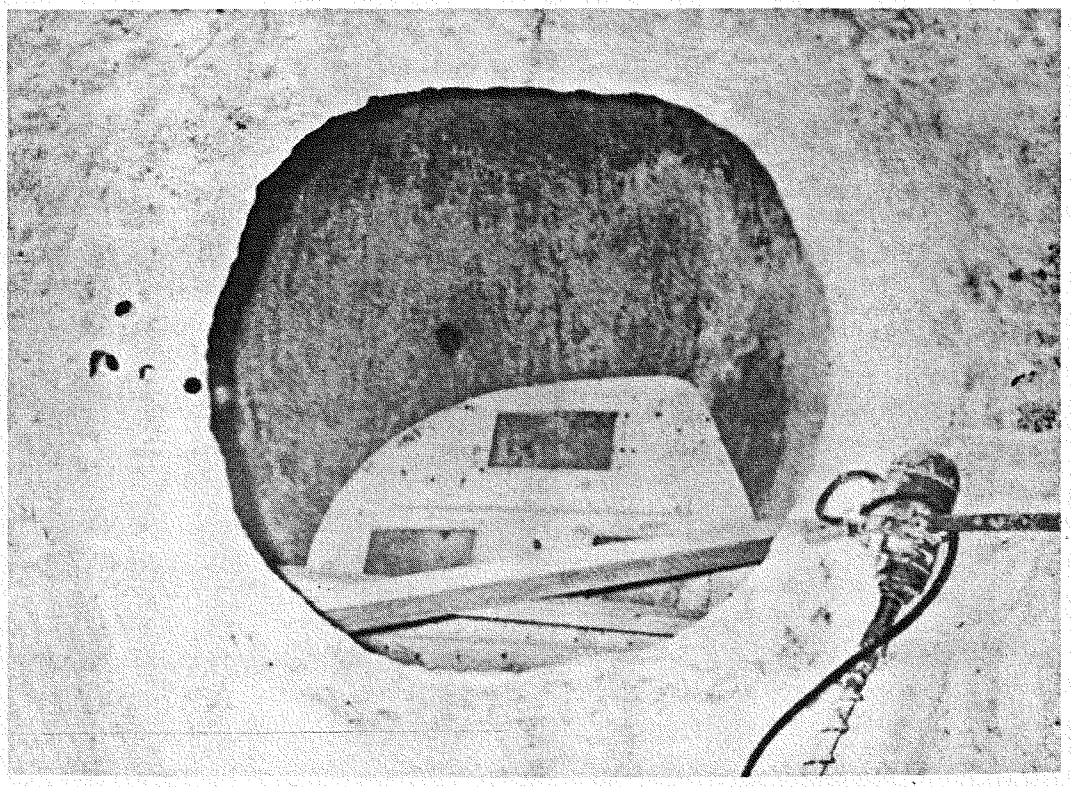


FIGURE 9. Face plate template inside Station 1.1

On 23 October 1959, the criteria was again relaxed to permit the use of up to ¼ lb in all areas of the Phase I sphere and ¼ lb in the Phase II sphere up to two feet of the finished surface.

A final relaxation was announced on 5 November 1959, which permitted the use of ¼ pound charges in the Phase II sphere up to one foot of the finished surface provided the shot holes were not stemmed.

Personnel Problems

Wages to Carey miners were paid on a portal-to-portal basis and approximately one-half hour was lost at the beginning and at the end of each shift while traveling from the hoist house to the mine level, changing clothes, and traveling from the locker room to the project area. Furthermore, all personnel were accounted for and out of the mining area while production shots were made in the Carey mining area, or during a blast to produce aggregate in the quarry at the surface. In effect then, less than seven hour's actual production was obtained from an 8-hour work shift. This fact, coupled with the inexperience of the men working and lack of experienced mining foremen contributed materially to the very low excavation rates realized, and subsequently to the extended period required to complete the project.

The low UMW wage scale was acceptable in Winnfield where lower-scale agriculture and lumbering provided the major portion of most employment opportunities, and new personnel hired at Carey were usually not adept at mining even after a considerable period of instruction. The staff assigned by Carey to Project Cowboy for the first shift consisted of an experienced mine foreman, and local crews hired specifically for the project, or transferred to the underground operations from some other division of the plant. Maintenance men also worked on a part-time basis. Since the first shift was regarded as the most capable, it was initially assigned to install the construction utilities.

The foreman for the second shift had previously been the mill foreman and had limited mining experience. The maintenance men for the second shift were again loaned to the project part-time after their normal duties of maintenance for the plant facilities were completed.

The foreman for the third shift was transferred from their Hutchinson, Kansas, operation and was a thoroughly experienced maintenance foreman, but not a mining foreman. Maintenance men for the third shift were hired locally, and on several occasions were incapable of coping with the problems of maintaining the underground operation. On several instances the maintenance men from the first shift were called in to perform specific maintenance duties on the third shift.

Progress

In areas where explosives were permitted the excavation advanced smoothly in compliance with imposed explosive limits. Drift rounds had previously been tested in an experimental adit and the production rounds, using this pattern, effectively excavated the rock. However, when excavation moved into the non-explosive designated excavation area, production dropped sharply, Of several methods of approach that had been tested in the experimental adit, the most acceptable method utilized a Chicago Pneumatic chipping hammer with a one-inch chisel bit. From this point on the problem was to obtain men with adequate skill and stamina to continue working in high temperature cavities with substandard ventilation. The production resolution of this method required approximately 10 three-shift days. During this period, management from various participating organizations, discouraged with the rate of advance, were attempting to find and test new excavation techniques. Alternatives suggested were an abrasive buffer head on a rotary percussion (jack-leg) drill machine, a chain saw, core drilling the entire area, and an abrasive rotary disk saw. All these suggestions were rejected as impractical.

The access drift to Station 1.1 was completed 15 October, and the excavation within the sphere 30 October. Hand cutting for grout keys and installed steel items was complete on 8 November.

The main access to Station 2.1 was started on 10 October. The 7 x 7-foot access drift into Station 2.1 was started on 1 October and completed on 20 October. Excavation in the sphere itself was complete on 7 December. Hand cutting for grout keys and installed steel items was completed on 16 December.

Excavation of the access drift to the vent shaft began 4 April and was completed 14 April 1960.

TABLE A

EXCAVATION RATES

Summary

EXPLOSIVE WEIGHT	STATION 1.1 (CU YD/SHIFT)	STATION 2.1 MAIN ACCESS (CU YD/SHIFT)	STATION 2.1 (CU YD/SHIFT)
40 lb/10 MS Tunnel	–	14.5	–
20 lb/10 MS Tunnel	3	–	4.5
2 lb/MS Tunnel	2	–	3
¼ lb/10 MS Tunnel	1.6	–	2.3
Hand Tunnel	0.3	–	0.4
Sphere	0.9	–	4

After the use of explosives was increased, excavation rates increased by a factor of three for Station 1.1 and by a factor of five for Station 2.1. A portion of these increased rates are attributable to increased use of explosives and partly to an increase in working space within the spheres as excavation progressed.

F. UTILITIES

Primary Power

The principal utility requirement for beginning the salt excavation was the extension of a 2400-volt feeder line to the project area. The Louisiana Light and Power Company set a 500 kva separately metered substation specifically for the Project's use on 5 August. Installation of the 2400-volt cable from the substation to the transformers in the project area was completed and checked out 8 September. (Figure 10) Up to this time there was no ventilation, little or no lighting, and insufficient power for drills. Salt excavation began 15 September after additional lighting had been provided in the project area and the ventilation fans had been installed and placed in operation.

Compressed Air System

Six diesel powered, rotary air compressors were rented in July from Louisiana Industrial Services and were assigned to Carey for operation and maintenance during the project period. (Figure 11) The owners of this equipment provided mechanics and technicians to instruct Carey personnel in operating techniques and to repair equipment when requested.

Delays were encountered in installing pipe for compressed air because Carey objected to the weight of the pipe (Schedule 40) to be supported by the shaft timbers. Subsequently, light gage spiral weld pipe was installed. The compressed air system down to the working areas was completed 5 September.

The time lapse of approximately one month between compressor delivery and completion of the system is attributable to three factors.

a. Later material delivery: Required material arrived at the site between 3 August and 22 August.
b. Skilled manpower shortage: The Carey union agreement required that this work be performed by their maintenance men, who were in short supply.
c. Third shift operation: The third shift was activated subsequent to this time, consequently the work could not be prosecuted on a round-the-clock basis.

G. CONSTRUCTION EQUIPMENT

General

Early progress of the work was hampered by late delivery of construction equipment and materials. Also, some of the government surplus equipment delivered to the site was not in operating condition. This is summarized in the following tabulation of delivery dates and condition of key items.

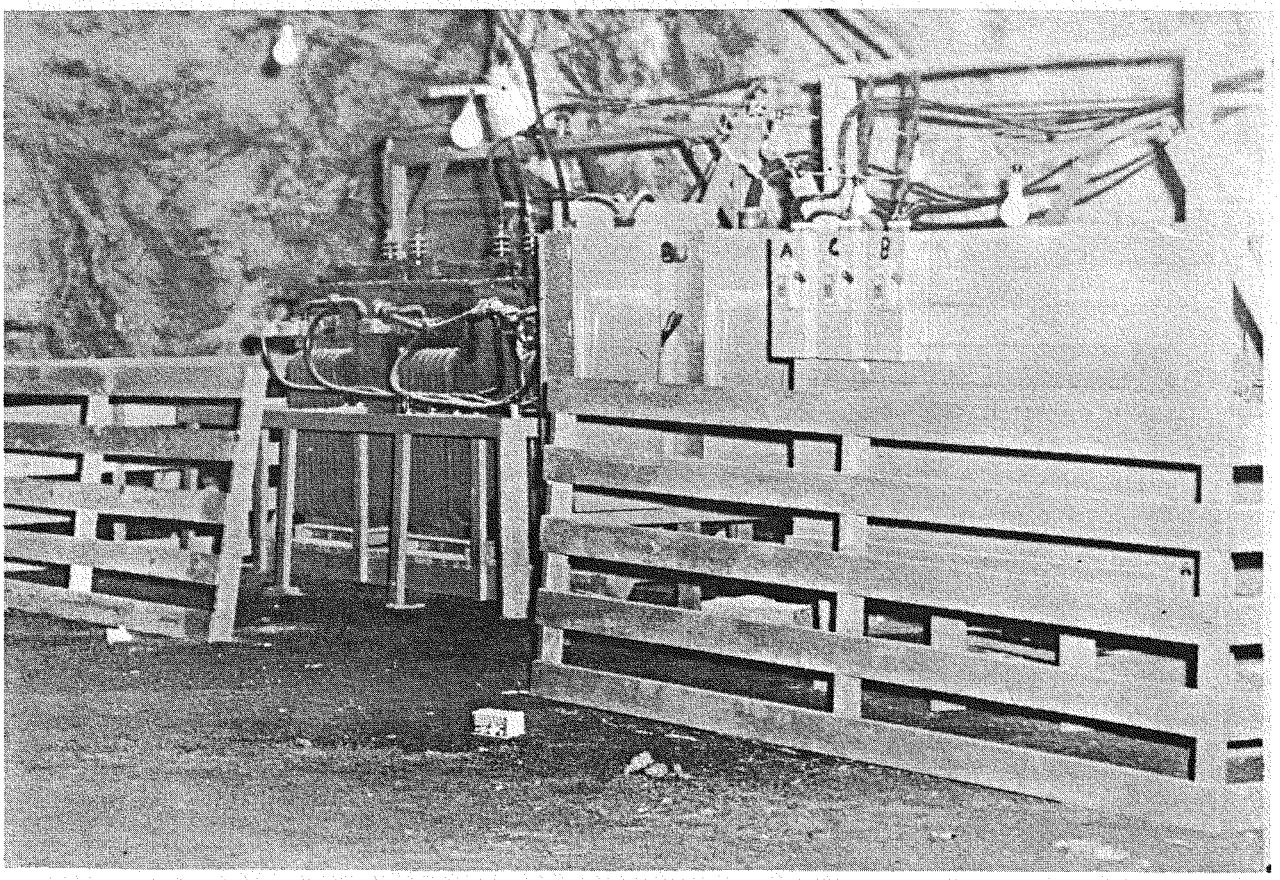


FIGURE 10. Power center – Drift B

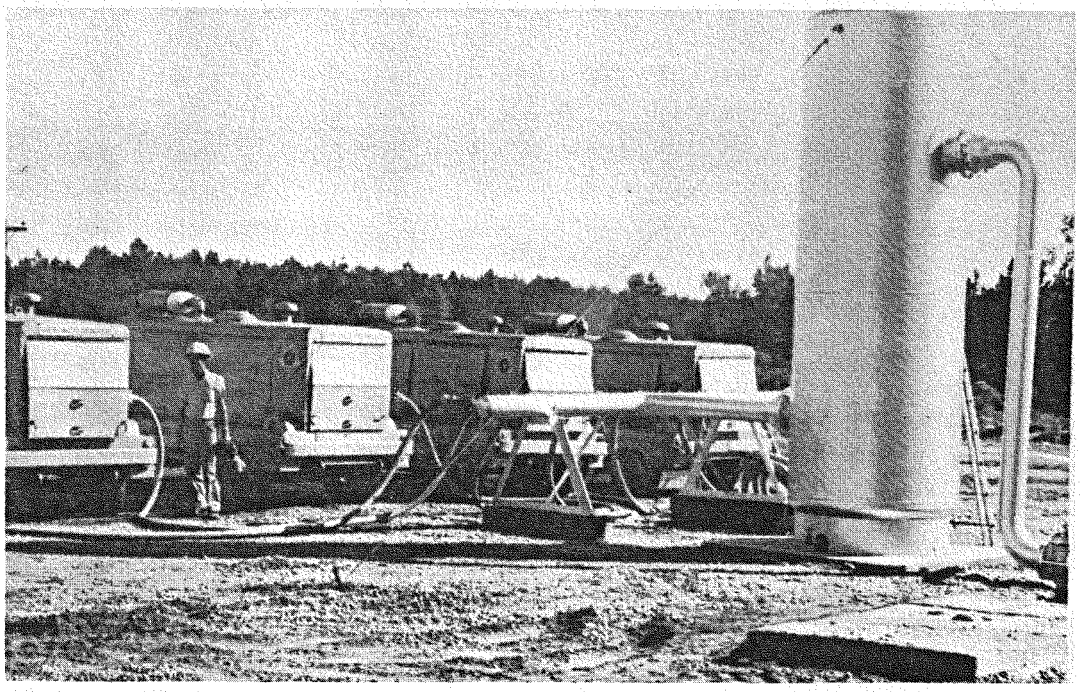


FIGURE 11. Compressed air bank

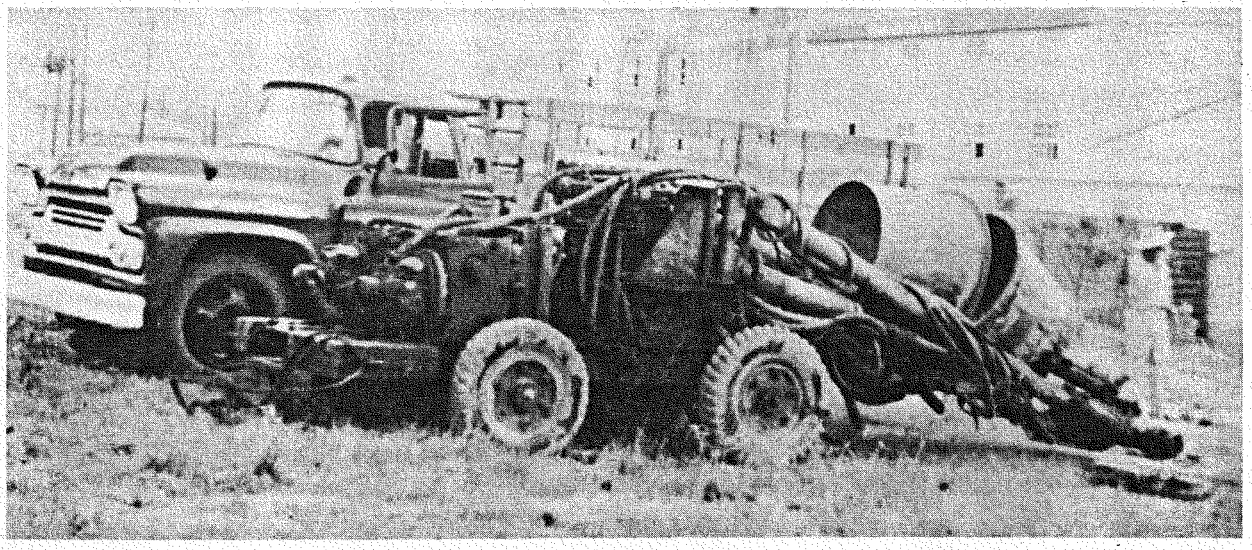


FIGURE 12. Pneumatic self-propelled Drill Jumbo

Description	J/S Delivered Date	Condition
Joy Jumbo (GFE)* (Fig. 12)	August 3	Not repairable
Mine Battery Charger (GFE)	August 3	Not repairable
5000 Volt - mine power cable (GFE)	August 12	New
Transformers (GFE)	August 12	Excellent
2400 Volt cable splice kits	August 4	New
Shuttle Car storage batteries	August 12	New
Vent Duct	August 11	New
Compressed air manifold	August 15	New
Compressed air pipe	August 3	New
Air receiver	August 22	New
Eimco Mucker (M/R REECo)	August 5	Excellent
Elec. Switchgear, Secondary	August 15	New
Flexible compressed air line	August 13	New
Transformers (GFE)*		
2 – 100 kva	August 5	Not operable
1 – 75 kva	August 5	Good
Vent Fan		
1 – 4500 cfm	August 12	New
1 – 3000 cfm	August 12	New
3 – 1700 cfm	August 20	New
1 – 3500 cfm	August 20	New
2 – 4700 cfm (GFE)	August 3	Fair
1 – 10 hp (GFE)	August 3	Not operable
Secondary lighting wire	September 3	New
Electric drill	September 2	New

Under the original schedule the construction equipment and utility material were required to be at the site, installed, and operating by 6 August.

Excavation

Initial excavation was made with a Carey-owned Goodman undercutter, and by drilling holes for standard explosives. The Goodman machine was at least 40 years old, had been unused for a long time prior to Cowboy, and broke down frequently. The Carey machine maintenance program was inadequate, procurement was poorly scheduled, and production time was lost while waiting for machine parts.

Loading

At Carey's request, the project acquired two types of ore loading machines. The first type was the Eimco pneumatic mucking machine which is standard in the hard rock mining industry. On the basis of a previous Carey commitment to provide shuttle cars, two of these machines, Model 630, were procured, but they were not used because the shuttle cars were not made available to move the ore from the mucker to the rail-mounted car.

Carey then requested conventional type front-end loaders, and two John Deere farm type front end loaders were supplied. These machines were powered with diesel engines which are not approved for underground operation because of noxious exhaust fumes, however; Carey used them because they were simple to operate. Although operations were shut down occasionally when the ventilation system did not remove the exhaust fumes, the front-end loaders proved to be adequate.

*Government-furnished equipment (GFE)

Muck was removed from inside Station 2.1 by a Joy Model S–211 double drum, slusher hoist with a 20-inch slusher bucket. The slusher proved to be an excellent tool. In Station 1.1 the muck was transferred to the front-end loader bucket by means of manual labor. (Figures 13, 14, 15, 16, and 17)

H. UNDERGROUND DRILLING

Drilling

Waterways Experiment Station performed all underground drilling. A number of the vertical holes, termed "shot holes," were terminated with right cylinders. (Figure 18) A total of 10,679 feet of 3, 5, and 8-inch holes were drilled. The instruments and explosives placed in these holes were stemmed with a salt-cement grout. Data concerning type and location of holes and drilling dates, is tabulated as follows:

CONSTRUCTION SCHEDULE
SCIENTIFIC STATIONS

SPHERES

STATION	STARTED	COMPLETED
1.1 (Phase I)	10/8/59	11/14/59
2.1 (Phase II)	10/14/59	12/16/59

VERTICAL SHOT HOLES

1.2	9/16/59	9/22/59
1.3	9/16/59	9/21/59
1.3-1	11/6/59	12/22/59
1.4	2/29/60	2/29/60

VERTICAL SHOT HOLES (Cont.)

STATION	STARTED	COMPLETED
2.2	9/19/59	2/24/60
2.3	9/26/59	10/13/59
2.4	9/24/59	10/2/59
2.5	10/3/59	10/15/59
2.6	9/22/59	10/21/59
2.7-A	12/14/59	12/22/59
2.7-B	1/7/60	Not Completed
2.7-C	1/11/60	Not Completed
2.7-D	1/13/60	Not Completed

VERTICAL INSTRUMENT HOLES

STATION	STARTED	COMPLETED
1.2-1	10/23/59	10/24/59
1.2-2	10/24/59	10/29/59
1.2-3	11/11/59	11/11/59
1.2-4	11/10/59	11/10/59
1.3-2	11/5/59	11/7/59
1.3-3	11/7/59	11/8/59
1.3-4	11/9/59	11/10/59
1.3-5	11/4/59	11/5/59
1-3-6	11/3/59	11/11/59
1.3-7	10/31/59	11/2/59
1.3-8	10/31/59	11/1/59
2.2-1	12/8/59	12/10/59
2.2-2	12/7/59	12/8/59
2.2-3	12/4/59	12/5/59
2.2-4	11/11/59	11/12/59
2.2-5	12/5/59	12/7/59
2.2-8	1/25/60	1/25/60
2.3-1	11/11/59	11/13/59
2.3-2	11/14/59	11/14/59
2.3-3	11/16/59	11/16/59
2.3-4	11/19/59	11/23/59

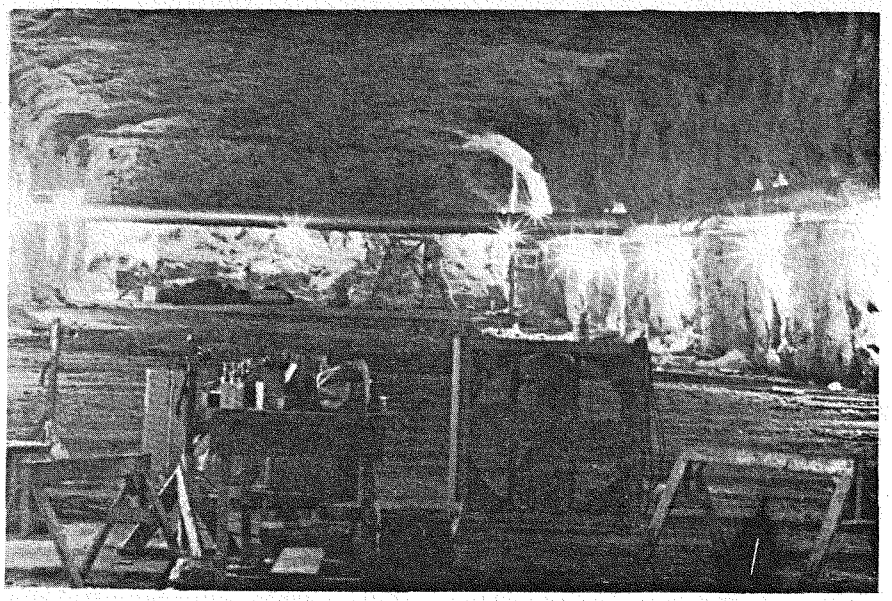


FIGURE 13.

General View – Drift B

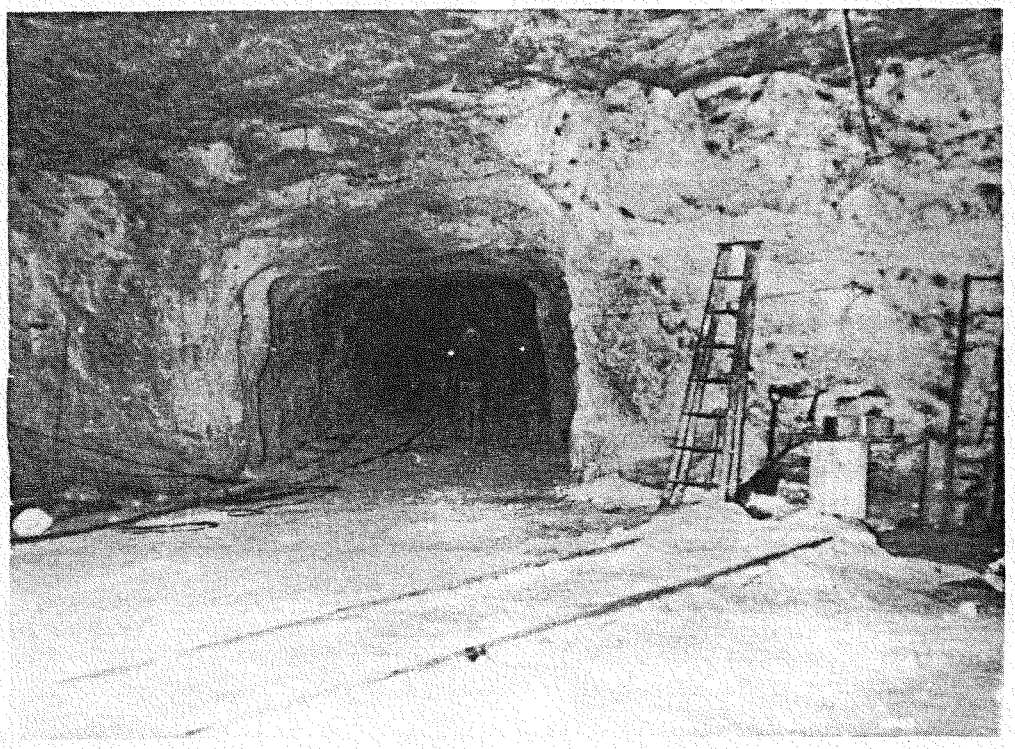


FIGURE 14. Portal of main access drift to Station 2.1

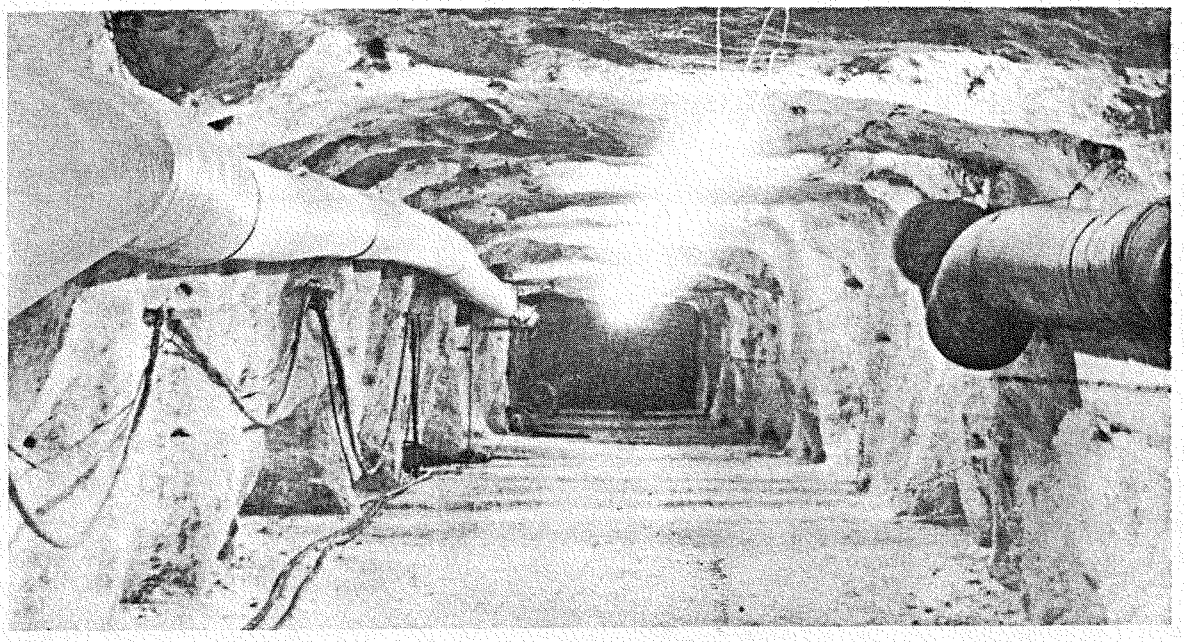


FIGURE 15. Station 2.1 main access drift

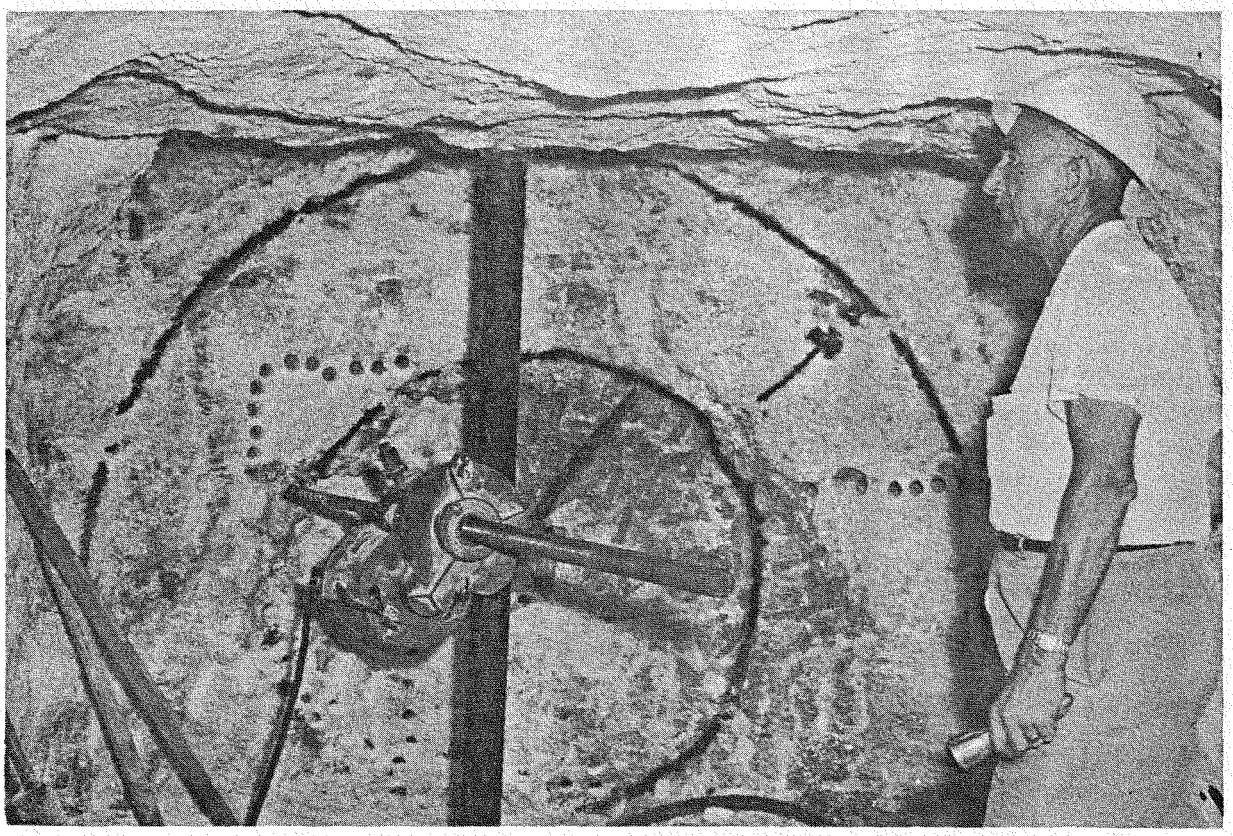


FIGURE 16. Station 1.1 – square to conical transition

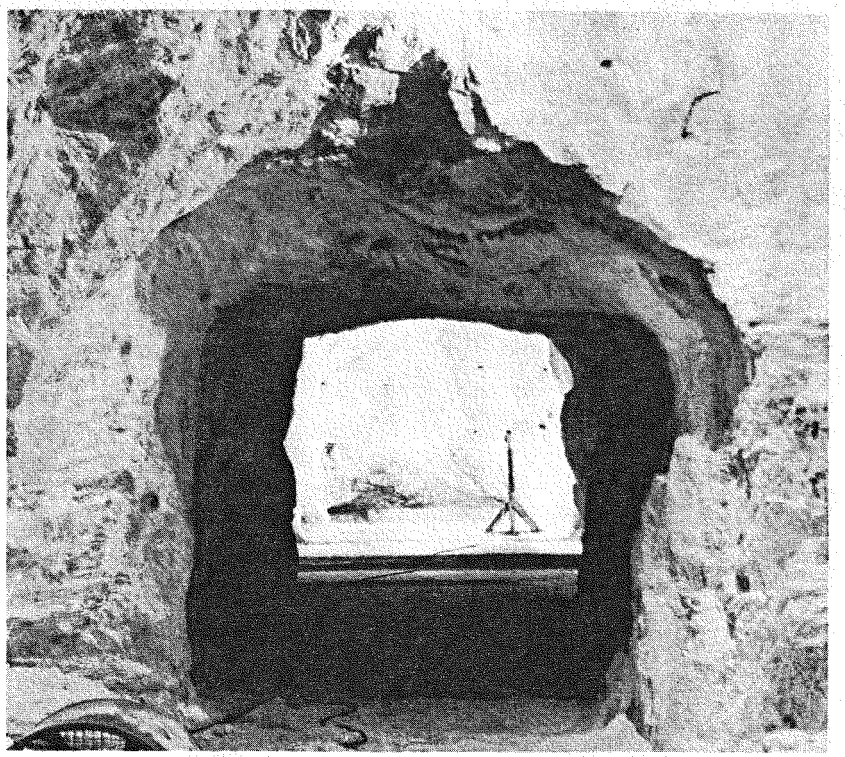


FIGURE 17.
Looking through Drift B
into Station 1.1 drift

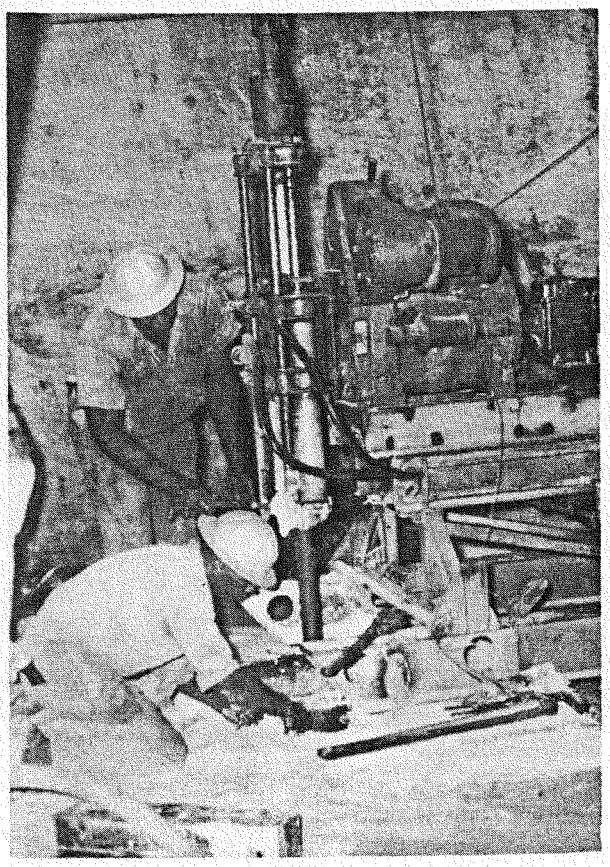


FIGURE 18. WES drill

VERTICAL INSTRUMENT HOLES (Cont.)

STATION	STARTED	COMPLETED
2.4-9	1/15/60	1/18/60
2.4-10	1/13/60	1/18/60
2.4-11	1/13/60	1/17/60
2.4-12	1/12/60	1/17/60
2.5-1	11/13/59	11/16/59
2.5-2	11/14/59	11/17/59
2.5-3	11/12/59	11/12/59
2.5-4	12/1/59	12/2/59
2.5-5	11/19/59	1/6/60
2.5-6	11/12/59	12/2/59
2.5-7	11/25/59	12/2/59
2.4-1	12/3/59	12/5/59
2.4-2	11/30/59	12/1/59
2.4-3	11/26/59	11/27/59
2.4-4	11/27/59	11/30/59
2.4-5	10/17/59	12/16/59
2.4-6	10/19/59	10/24/59
2.4-7	10/24/59	10/27/59
2.4-8	10/21/59	10/23/59
2.5-8	11/18/59	11/25/59

VERTICAL INSTRUMENT HOLES (Cont.)

STATION	STARTED	COMPLETED
2.5-13	Feb. 1960	Feb. 1960
2.5-14	Feb. 1960	Feb. 1960
2.6-1	12/11/59	12/14/59
2.6-2	12/10/59	12/11/59
2.6-3	12/9/59	12/10/59
2.6-4	12/7/59	12/8/59
2.6-7	Feb. 1960	Feb. 1960
2.6-8	Feb. 1960	Feb. 1960
2.7-1	1/19/60	1/21/60
2.7-2	1/18/60	1/19/60
2.7-3	1/21/60	1/23/60
2.7-4	Not Completed	

HORIZONTAL INSTRUMENT HOLES

STATION	STARTED	COMPLETED
1.1-1	10/13/59	10/14/59
1.1-2	10/14/59	10/15/59
1.1-3	10/15/59	10/17/59
1.1-4	10/8/59	10/10/59
1.1-5	10/3/59	10/8/59
1.1-6	10/1/59	10/2/59
1.1-7	10/10/59	10/12/59
1.1-9	2/15/60	2/16/60
2.1-1	11/2/59	11/3/59
2.1-2	11/3/59	11/4/59
2.1-3	11/4/59	11/5/59
2.1-4	10/31/59	11/2/59
2.1-5	10/30/59	10/31/59
2.1-6	10/27/59	10/30/59
2.1-7	11/9/59	11/10/59
2.1-8	11/10/59	11/10/59
2.1-9	11/6/59	11/6/59
2.1-11	11/11/59	11/15/59
2.1-13	1/8/60	1/8/60
2.1-14	1/8/60	2/8/60
2.1-15	1/9/60	2/9/60
2.1-16	1/9/60	1/9/60
2.1-17	1/11/60	1/11/60

U.S.B.M. HOLES

Holes drilled in January and first two weeks of February 1960:

U.S.B.M. Holes Nos. 1 thru 39 in Carey Drift No. 4
U.S.B.M. Holes in Carey Drift "A" as follows:

2.14-13	2.3-5	2.6-5
2.14-13A	2.3-6	2.6-6
2.14-13B	2.5-9	2.7-5
2.14-14	2.5-10	2.7-6
2.14-14A	2.5-11	2.2-6
2.14-14B	2.5-12	2.5-14

Labor Support

Carey provided labor support to WES by cleaning up loose materials, salt debris, and accumulated water. Carey also assisted WES and other organizations by handling materials and operating the hoist and rail haulage system.

Survey Support

H&N survey crews were employed to set and align drill rigs utilized by WES to drill the horizontal, inclined, and vertical holes for the project. To accomplish this, special survey techniques were utilized, which involved sighting a transit through the hollow drill rods for the horizontal and inclined holes.

During drilling operations for a single hole the transit was maintained at its initial set-up point and regular alignment checks made as the drilling progressed. As-built locations of the ends of the holes were determined by simple modification of this drill set-up method.

The drill rigs at the vertical holes were set up by plumbing the drill rod with a transit. As-built locations of a vertical hole were made by attaching a 90° prism to the transit telescope and sighting on an illuminated target lowered to the bottom of the hole. When the end location of drill holes could not be sighted by this method, they were determined with commercial oil well surveying instruments. H&N procured the services of the Eastman Oil Well Surveying Company who had available a multi-shot directional instrument capable of surveying holes whose inclination was up to 120 degrees from the nadir.

I VACUUM AND GAS SYSTEM

Award

H&N Purchase Order 71480, dated 16 November 1959, was awarded to Barnet Brezner of Alexandria, Louisiana, to install the vacuum and gas system, and certain electrical work (Figure 19) connected with the signal, intercom, and scientific power systems. Notice to proceed was issued 20 November and Jobsite activity began 23 November.

Schedule

Brezner's original completion dates were 30 December for Station 1.1 and 14 January for Station 2.1. On 10 December he was authorized to accel-

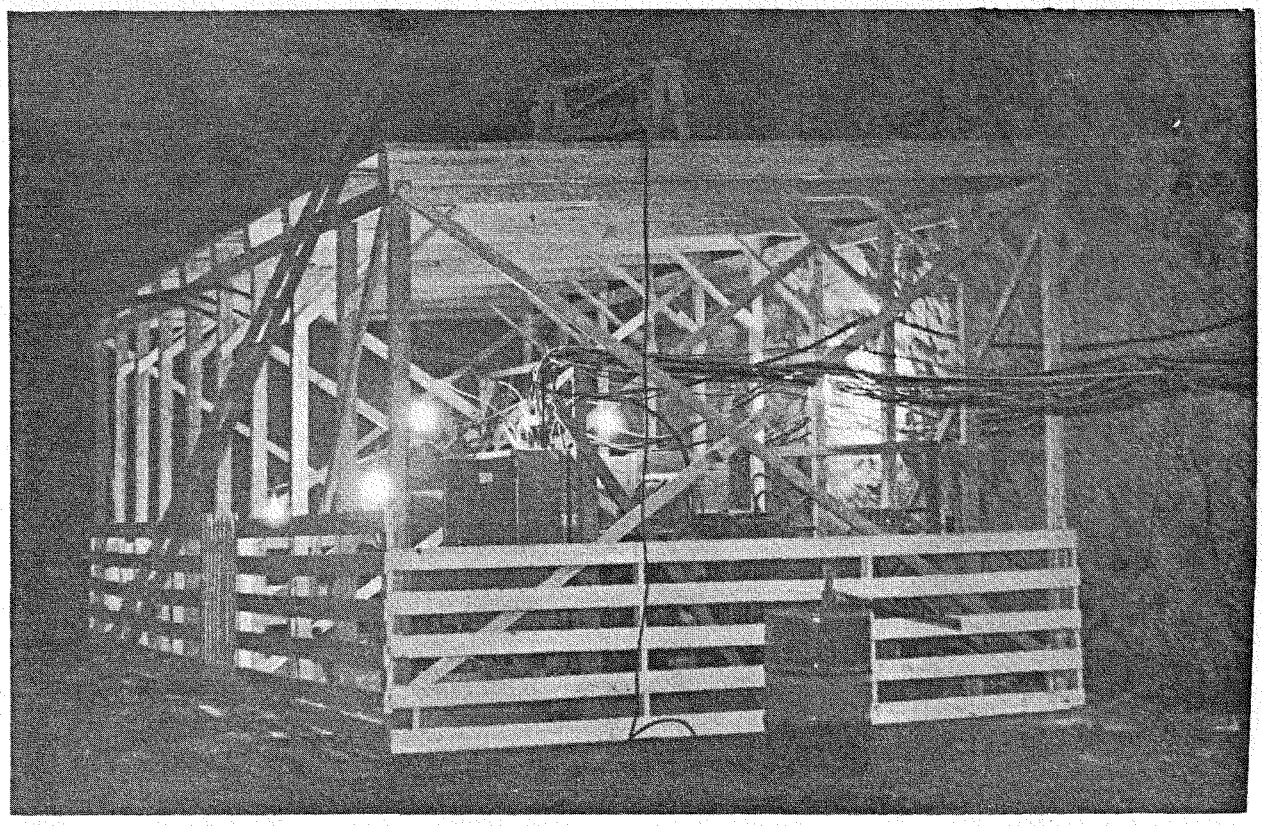


FIGURE 19. Underground sub-station with transformer platform

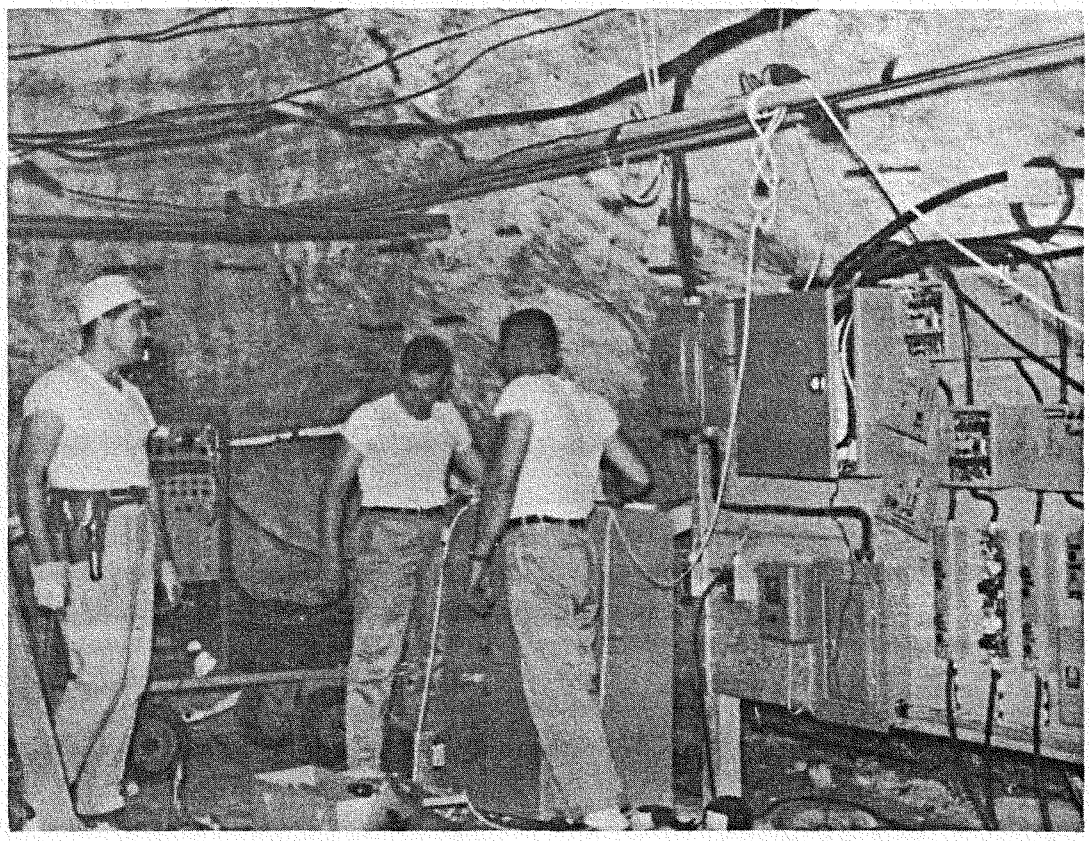


FIGURE 20. Station 1.1 vacuum system temporary control panel

erate work on Station 1.1 for completion 15 December, and on 16 December he was authorized to accelerate his work for Station 2.1 to complete the entire facility by 4 January. To meet the shot schedule, temporary wiring (Figure 20) was installed at Station 1.1.

Changes

Advanced to accommodate scientific requirements, the new completion dates would have been compatible with original overall plans if the ventilation shaft construction had been on schedule. However, this item was behind schedule and obviously could not be integrated into the advanced plans.

To conduct experiments without the use of the ventilation shaft required the use of manually-placed solid explosives. Thus, the immediate requirement for a charging and purging system was eliminated; however, a temporary exhaust system was required to discharge detonation gases through the mine ventilating system. Recording equipment that was originally to be located in trailers at the surface was installed for protection in a new underground bunker built near the base of the mine shaft.

To provide for this underground instrumentation, an H&N purchase order was awarded to the H. E. Gorham Company, Winnfield, Louisiana, for the construction of the Sandia Instrument Bunker. (Figure 21) This same purchase order provided for expansion of the bunker (which was completed 14 December) to accommodate LRL and United Kingdom instrumentation. (See Figure 22, Underground Bunker) Barnet Brezner installed power and instrument wiring within the bunker, three Transicold units for air conditioning and dehumidification, and a 112-½ kva transformer power supply.

As a result of this relocation of the recording equipment, it was necessary to reverse the coaxial and signal cable plan from the original path through the ventilation shaft. Timing and firing circuits were installed from the underground bunker to trailers located near the mine tipple. The contractor provided complete power facilities for two trailer parks (one at the command post near Carey's carpenter shop, the other for the scientific trailers near Carey's water tower) as well as a power substation and wiring at the underground instrument bunker.

Temporary control wiring and the ventilation system at the Phase I Sphere were completed 11

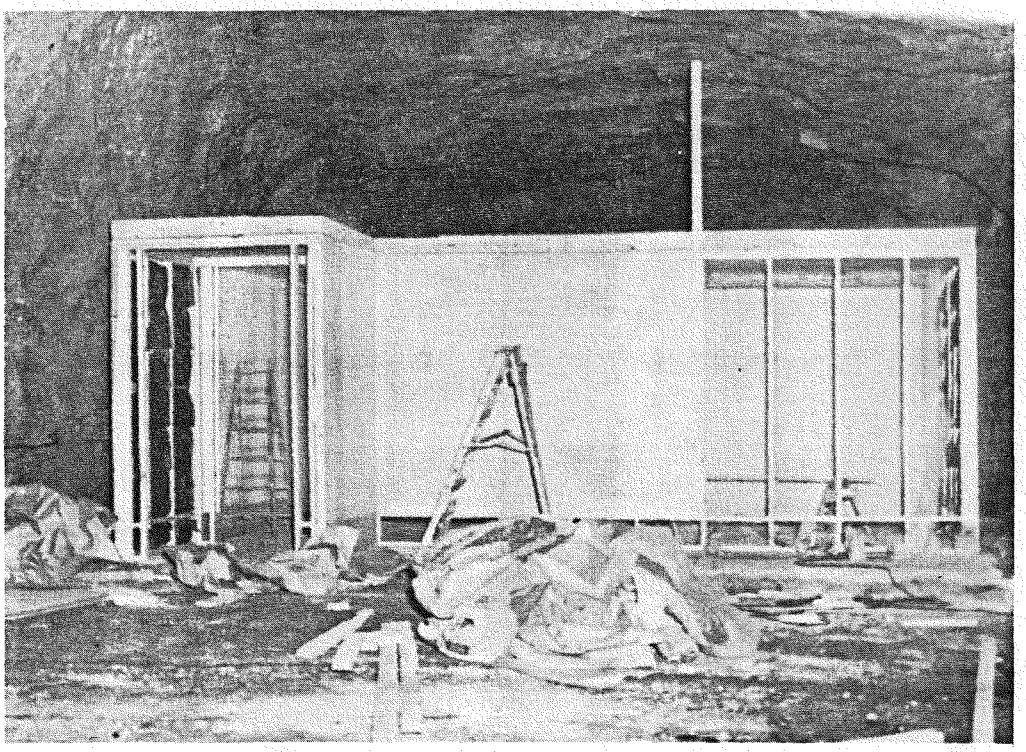


FIGURE 21. Sandia underground bunker under construction

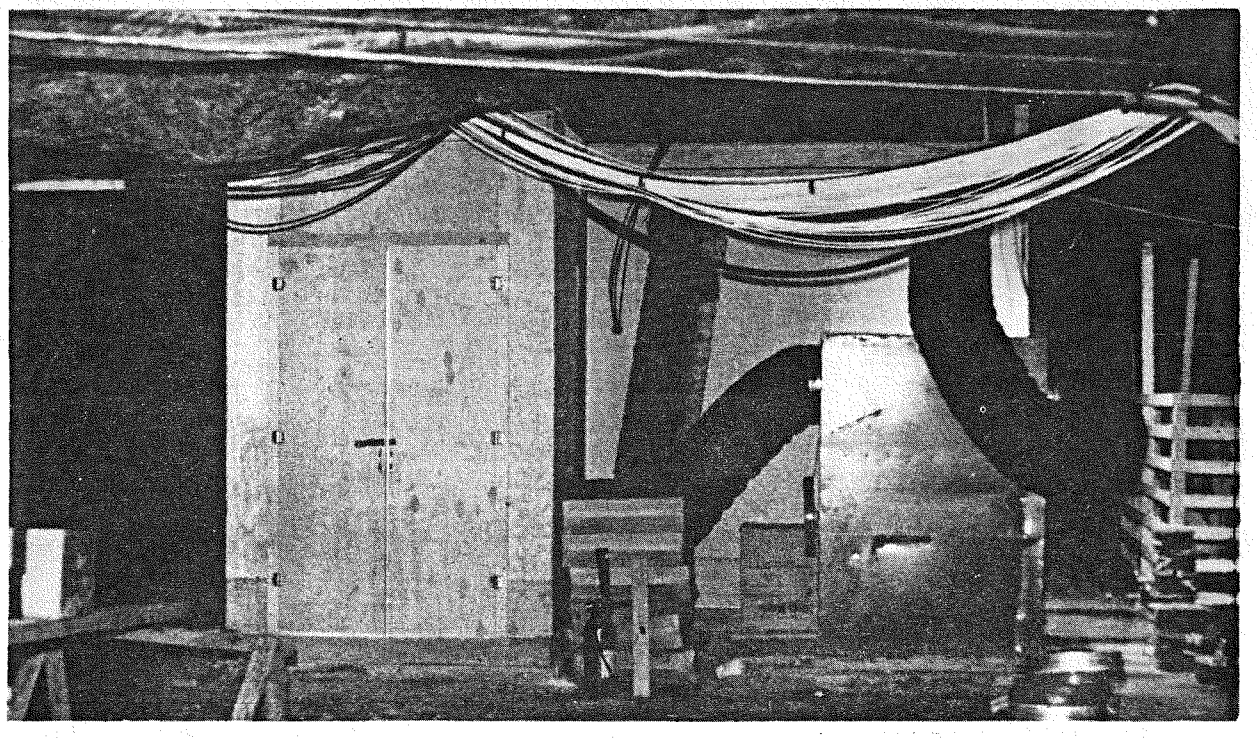


FIGURE 22. LRL underground bunker complete

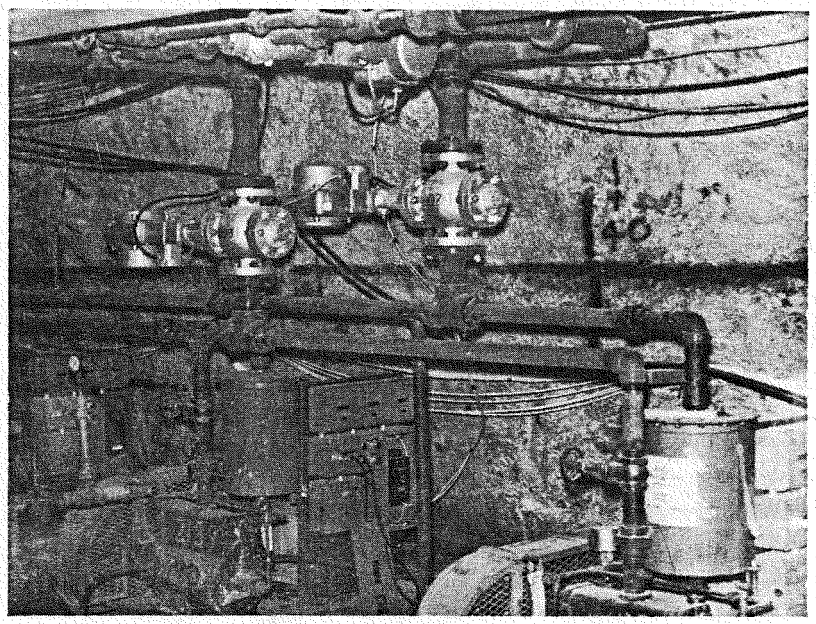


FIGURE 23.
Station 2.1 vacuum pumps and piping

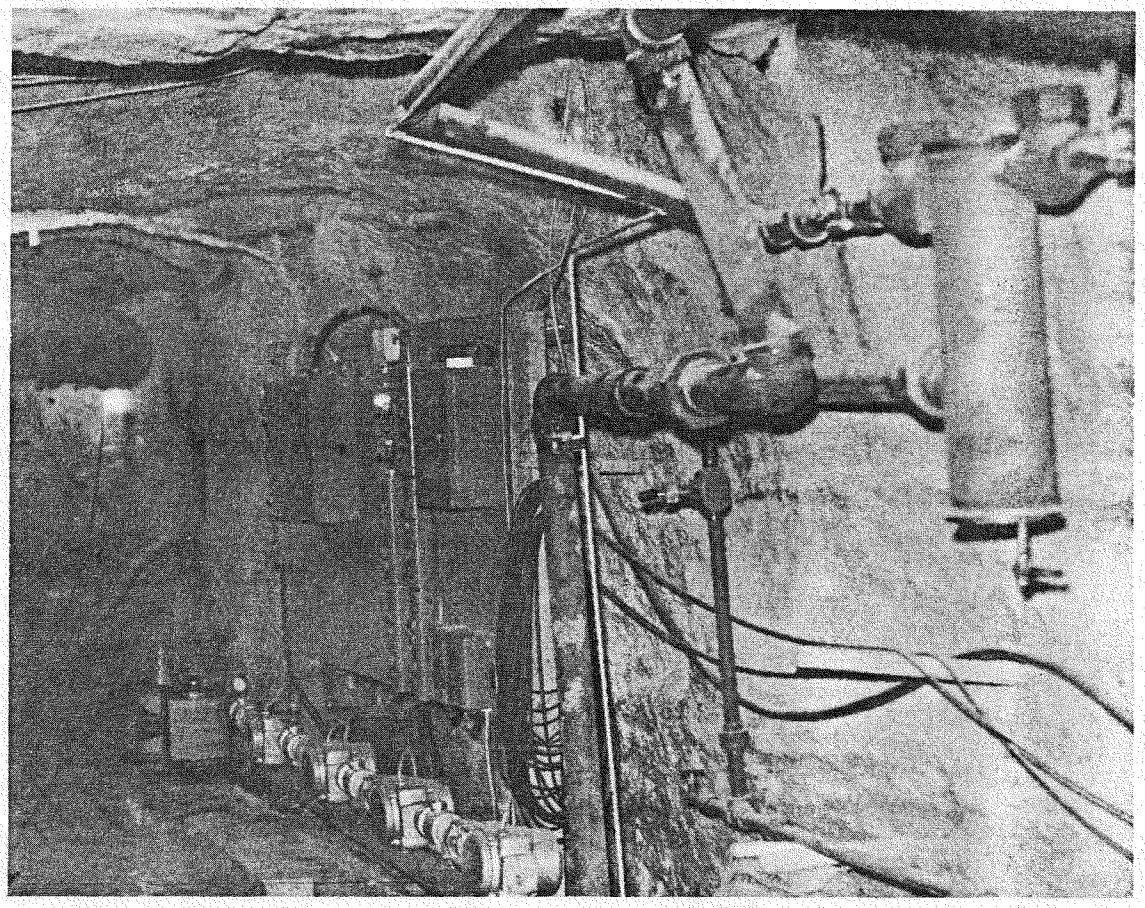


FIGURE 24. Vacuum gas installation in Station 2.1 access drift

December 1959. Power, signal, and mechanical work at the Phase II Sphere were completed 12 January 1960. (Figures 23 and 24) Construction emphasis was then shifted to the permanent installations at the Phase I Sphere. This facility was completed 18 January 1960. After completing additional wire and cable installations, Brezner departed the site 20 January 1960.

Test Support

Support labor was provided during the test period by Barnet Brezner, and by Louisiana Industrial Services, Inc., under purchase orders with H&N. This support included ironworker crews to install and remove plugs for the experiment, and electricians to perform maintenance and checkout of instruments and controls.

J PLUGS AND LINERS

Award

H&N Purchase Order 70047, dated 20 October 1959, was awarded to Farnsworth & Chambers, Inc., Houston, Texas, for the fabrication and installation of the plugs and liners. The award was made on the basis of low bid, and Notice to Proceed was issued 5 November. The purchase order included a provision for the delivery of government-furnished steel plate to the fabricator without cost. When this steel was delivered, it was rejected and replaced by purchased material.

In awards to lower-tier contractors, Farnsworth & Chambers, Inc. assigned the fabrication to Todd Shipyards, Houston, and the field installation to Western Steel Erectors, Oklahoma City; and provided supervision for field erection from their own staff.

Schedule

The contractor's original schedule called for completion of Phase II facilities 21 December, and of Phase I facilities 20 January. This original schedule was affected by delay in steel procurement and two program accelerations by the User; and was finally revised to complete the Phase II facilities 4 January and Phase I facilities 15 December.

Progress

Shop fabrication was complete and field erection began 7 December. From 9 to 14 December two circular plugs and a square liner were set in

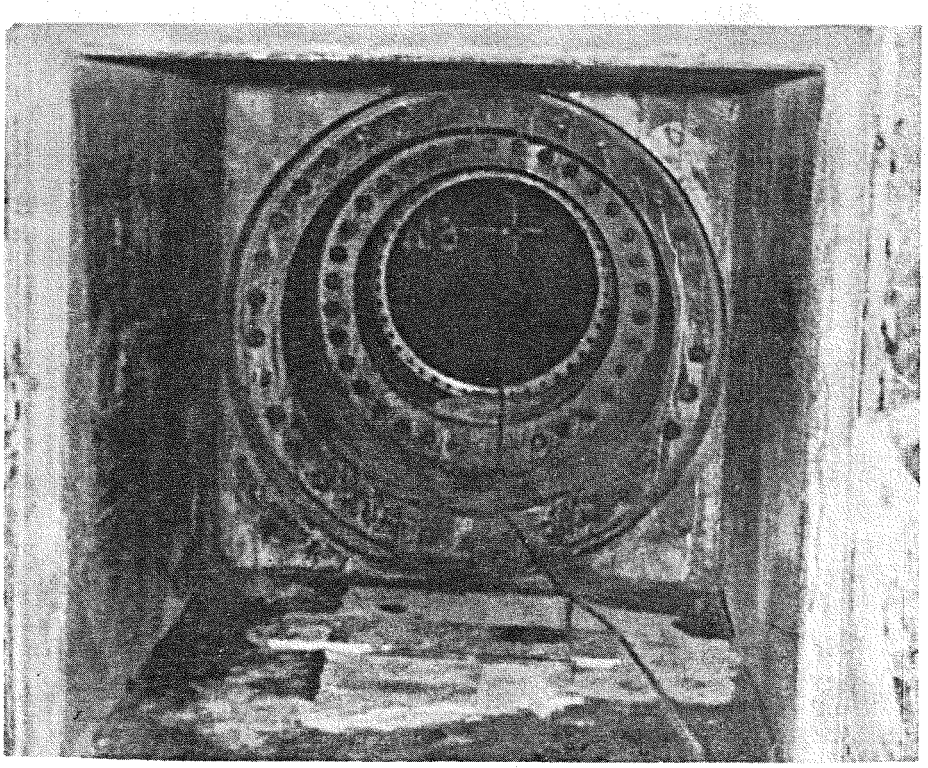


FIGURE 25. Looking through unfinished liner into 12-foot sphere. Bulkhead for Shots 1 through 4 in place

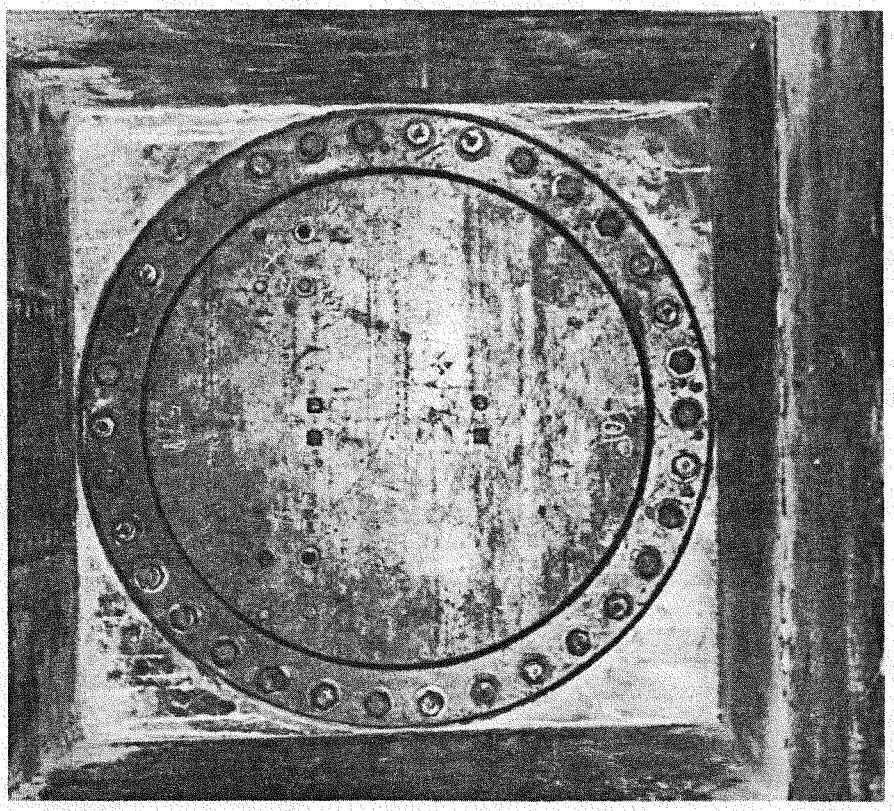


FIGURE 26.
Station 1.1 access with circular plugs in place

the Phase I Sphere and all welding was completed. (Figures 25 and 26) On 14 December the sphere was turned over to the Users, temporarily, for two low-yield shots, and construction emphasis was shifted to the Phase II Sphere. After the low-yield shots, all remaining steel liners, floor plates, and turntables were set and welded at the Phase I Sphere. (Figures 27 and 28)

The Phase II Sphere installations were made from 15 December until 29 December, and from 4 January to 8 January, at which time the plug and liner assemblies were completed.

Extras

The following items of extra work were added to the original purchase order:

1. Farnsworth & Chambers was reimbursed lump sum amounts for additional erection crew time and for premium weekend work to meet the accelerated completion schedules for Stations 1.1 and 1.2.
2. Negotiations were completed in the field for extra crew time which was required to install steel bulkheads for WES grouting and for extra scientific support in connection with the temporary use of the Phase I Sphere.
3. Preliminary studies indicated that excessive time would be required to install and remove some 2000 concrete blocks behind the last steel plug, and that this could seriously delay the postshot re-entry and the entire shot schedule. Therefore, the contractor was requested to furnish five horizontal steel struts as backup in lieu of the blocks.
4. With continuing experimental detonations, rock falls were expected over the underground transformer area and the underground bunker which would seriously damage equipment and delay the scientific program. Consequently, the contractor was directed to install a heavy gauge chain link horizontal fence held by expansion bolts.
5. When it was recognized that Carey had neither the equipment nor experienced manpower to install and remove the plugs during the scientific experiments, the work was assigned to Farnsworth & Chambers while this organization was on-site. Extra stand-by time was allotted for this work.

(After F&C left the site, this service

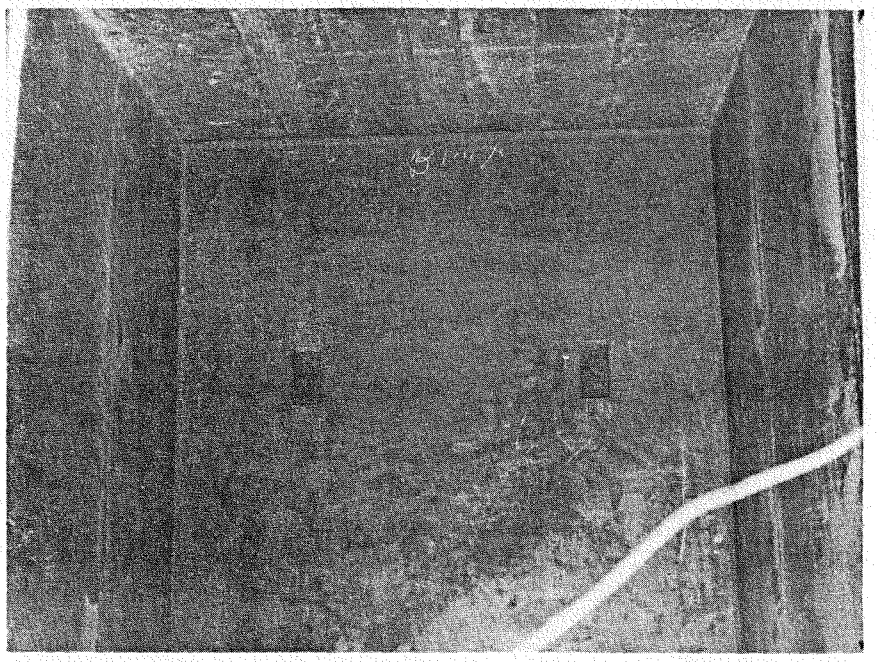


FIGURE 27. Square plug dry run – Station 1.1

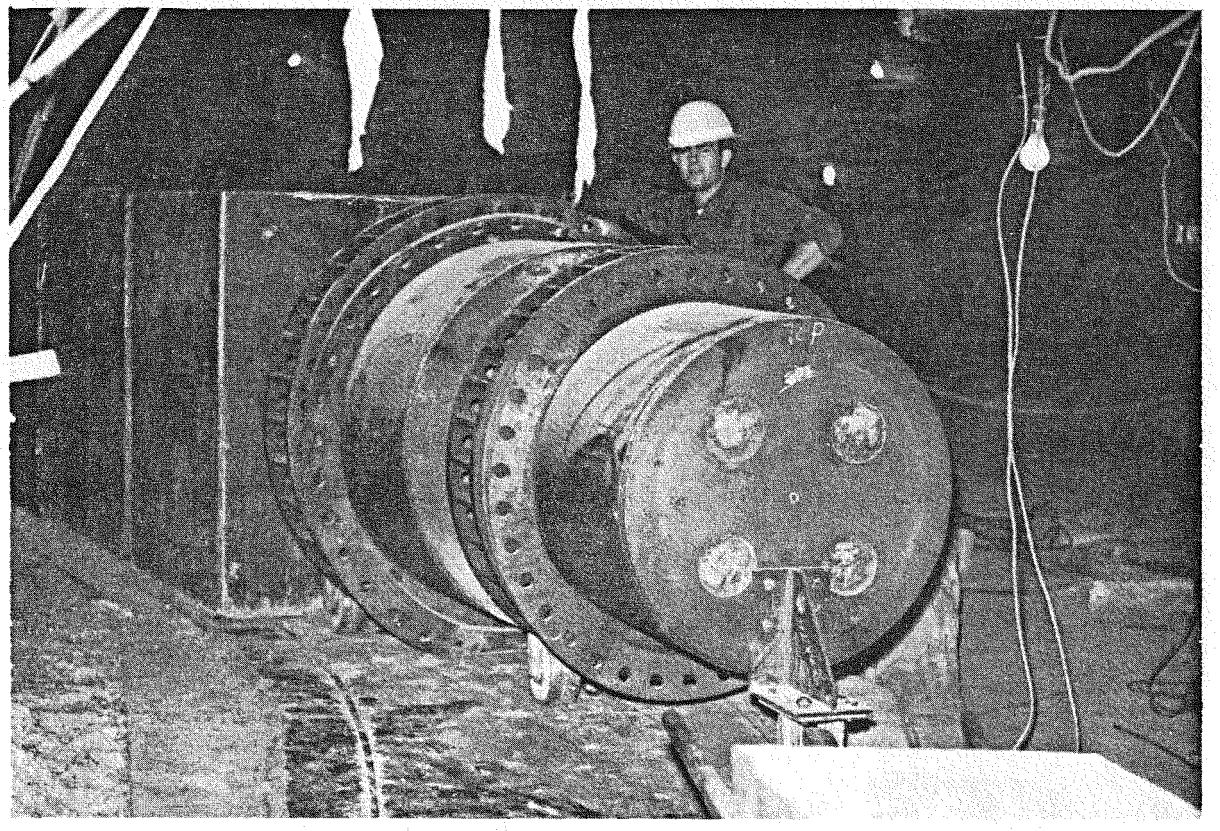


FIGURE 28. Plug array for 12-foot sphere

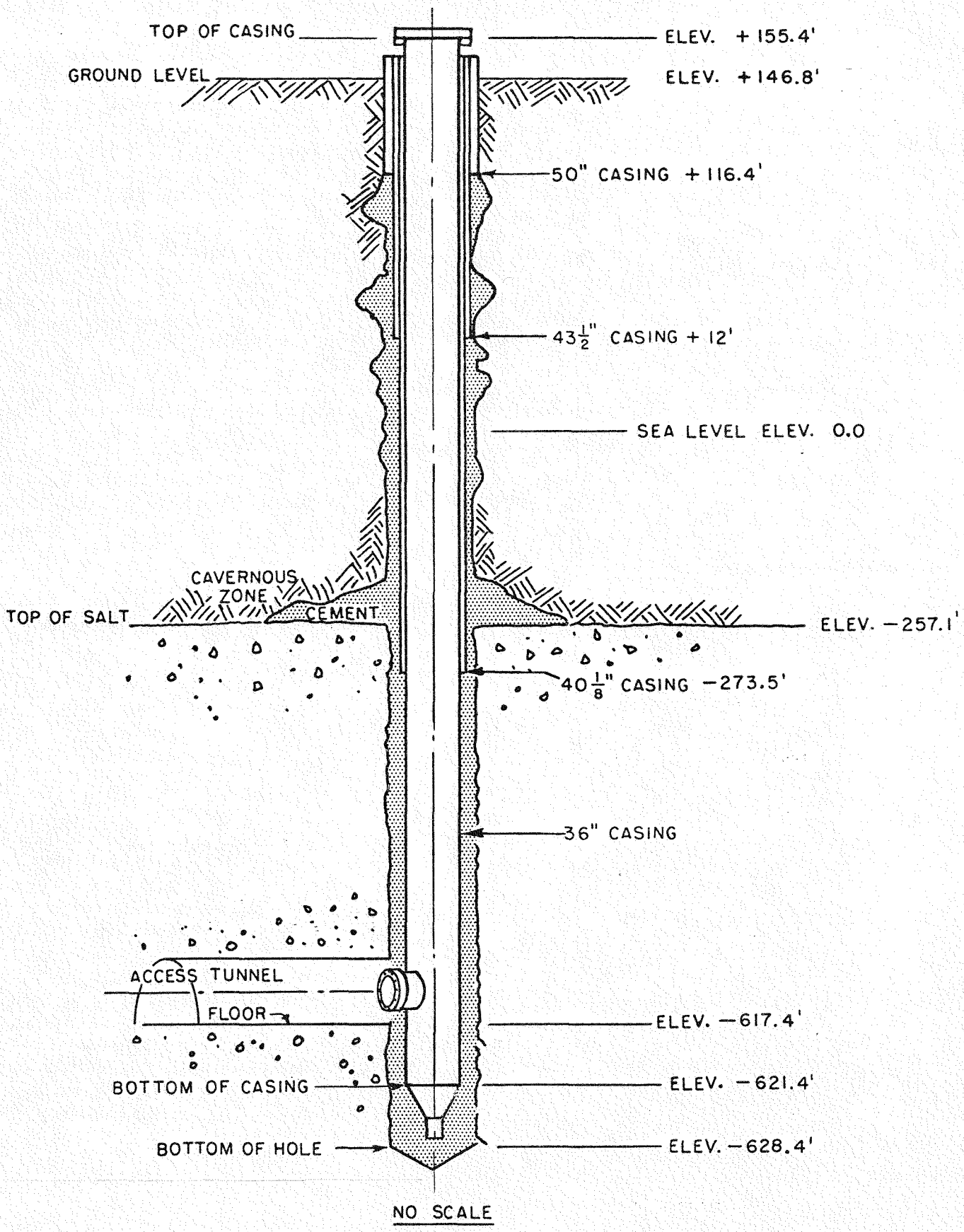


FIGURE 29. **PROJECT COWBOY – 36-INCH DIAMETER VENT HOLE**

was obtained by H&N purchase order to Louisiana Industrial Services, Inc.)

Farnsworth & Chambers left Jobsite 20 January after all work under this purchase order had been successfully completed.

K. VENT SHAFT

Background

Construction for Project Cowboy included a 36-inch ID, steel cased, ventilation shaft approximately 800 feet deep which would carry instrument cables, gas charging, and exhaust piping from ground surface to the working level of the mine. It was known that the drilling would penetrate an aquifer zone of serious proportions which had to be completely sealed off to prevent flooding damage to the Carey mine. (Figure 29) As a prerequisite, Carey had required the Government to indemnify the mine property against any damages stemming out of Project Cowboy up to a maximum of $8,000,000. Thus, it was apparent that every precaution had to be exercised when advancing the vent shaft down to the mine level.

Award

Six competitive bids were received and opened 12 August 1959 at the H&N Office in Winnfield. The bids ranged from $223,889 down to the bid of $97,731 submitted by Modern Foundation Company (hereafter identified as MFC) of Shreveport, Louisiana. On checking the low bidder's qualifications, it appeared that his experience was chiefly in building construction and foundation work, he had not drilled in rock below 65 feet, had no experience with circulating fluids, and did not own adequate equipment.

These findings were submitted to AEC/ALO in support of an H&N recommendation to reject the low bid. When AEC declined to accept the recommendation, H&N issued Purchase Order 70860, dated 21 August 1959, to MFC. Notice to Proceed was issued 25 August.

Schedule

A pre-construction conference held at the MFC office on 22 August 1959 served to substantiate the previous H&N finding that this organization was not qualified for the work. At this meeting MFC presented a schedule that exceeded the allowable construction time by a few days, and allowed no contingency for equipment repair time, lost circulating time, or logging. The contractor had not selected equipment nor had he developed a plan of action. H&N attempted to develop the work concept used in preparing his bid.

At this point, two factors could be noted:

a. The contractor selected for this difficult work of drilling a ventilation shaft through an aquifer into a working salt mine was not a drilling contractor. His bid proposal noted drilling experience to a depth of only 65 feet into rock, he had no equipment suitable for this work, nor did he have an experienced drilling engineer to plan and organize the work.
b. From available geological information, it was obvious that a serious problem would be involved in drilling through and sealing the aquifer even under the best conditions. The responsibility for this was divided between the WES Concrete Laboratory reporting to the AEC and responsible for grouting, and the drilling contractor responsible to H&N for drilling.

Progress

MFC began work at the site on 26 August 1959. By 30 August 1959, the mud pits and overflow piping were complete. Using a truck-mounted drilling rig he set a 32½-foot section of 50-inch surface casing to a depth of 28½ feet.

On 7 September 1959, MFC completed set-up of a rented oil field drill rig, and a 9-inch pilot hole was spudded in to a depth of 32 feet. The rig was a Brewster N-4, with an 86-foot telescoping mast, which would be commonly described as a work-over rig used for maintenance of producing wells or drilling shallow wells (See Figure 30 Brewster N-4 Drill Rig).

Drilling operations from the first few hours were hampered by lost circulation problems. The contractor's drilling program, as finally developed, proposed drilling a 9-inch pilot hole and successively reaming to 15, 26, 36, and 46-inch diameters (Figures 31 and 32). A log of the cementing operations conducted by WES with H&N support shows that between 7 September 1959 and 27 January 1960, 39 attempts were made to cement the lost circulation and caving zones.

Halliburton Oil Well Cementing Co. was engaged by H&N Purchase Order 71364, dated 20 October 1959, to place cement when the volume

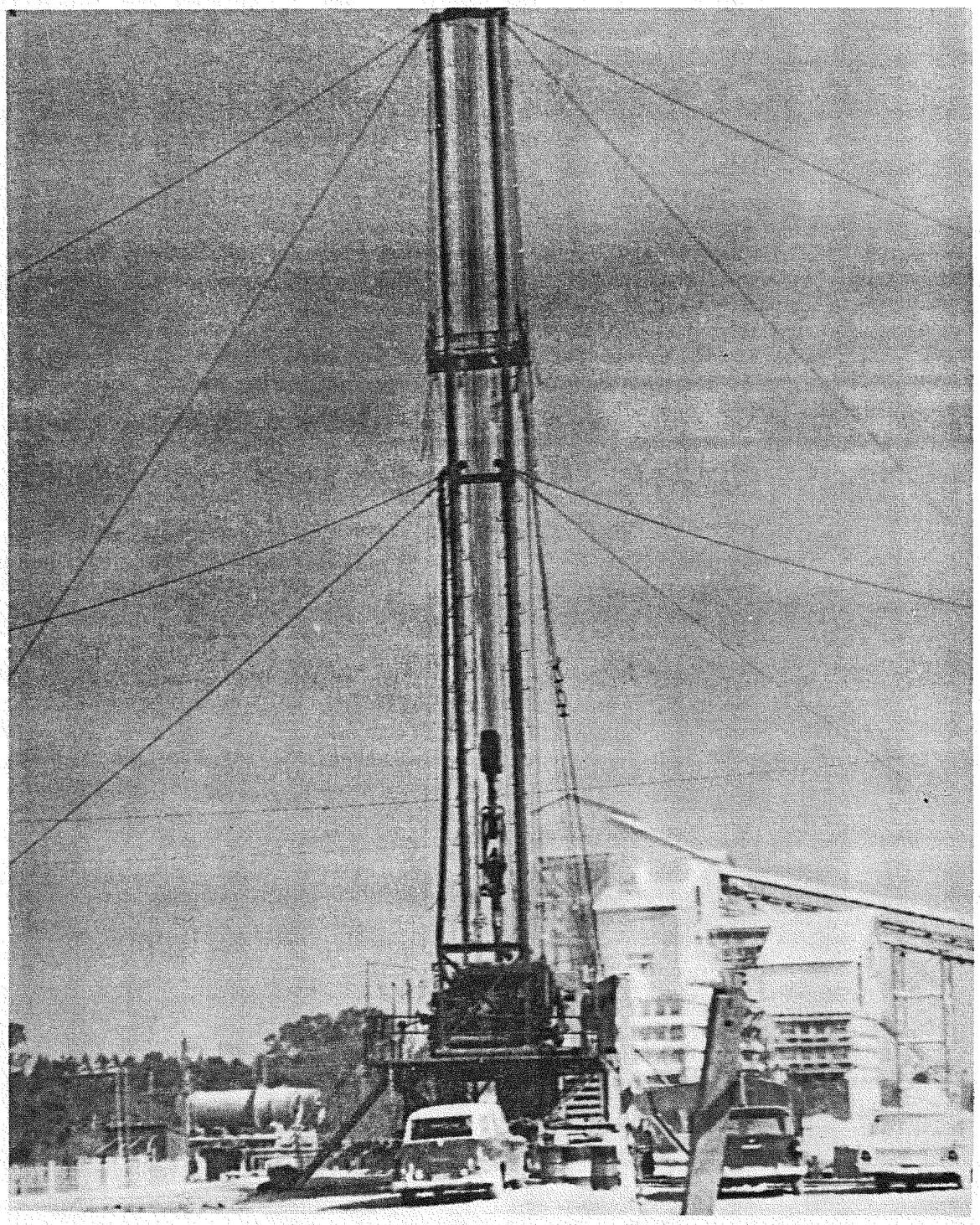


FIGURE 30. Original drill rig (N-4) 36-inch vent hole

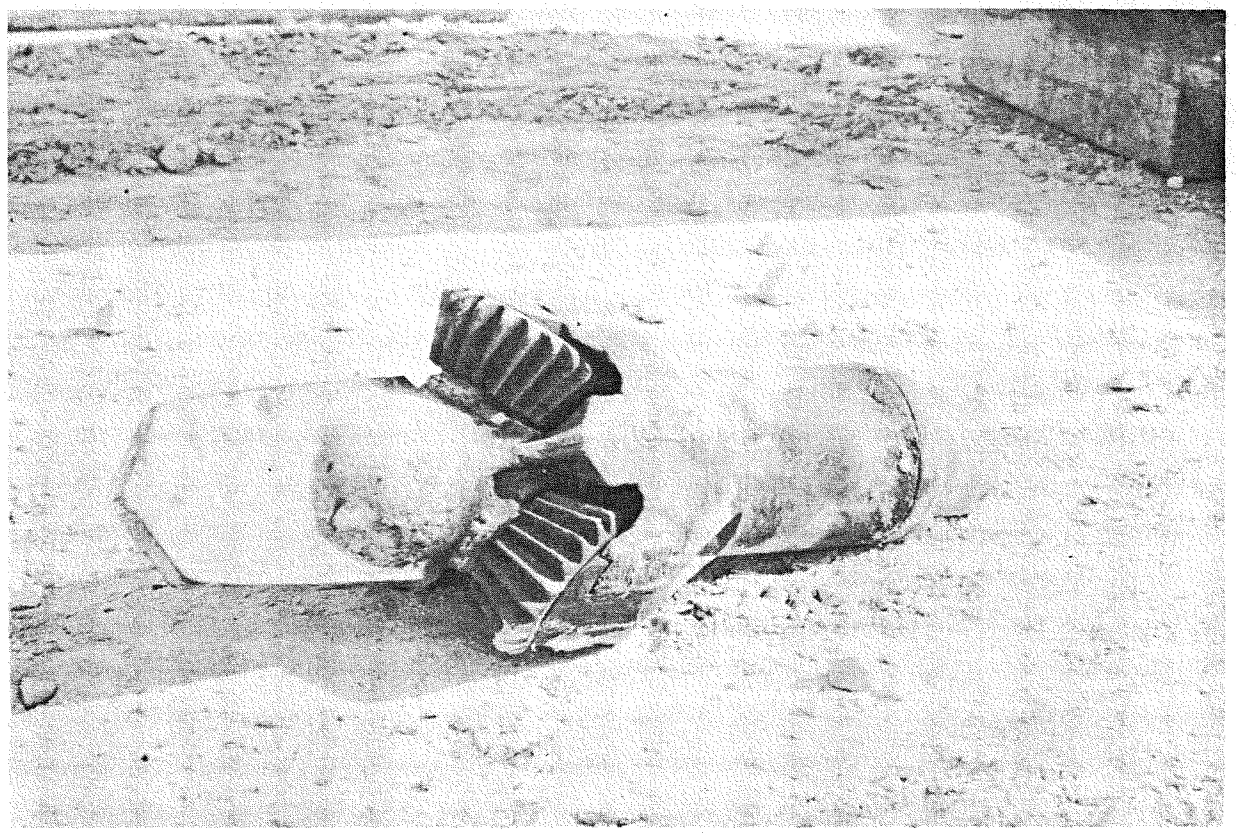


FIGURE 31. 15-inch reamer

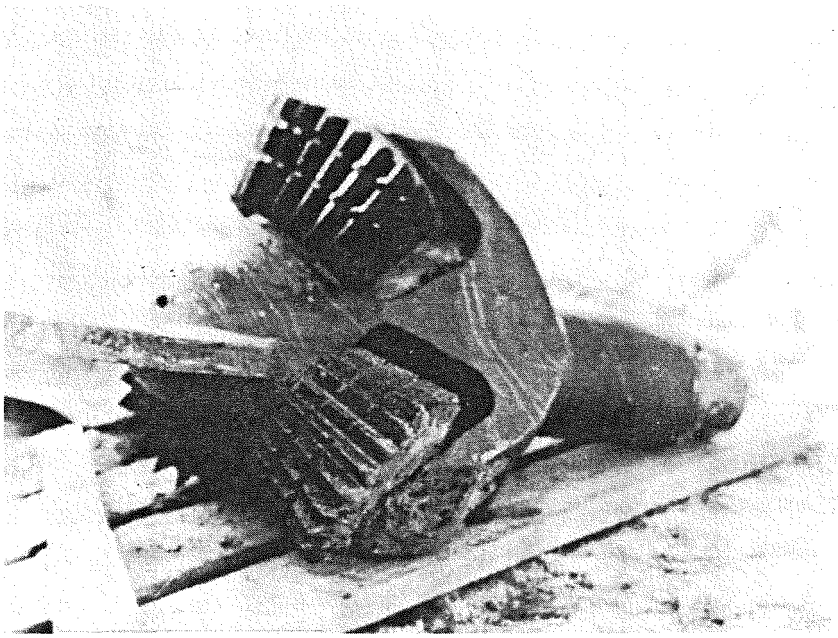


FIGURE 32. 26-inch reamer

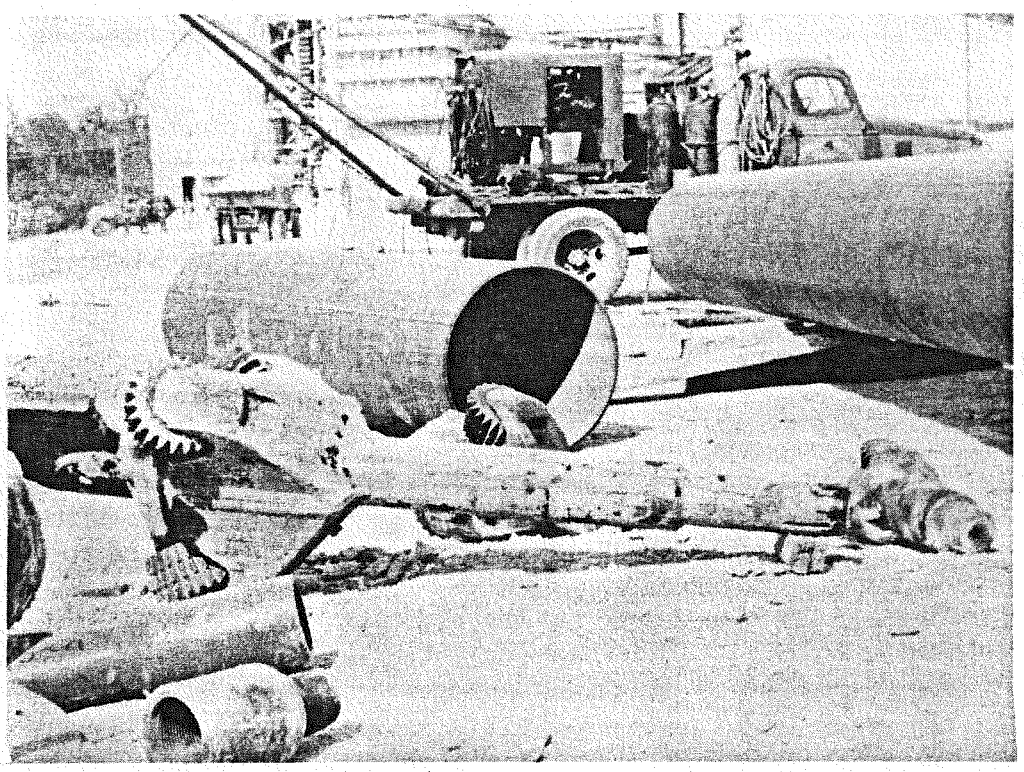


FIGURE 33.
36-inch reamer
(2 guide vanes
missing)

exceeded the capabilities of the WES mixing equipment.

Between 13 October and 4 November, structural failures were noted on the 26 and 36-inch reamers (Figure 33). On 4 November, while the contractor was reaming with the 46-inch diameter bit at 385 feet, side wall sloughing in the area from 30 to 115 feet caused the reamer to stick in the hole, requiring two hours to free the equipment. On 5 November, when reaming had progressed to 400 feet, the contractor pulled the 46-inch reamer for inspection and found one roller cone and one end plate missing from the bit. Subsequently, he spent approximately 240 hours operating with various types of fishing tools and finally retrieved all material on 14 November 1959. During this fishing period, he expressed concern about the caving conditions in the hole and claimed that if WES cementing operations had been conducted correctly, and had pressure grouting operations been used, this sloughing zone would have been consolidated.

At this point, H&N expressed an oral opinion that the Government had no obligation to seal this zone to prevent caving, only to seal it to prevent lost circulation. Pressure grouting in a 9-inch or 15-inch hole would not have assured penetration out to a 46-inch diameter (15½-inch penetration), and there was no assurance that this area would have been consolidated. Furthermore, caving conditions must be remedied by MFC at his own expense, since this was one of the contracting risks normally included in preparing a bid, and a risk that he must assume. It was also noted that these cave-ins may have been accelerated from abrasions caused by the fishing tools.

To preclude further sloughing, MFC proposed to install at Government expense a 42-inch diameter sub-casing down to the aquifer in the 400-foot area. Alternately, H&N and WES jointly recommended placing a cement plug and drilling through the center, leaving a cement sidewall (See Figure 34 Cement Plug Detail). The cementing operation was made 15 November 1959, and was temporarily successful. By 20 November 1959, full bore drilling of the 46-inch diameter bore had been completed to 410 feet, and into the aquifer. The last portion of the hole was drilled blind or without circulation.

Drilling then continued with the 26-inch reamer to 425 feet, the 36-inch reamer to 420 feet, and the 46-inch reamer to 419 feet. Placing a plug above the lost circulation zone was finally accomplished 24 November. The plug was drilled on the 26th and Halliburton attempted to set a packer on the 27th. The packer would not seat, therefore a second plug was placed by Halliburton utilizing 250 sacks of Calseal. Attempts to set the packer in the second

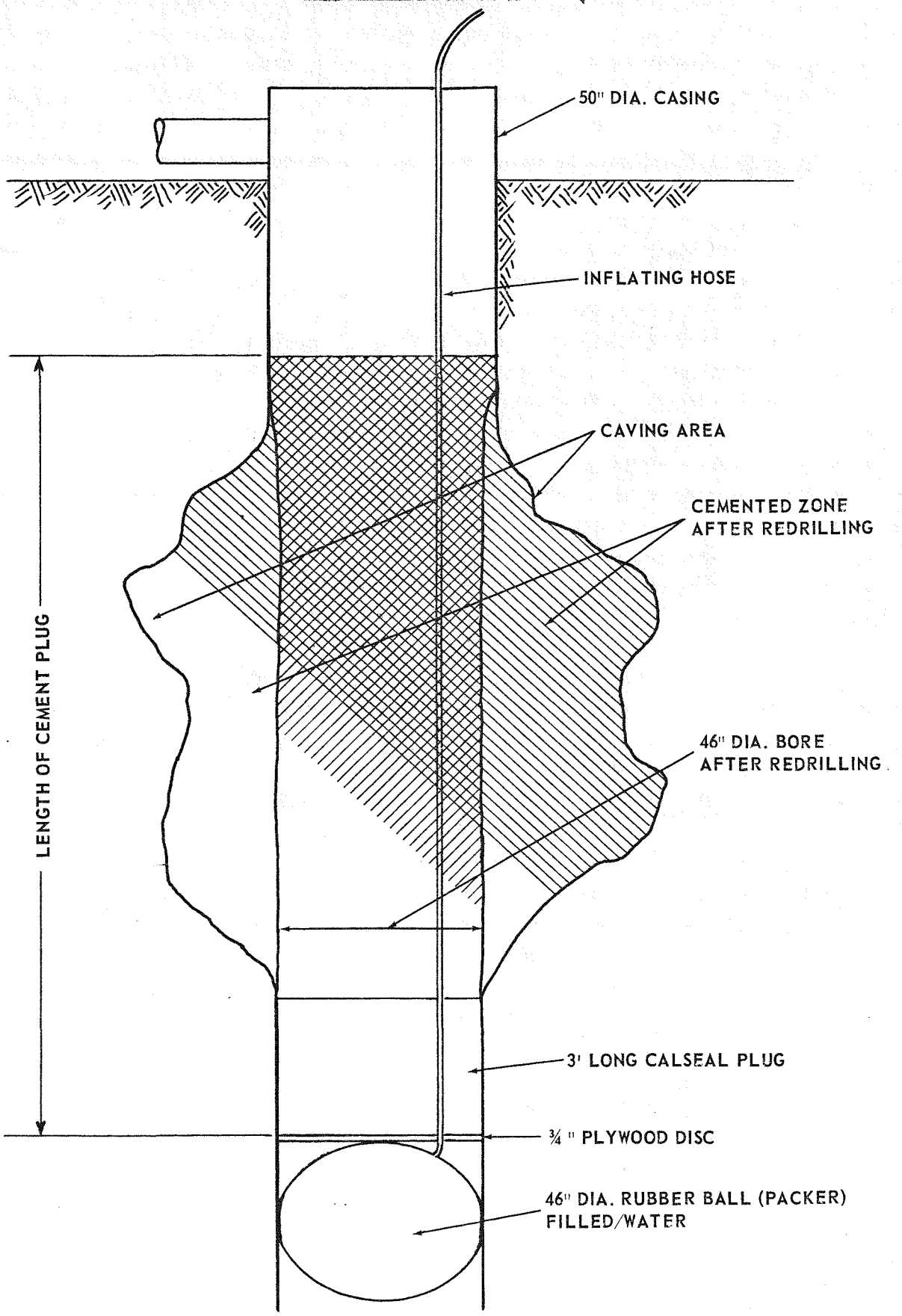


FIGURE 34. CEMENT PLUG DETAIL

plug were also unsuccessful. On 28 November WES pumped in sanded grout to form a third plug, 36 feet in height, with the top at the 300-foot level.

At this time the H&N management recognized that the successful solution of the lost circulation problems encountered in drilling the vent hole would require the services of a specialist, with a considerable background of salt dome drilling experience. Under H&N Consultant Agreement No. 5, effective 28 November 1959, Oscar R. Lyon was retained to formulate a plan for sealing the lost circulation zones and the major aquifer, and to evaluate the general prosecution of the work to date.

Arriving at Jobsite 29 November, Mr. Lyon reviewed the situation, and advised to continue as planned: stand by until the plug had cured, then pressure grout using Halliburton. This last plug was drilled and a Halliburton packer set on 2 December. The following day the lost circulation zone was cemented to what appeared to be a refusal pressure. After allowing for cement curing time, the plug was drilled out to the full 46-inch bore. Circulation was again lost at the 431-foot depth. Mr. Lyon then suggested that sub-casing (as previously proposed by MFC) be placed to the top of the salt strata at 428 feet. AEC approved MFC's proposal to ream the hole with a specially fabricated side-wall reamer, and to furnish and place 42-inch ID x 3/16-inch wall casing to a depth of 428 feet. To condition the hole to accept this 42-inch casing, the contractor completed 46-inch reaming to 431 feet.

On 14 December 1959, the contractor began reaming with his side-wall reamer and worked with the tool approximately 7 hours when he considered the sidewall caving conditions sufficiently hazardous to cease operations. A caliper log of the hole was run at this time, which indicated a 51-inch diameter hole below 372 feet, and very large cavities (in the cement sidewall placed 15 November) beyond the limits of the 60-inch caliper from 42 feet down to 130 feet. The contractor began running the 42-inch casing on 15 November.

When the casing lodged at 180 feet, a meeting was called to discuss the problem and it was agreed to remove the 42-inch casing, run a directional log, compare it with the most recent caliper log, and determine the maximum diameter casing that could be set in the hole in the area above 160 feet. The casing would be installed to protect this portion of the hole from sloughing, and permit the completion of the sidewall reaming with the mandrel reamer, and installation of the 42-inch casing. At this meeting, H&N contended that a 45-inch diameter casing could be run to approximately 135 feet deep. MFC disagreed and subsequently offered (at Government expense) to fabricate, furnish, and install 135 feet of 43½-inch casing, and to fabricate an expandable underreamer which would pass through this 43½-inch casing and ream the hole below 135 feet to the bottom to accept the 42-inch casing string. This proposal was accepted and the 43½-inch casing was run 18 December 1959. The expanding reamer (Figure 35) was completed 20 December 1959 and reaming began on this date at a depth of 159 feet.

Mr. Lyon completed his work and was released on 18 December 1959 although the Consultant Agreement had provided for an option on his services through 29 February 1960.

Consultant Agreement No. 6 was issued to Dr. E. O. Bennett, another oil well consultant, for services from 17 December 1959 through 29 February 1960, later extended through 30 April 1960. After a preliminary survey, Dr. Bennett recommended that MFC obtain a heavier drill rig, and that the 42-inch casing should be discarded because it might collapse under hydrostatic head. In its place, Dr. Bennett suggested an engineered string of 40-1/8-inch ID casing varying in thickness from 5/8-inch at the bottom to 3/16-inch at the top.

These recommendations were discussed and accepted in meetings attended by WES, H&N, MFC, and Carey, and it was agreed that this sub-casing would be cemented by Halliburton under H&N direction.

On 23 December 1959, MFC's proposal for furnishing and installing the 40-1/8-inch ID casing was accepted, and the casing was delivered to the site on 28 December 1959.

Due to the magnitude of the problem in cementing the aquifer and the inherent damage that could result in the mine, Carey employed a drilling consultant to advise them on the adequacy of the casing and cementing work. This individual represented Carey at subsequent meetings convened to evaluate the work program.

At the direction of H&N a new drill rig was set up over the hole on 28 December 1959 (See Figure 36 Brewster N-45 Drill Rig) Technical details of the new drilling equipment are as follows:

Drawworks	Brewster N-45 (nearly new) Torque Converters Air Clutches, Hydromatic Brakes, Twin GM 671 six Cylinder Diesels.

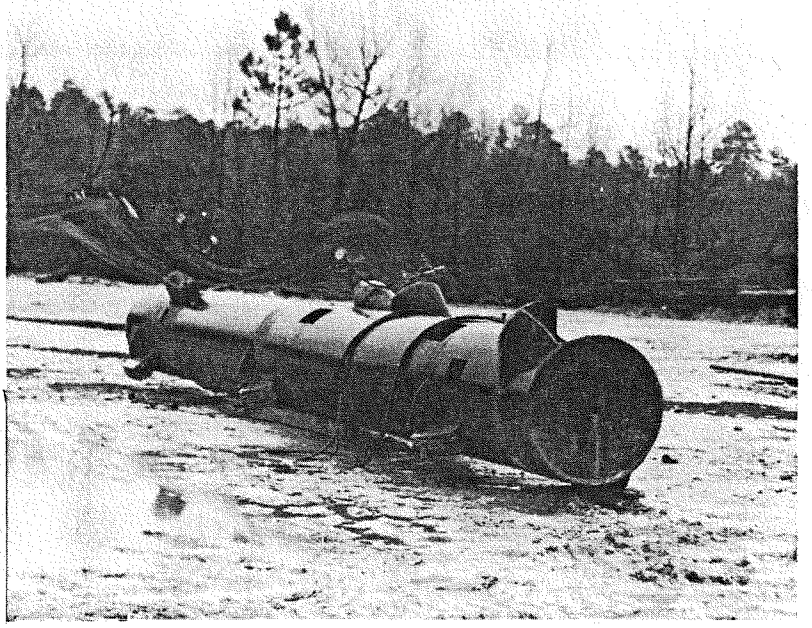


FIGURE 35.
44-inch expanding under-reamer

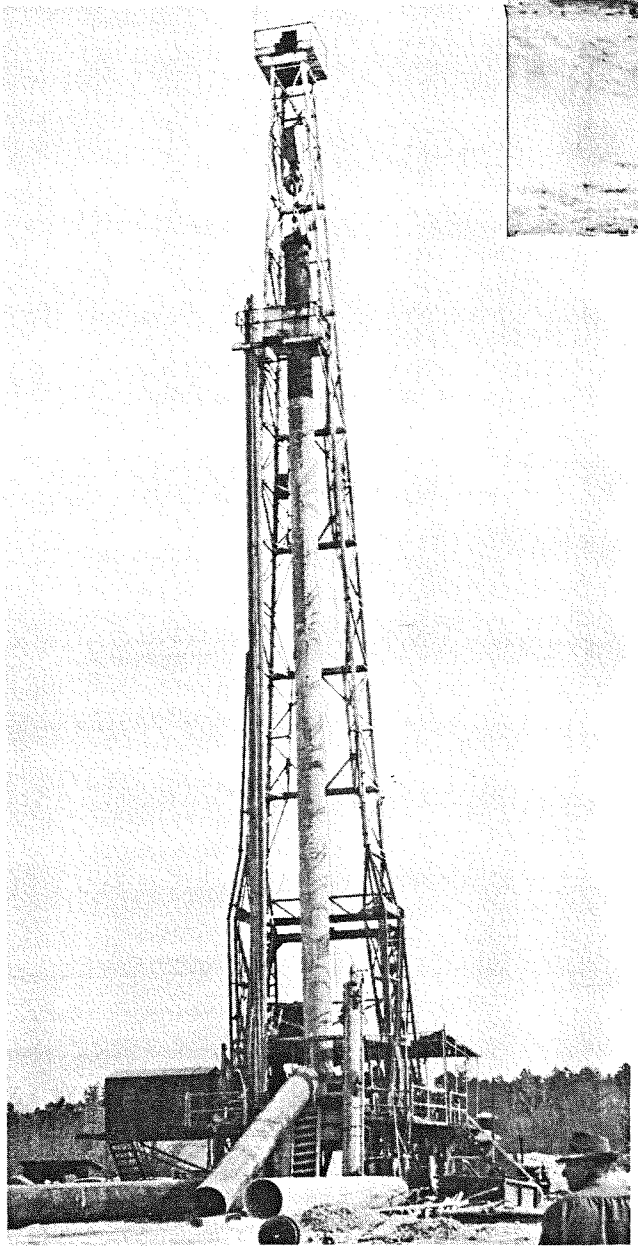


FIGURE 36.
Second drill rig (N-45) running 36-inch casing at the vent shaft

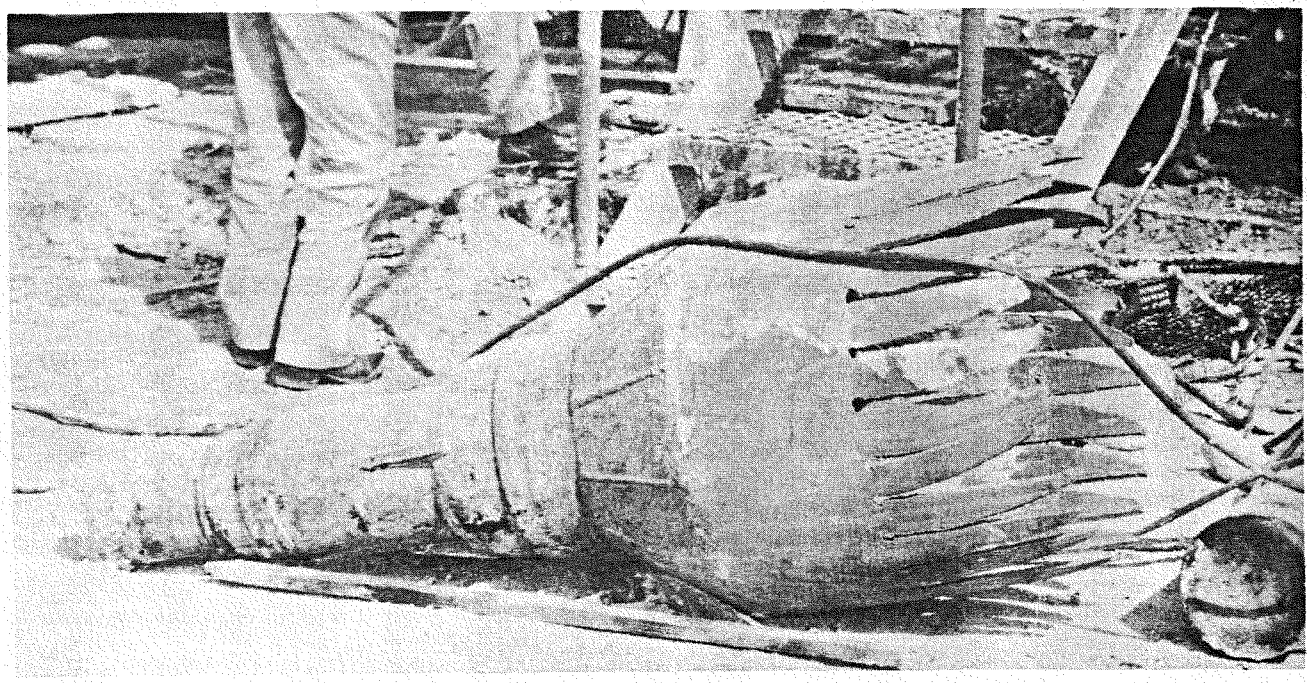


FIGURE 37. "Junk" basket

Derrick — Lea C. Moore 440,000-lb Treble Jackknife 128 feet on 9-foot Sub-structure, McKessick 150 T Block, with Web Wilson Hook, Brewster S-4 Swivel.

MFC made an unsuccessful attempt to run the 40-1/8-inch surface casing without reaming the hole on 31 December 1959, and 1 January 1960. The casing lodged at 205 feet and was pulled out of the hole. From 2 January to 5 January the hole was reamed with the 44-inch expanding underreamer after which the casing, fitted with a precast concrete plug and Halliburton packer, was run to the design depth of 431 feet on 5 and 6 January. On 7 January the annular space between the drill hole and surface casing was cemented with 2000 sacks of cement, which was only partially successful because of the inflow of slurry into the casing.

As much as 80% of the material pumped down through the drill stem appeared in the casing above the packer. This material in the casing was washed and drilled out to the depth of the precast plug and a 6-1/8-inch hole drilled through the plug to the 417-foot depth to allow seating of another packer. After cuttings and debris were cleaned out of the hole, a Halliburton retrievable packer was set in the hole and a staging cement operation was begun. This staging consisted of approximately 300 sacks of regular Portland cement, with time allowed between stagings for the cement to attain its initial set.

Concurrent with this staging operation, some 15,000 sacks of cementitious material was pumped from the surface through pipes to seal the annular space between the casing and the wall of the hole. This operation continued until a refusal pressure of 200 psi was attained on 26 January. All cement placed through the packer and in the annulus was seeded with Iodine 131 radioactive material and, at regular intervals, neutron logs were performed to determine the locations of the cement deposits.

The final cement plug was drilled out to a depth of 426 feet on 29 January and preparations were made to perforate the casing and prove the adequacy of the pressure squeeze cementing. Four shaped explosive charges of ½-inch diameter penetrated the casing at 405-foot depth with no loss of circulation, indicating that the cementing was successful. The consultant retained by Carey stated that he was convinced the cement was intact and of sufficient thickness.

With the cementing operation completed MFC was directed to resume drilling. However, before drilling could proceed it was necessary to fish out of the hole some steel, consisting of fish-tail bits, pieces of the sidewall and expanding reamers, and pieces of the packers. (Figure 37)

From 31 January through 5 February the contractor made numerous attempts to remove junk with a job-built fishing tool without success, but on 6 February he used a permanent magnet to remove the debris, and resumed drilling.

The hole was reamed with progressively larger bits. Reaming to 15-inch diameter was completed to 788 feet on 16 February, and 26-inch reaming to 787 feet was completed on 19 February. During reaming with a 39½-inch bit, the drill pipe twisted off three times because of the large amount of torque required for this bit. Reaming to 39½-inch diameter was completed to 788 feet on 28 February.

At this point MFC was ready to install the 36-inch ID (37½-inch OD) casing. However, Carey protested to AEC that the 39½-inch bore did not allow sufficient thickness outside the casing to provide the required cement protection. With AEC approval, the contractor proceeded to under-ream the hole from 39½-inches to 44 inches under an extra work agreement. This under-reaming extended from the bottom of the installed sub-casing (431 feet) down to a depth of 786 feet.

The reamer proved to be a very inadequate tool and required repairs on 14 occasions, several of which were complete rebuilding jobs. The drill pipe parted twice, the reamer broke in half once, and on each occasion, it was necessary to fish for metal debris. After a period of use the pin holes in the reamer actuating arms became elongated and the reamer no longer cut a full 44-inch hole.

At MFC's request, after much rereaming, H&N brought in a mechanical engineer who verified that the reamer measured only 42-3/8 inches in operation.

On 20 March 1960, after the 14th repair, the center set of cutters had a diameter of 43-7/8 inches. This reamer produced, essentially, a 44-inch diameter hole as determined by a Schlumberger caliper log, and the hole was approved for running casing.

Disregarding certain H&N instructions and Halliburton recommendations, MFC installed the 36-inch casing between 20 and 23 March 1960. The instructions pertained to providing handling equipment to maintain tension and prevent collapse of the casing and casing shoe. Although the equipment was inadequate to relieve the cementing shoe of end bearing, the welding and alignment appeared to be satisfactory.

On 24 March 1960, a casing head pack-off was provided at the top of the casing with connections for cementing, circulating heavy mud, for the Lane Wells Gamma Ray Logging Tool, and for a pressure gauge. Pack-offs provided were crude job-built flanges which leaked and slowed the progress of the work. (Figure 38)

The Baker stinger was set in the Baker Duplex float shoe on 25 March 1960..

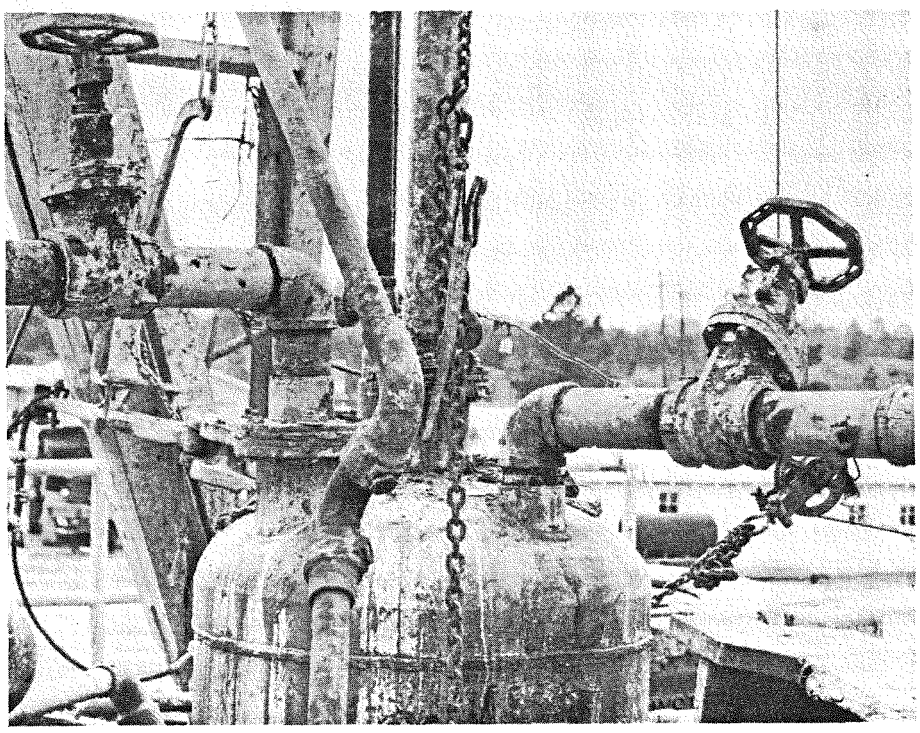


FIGURE 38. Packoff 36-inch casing

A mud-circulating line was run to the bottom of the casing and the fluid in the casing displaced with special 17.5 pounds-per-gallon mud. Three days were required to fill the casing with the heavy mud because of inadequate equipment. Only one mud tank was available and the work was first attempted using only one Halliburton Pump Truck. After some 24-hour delay a second truck was added which materially speeded up the work.

On 28 March 1960, after checking and verifying the weight and salinity of the mud, orders were placed for Halliburton cementing equipment, materials, and for Lane Wells Gamma Ray Logging equipment. After a Gamma Ray Base Log was made, the casing was pressurized to 50 psi. Saturated brine was circulated through the drill pipe and around the casing to flush out the annulus prior to cementing. Two Halliburton cementing units were hooked up to the cementing line so that either truck could be used to place cement.

Cement slurry was pumped at the rate of 600 to 800 cubic feet per hour at pressures between 50 to 100 psi measured in the cementing line near the pump trucks. Frequent test samples were secured by WES representatives from the cementing line and from the mixing hopper. WES representatives and Halliburton supervisors continuously monitored the mixing operations to assure maintenance of proper viscosity and water-cement ratio.

When the cement by calculated volume was within 200 feet of the surface, the pressure inside the casing was increased to 75 psi. The pressure of 100 psi was not applied as planned because the contractor stated that the additional pressure might cause failure of his improvised pack-offs for the 4½-inch drill pipe and 4-inch line pipe.

Computations of slurry volume estimated at 1690 cubic feet were confirmed when slurry returns were noted at the surface. Pumping was continued for 45 minutes while the remaining cement was placed to purge any contaminated mud-cement zones. On completion of cementing, the Baker plug ball was inserted and pumped down to shear the pin opening the circulating ports above the stinger. The heavy mud was then circulated while still maintaining the 75 psi pressure on the casing. By this means the cement slurry was completely flushed from the drill pipe.

The pressure of 75 psi was maintained on the casing until WES representatives affirmed on 29 March the initial set of the cement as verified by test samples. Initial set occurred some 10 hours after placing and the pressure was released from the casing at that time.

Tests conducted by WES on representative samples indicated that the cement had attained a compressive strength in excess of 150 psi on 30 March, some 35 hours after final placement. The mud was removed from the casing by pumping water into the casing through the drill pipe and allowing the mud to flow out through the 4-inch outlet connection in the casing head pack-off and into the mud pit.

Although an effort was made to find a buyer for the liquid mud from among the liquid mud rental agencies in the area, no one was interested because of the distance to the nearest oil fields.

Attempts made by MFC to remove the water from the casing including the following operations: a water jet on the drill pipe, an air lift pump on the drill pipe, and a field fabricated bailer.

Arrangements were made for the Lane Wells Perforating equipment to be available at the site on completion of bailing. A 30-inch diameter disk was rigged to the Lane Wells Sinker Tool to accurately measure the water level in the casing. The casing was perforated on 3 April with four shaped charges spaced at 90° quadrants on a circumference at a depth of 773 feet. The water level in the casing before and immediately after perforating was 749 feet. One hour later it was static at 749 feet.

MFC was then directed to bail the hole dry leaving the interior of the casing clean, dry, and free from welding burrs. When adequate ventilation had been established by completing the connecting access drift, a man was lowered into the hole to clean the walls of the casing and grind off any rough projections.

The slip-on and blind flange for the casing at the surface were welded in place on 3 April and MFC moved off the site.

Anderson-Dunham Co. was engaged by MFC to clean up the site which was jointly inspected by representatives of AEC, Carey, and H&N, and was found to be satisfactory.

Carey excavated the access drift from the mine to the shaft bottom, completing the drift 14 April.

The access door (Figure 39) was installed 19–20 April by Frazier Machine Shop, Winnfield, whose services were obtained by H&N purchase order.

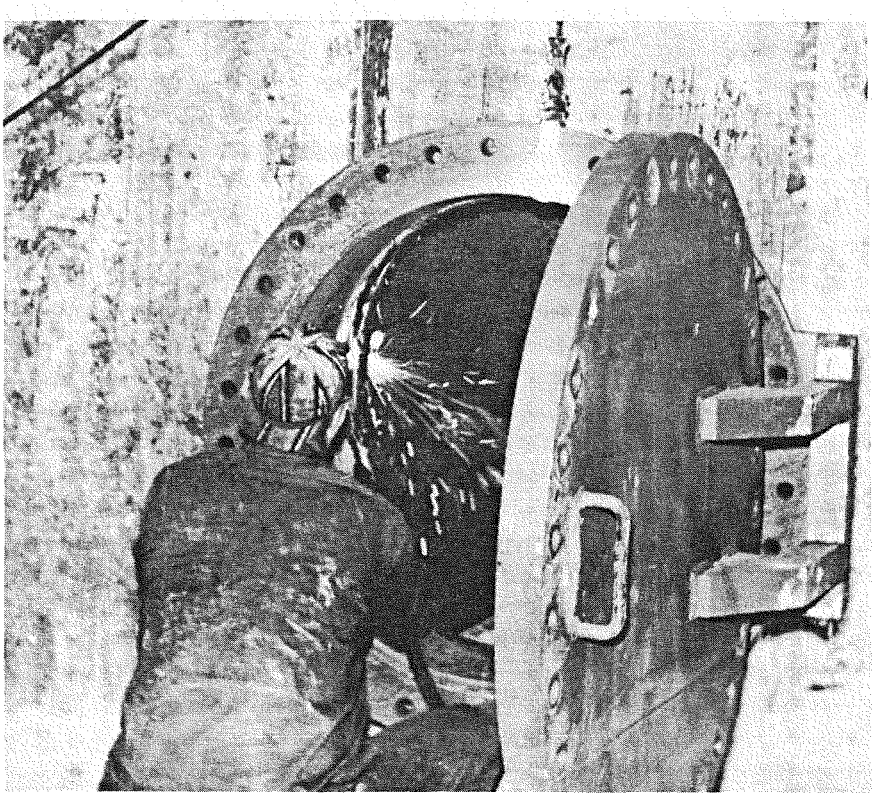


FIGURE 39.

Vent shaft access door in mine

SUMMARY

HALLIBURTON CEMENTING SERVICES

DATE	TYPE OF SERVICE	DEPTH (FEET)
6 October 1959	Set 9-inch φ open hole packer and cemented	385
7 October 1959	Set 9-inch φ open hole packer and cemented	385
8 October 1959	Set 9-inch φ open hole packer and cemented	385
15 October 1959	Cementing through drill stem in 26-inch φ hole	416
16 November 1959	Cementing through drill stem to prevent caving–46-inch φ hole	102
27 November 1959	Set 7-inch φ packer in cement plug and cemented–46-inch φ hole	368
2 & 3 December 1959	Set 7-inch φ packer in cement plug and cemented	340
19 January thru 22 January 1960	Set 7-inch packer in cement plug and stage cemented	438
26 & 27 January 1960	Set 7-inch packer in cement plug and stage cemented	438
28 March 1960	Cemented 36-inch casing and circulated heavy mud	786

CEMENTING LOG

Operation No.	Date	Depth (Ft)	Cement Used (Sacks)	Hole Dia. (Inch)	Operation No.	Date	Depth (Ft)	Cement Used (Sacks)	Hole Dia. (Inch)
1	9/7	53	162 w/sand	9	21	10/7	416	240	18
2	9/8	59	135	9	22	10/8	416	152	18
3	9/9	61	162 w/sand	9	23	10/8	416	54	18
4	9/10	70	81 w/sand	9	24	10/13	413.5	55 Calseal	26
5	9/11	102	90	9	25	10/13	407 Plug	10 (30% Calseal)	26
6	9/12	115	95 w/sand	9	26	10/14	407	60 (30% Calseal)	26
7	9/22	404	594 w/sand	9	27	10/15	407.5	110	26
8	9/23	404	162 w/pea gravel	9	28	11/15	407	60	36
9	9/25	406	54	9	29	11/16	407	1500	36
10	9/32	406	34	9	30	11/17	425	654	46
11	9/29	408	54 w/sand	18	31	11/24	375.5	138	46
12	9/30	409	67 w/sand	18	32	11/25	375.5	50 Plug	46
13	10/1	411	94 w/sand	18	33	11/27	368	250 Plug	46
14	10/1	411	175 w/sand	18	34	11/28	368	270 Plus WES-sand	46
15	10/2	412	94	18	35	12/2	345	2000	46" Packer
16	10/3	416	27	18	36	12/3	345	1210	46" Packer
17	10/3	416	54	18	37	1/4	431	2000	46
18	10/4	416	162	18	38	1/19-1/22	431	14,000	40-1/8
19	10/6	416	460	18	39	1/26-1/27	407	1,750	40-1/8
20	10/7	416	108	18					

L. MISCELLANEOUS CONSTRUCTION

Shelters

A 16 x 40-foot shed with a concrete floor was erected as an addition to the Carey machine shop. This was built at Carey's request to provide shelter for mechanics and equipment during periods of overhaul and assembly. The work was performed by H. E. Gorham Co., Winnfield, on an H&N purchase order for $862.00. A 6 x 6-foot skid-mounted plywood building was erected by Gorham on the same purchase order for $200.00. This building was erected near the Carey water tower to house the main radio station.

A 6 x 6-foot weatherproof building was erected by D. Spencer on an H&N purchase order to house the telephone terminal equipment. The cost was $195.00. This structure was erected near the vent shaft, and later was moved to a location near the mine shaft where it was used for storage of EG&G electronic equipment.

Warehouse Modifications

USC&GS obtained AEC approval to move into a portion of the Winnfield warehouse which was suitably modified to include additional lighting, an air conditioning circuit, dark room facilities, and frame enclosure walls to separate and protect areas designated for storage of scientific equipment and contractor materials. The work was performed under H&N purchase orders issued to Gorham and Spencer, for a total cost of $1910.00.

M. SAFETY

Scope of Activities

The U. S. Bureau of Mines provided mine safety guidance in conformance with agreements

contained in Memorandum of Understanding No. AT(29-2)-914.

Although the Carey safety record was very satisfactory, USBM recommended certain improvements because of the increase in activity and number of people.

The USBM also made frequent checks for atmospheric contamination in the mine, assisted in placing a check-in and check-out system for personnel into effect, and provided safety guidance in connection with HE handling, postshot re-entry, and detonation gases.

Through the combined efforts of Carey, USBM, LRL, and AEC, sets of "Safety and Operational Rules and Procedures" were published and distributed to all agencies represented in the mine.

Preventive Actions

One significant hazard detected in the Carey plant was the loading bin structure at the bottom of the mine shaft. All traffic on or off the hoist cage must travel over the bin platform. In October 1959, a sudden settling of the platform was noted and immediate inspection of the supporting structure was made by H&N. It was discovered that most of the wood members were in an advanced state of deterioration due to fluoridation of the cells and abrasion from the salt. An H&N structural engineer was brought in to inspect and prepare a report covering the situation. The report was forwarded to the AEC by memorandum from the H&N Project Engineer, dated 16 October 1959. Carey made extensive repairs to the bin structure during the balance of the month.

V CONSTRUCTION SUPPORT

A. JOBSITE MOBILIZATION

Buildings

H&N personnel arrived at the site 13 July and established temporary offices at a Winnfield motel. A building was leased at 109 Jones Street, Winnfield, and was occupied 5 August, providing office space for all participating agencies except USC&GS. A warehouse at 200 Court Street, Winnfield, was leased, and occupied 6 August, providing office and laboratory space for USC&GS, and storage space as required. The Winnfield office building rented for $375.00 per month plus $150.00 per month for air conditioning equipment. The warehouse building rented for $200.00 per month plus $50.00 per month for air conditioning equipment. In addition, modifications costing $1910 were made for the convenience of the occupants. An office trailer for H&N engineers at the mine site was rented late in July. This trailer was later moved to the vent shaft and replaced by an AEC trailer. The leases were negotiated by H&N, and rents were included in H&N budgets.

Equipment

Office furniture was obtained from GSA surplus at Bossier Air Force Base, Bossier City, Louisiana, supplemented as necessary with local rentals. Office machines and reproduction equipment were rented in Alexandria, and all rental arrangements were made by H&N.

B. COMMUNICATIONS

Scope

Communication facilities at Project Cowboy consisted of (1) telephone, with special cable extended from Winnfield, Louisiana, to the Carey Mine, (2), teletype service, (3) signal cable system for three nearby locations, and (4) a 41 mc radio system composed of fixed stations and mobile units. Telephone service provided by Southern Bell Telephone connecting to Winnfield, with an original trunk capability of six pairs, was later expanded when phones were added at certain points in Winnfield.

Design

H&N Communications Section, Los Angeles Office, prepared plans for surface and subsurface signal and intercom facilities. Design began in July 1959, and preliminary prints were issued 1 September. Final prints were issued 21 September; however, revisions were necessary as a result of additional requirements initiated by LRL and EG&G.

Equipment

A magneto telephone system consisting of EE 8 instruments and field wire, obtained from Government stock, was originally planned for local communication service between the Carey office, the top of the mine shaft, the bottom of the mine shaft, and two points within the mine. This system was not installed since commercial telephone facilities were adequate for operational and general requirements.

Commercial teletype facilities located in the Winnfield Office were leased from the local telephone company. The equipment consisted of a Model 19 machine (with reperforator).

The principal timing and firing system consisted of a 26-pair No. 19 PAP telephone cable extending from the EG&G trailer located at the mine shaft, to the following subsurface points in the order of routing: (1) Sandia Bunker and subsurface seismic Station No. S–51, (2) Station A Alcove, associated with the 30-foot sphere, (3) six pairs to the USBM instrument shelter, (4) Station C Alcove, associated with the 12-foot sphere, and (5) Station B in Drift "C". A six-pair No. 19 PAP telephone cable also extended from the EG&G trailer to three local surface seismic stations; one located at a point midway between the two subsurface spheres, and the second and third located 800 and 1600 feet respectively from the first station on a northerly bearing. Timing signals were also fed from EG&G trailer to LRL trailer No. 20 in the near vicinity over short runs of 11-pair signal cable. Engineering plans developed in the Los Angeles Office were based on material requirements, and installation practices generally following those established at NTS.

After initial AEC/ALO negotiations with RCA, the radio system, consisting of seven 41 mc 100 and 60 watt fixed stations and 16 sixty watt

mobile units, was obtained on a lease agreement covered by H&N purchase order.

The key 100 watt fixed-based station, located at the Carey water tower, was remotely controlled from the H&N trailer, LRL trailer 20, Sandia Trailer "B", EG&G timing and firing trailer, LRL Bunker (subsurface), and Sandia Bunker (subsurface). The H&N and the USC&GS Offices, Winnfield, also remotely controlled this station over a telephone line. Other 60 watt fixed-based stations were located at the Starlight Motel in Many, Louisiana; and one each at four outlying seismic stations designated Stations 8 through 11. (Two of the four radio equipped seismic stations were located as far as 60 miles from GZ.)

Sixteen vehicles were equipped with 41 mc, 60 watt mobile units for coordination of general construction and operations. Useful range of these units was approximately 20 miles.

C. TRANSPORTATION

Equipment

The ALO Supply Division negotiated for a total of twenty vehicles (sedans, station wagons, pickup trucks) from GSA Interagency Motor Pool at Fort Worth, Texas. Approximately seventeen additional sedans were obtained from a car rental agency in New Orleans through arrangement with GSA. Five Government-owned 4-wheel drive jeep stations wagons were transferred from Carlsbad, New Mexico, for use by the USC&GS in the operation of the outlying seismic stations. These five vehicles were later supplemented by two 4-wheel drive weapons carriers loaned to Cowboy by England AFB at Alexandria, Louisiana.

A government-owned pickup truck was transferred from Los Alamos for hauling high explosives. Quantities of HE in excess of 1000 pounds were transferred from Shreveport to Winnfield by the Couch Motor Lines of Shreveport, Louisiana.

Support

H&N maintained and dispatched all AEC controlled vehicles except those operated by USC&GS. Drivers were required to carry a valid U.S. Government Motor Vehicle Operator's License.

Rental car service available at the Shreveport (100 miles) and Alexandria (60 miles) Airports was generally used by visitors.

H&N operated a Visitor's Bureau to coordinate the transportation and hotel accommodation needs at Winnfield, and obtained reservations on request.

Materials and equipment were shipped by common carrier, either rail or truck line, except those expedited items which were shipped by air to Shreveport or Alexandria and trucked to Jobsite.

H&N operated a shuttle service to Shreveport and Alexandria (as required) to meet incoming planes and pick up passengers, material, and equipment.

Government credit cards were provided for all gasoline and oil purchases, and for lubrication of vehicles assigned to the scientific agencies. H&N made arrangements with two Winnfield garages to lubricate vehicles assigned to H&N, and make minor repairs as required on all vehicles.

D. JOBSITE PROCUREMENT

General

One of the construction services provided by H&N was the procurement, whenever expedient, of materials and services from local suppliers. A member of the Los Angeles Office Procurement Department was assigned to Winnfield for the duration of the project, and he was assisted for about 10 weeks by an Expediter from the Los Angeles Office. As design changes were made at the site, requisitions were prepared in support of purchasing. A total of 282 requisitions for 613 line items were written by H&N at Winnfield.

Technical Inspection

H&N provided technical inspection service for purchased items as follows: hydramotor control valves; fabrication and tests of the poppet valves and hydraulic operator; fabrication of the above ground portion of the vent system, and the below ground access door to the vent shaft; fabrication and cleaning of condensate tank; cleaning of pipe, fittings, and valves, for oxygen and hydrogen service, fabrication and test assembly of the plugs, liners, and turntables; fabrication and tests to destruction of two types of plastic HE supports; and fabrication of PVC plastic supports and fabrication and assembly of acrylic plastic HE containers.

In addition to technical inspection, support labor and supervision was provided for the field assembly of a 200 lb HE plastic support; the field modification and installation of a 1000 lb HE plastic support, together with an acrylic HE container mounted on the support. (Figures 40, 41, and 42)

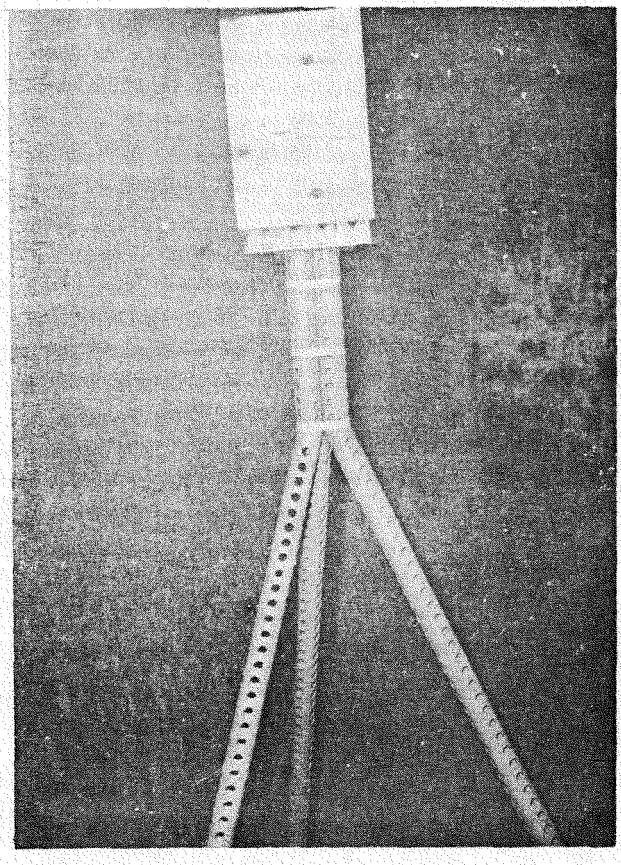


FIGURE 40. T-1 tripod with dummy head

Procurement Support

Purchase orders were issued for local maintenance service for the air conditioning units at the underground bunkers, the power generators at the seismic stations, the plugs and liners, the ventilation system, and the scientific power system. Scientific support also included H&N procurement, expediting, and pickup of equipment and materials for the various agencies.

E. LABOR SUPPORT

Initially, Carey provided labor support to WES for grouting in the vent shaft, but later Carey withdrew this support because of possible conflict with a union contract. By AEC direction, H&N then hired three 7-man crews to assist the WES organization. Employment of these crews was terminated when Halliburton was brought in to perform grouting.

From the H&N clerical staff, clerical assisttance was provided as required by the scientific groups.

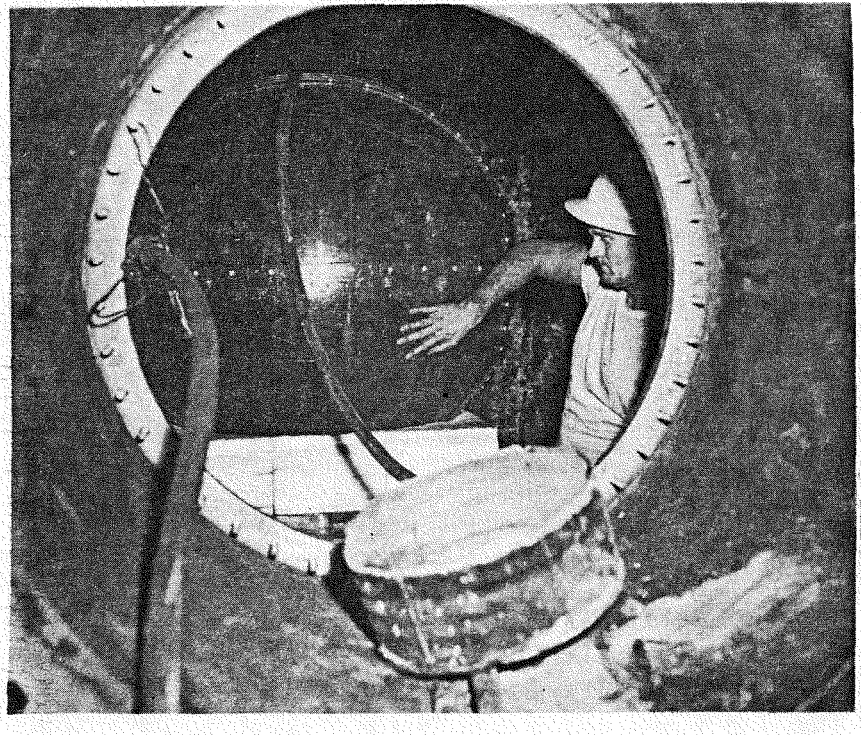


FIGURE 41.
Plastic HE container in position in Station 1.1

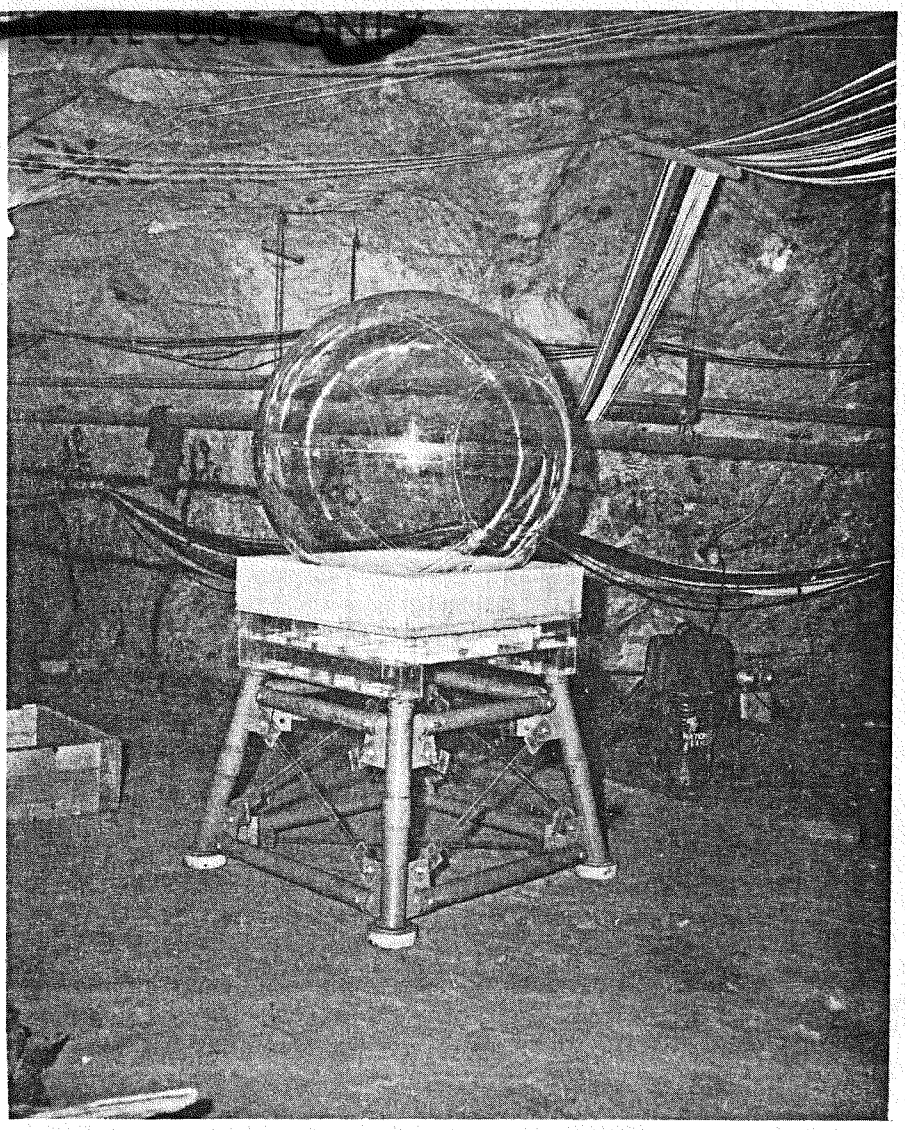


FIGURE 42.
Plastic HE container and stand

F. ROLL-UP

General

The final Cowboy HE charge was detonated 5 March 1960. Roll-up activity began immediately thereafter and was essentially complete by 27 April 1960.

Roll-up operations were affected by three major considerations: (1) the U.S. Bureau of Mines rock dynamics investigations in the Carey mine from 15 March to 15 April, (2) excavation of the access tunnel to the bottom of the vent shaft between 1 and 15 April, and (3) initiation of Project Plowboy on 4 April. (Project Plowboy is a postshot investigation of Project Cowboy shots at Stations Nos. 1.3 and 2.5. Certain equipment and materials were retained at the site for Plowboy.)

Clean-up

Barnet Brezner was authorized by H&N purchase order to dismantle, clean, and store, as directed, all Phase II facilities to be reserved for possible future operations. Major portions of the equipment and piping were cleaned and stored in the underground dustproof bunker, and the bunker padlocked. Space in the bunker was available because the scientific instrumentation had been removed at the completion of the Cowboy tests and had been reinstalled in the scientific trailers. Equipment in the Phase II access drift was mothballed in place. The work was completed 14 April and Brezner left the site. (Figures 43, 44, and 45)

Clean-up operations by Carey consisted of removing experimental shot debris from the coupled shot area and clean-up of Phase I, Drift B. (Figure 46) Carey removed the compressed air line underground, except for the portion retained for Project Plowboy, and covered the instrument cable with sandbags between the project area and the bunker. Cable in the coupled shot area was coiled and hung on wall pegs. All construction equipment not retained for Project Plowboy was hauled to the surface, cleaned, and crated.

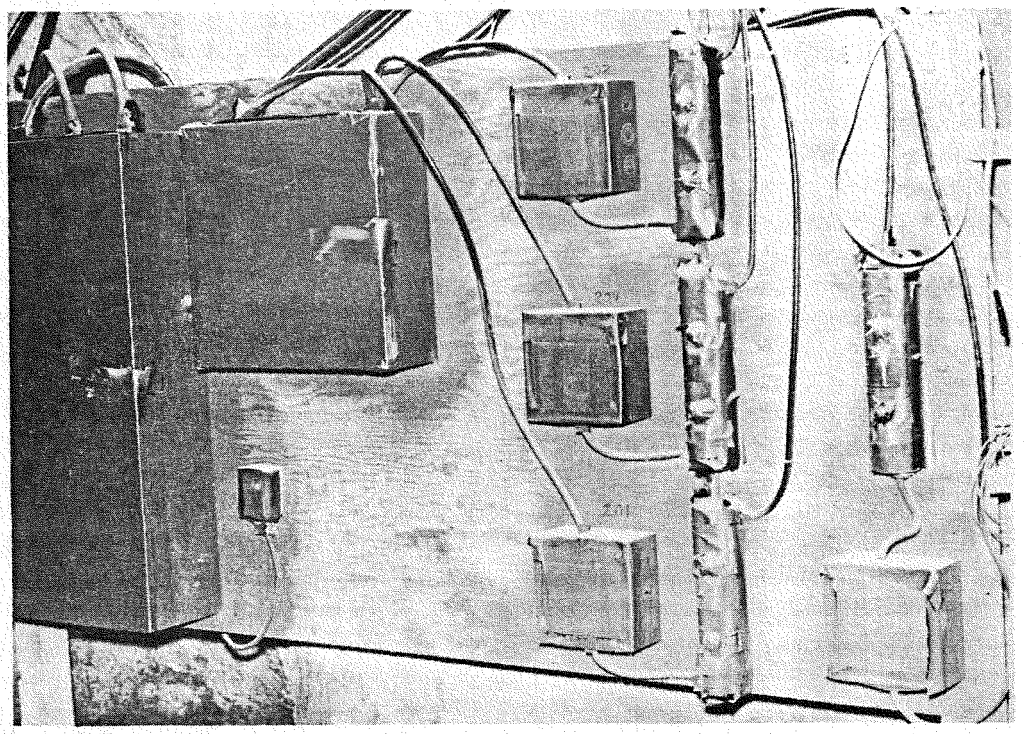


FIGURE 43. Vacuum pump and valve control panel

FIGURE 44. Valves and fittings stored in bunker in plastic bags

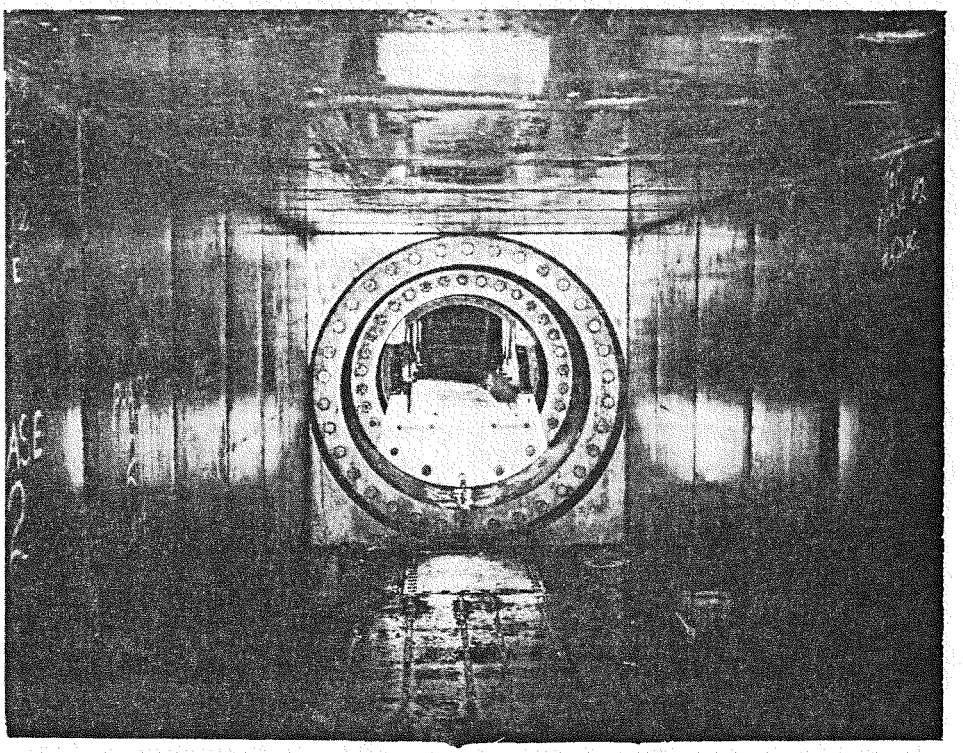


FIGURE 45. Mothballed liner

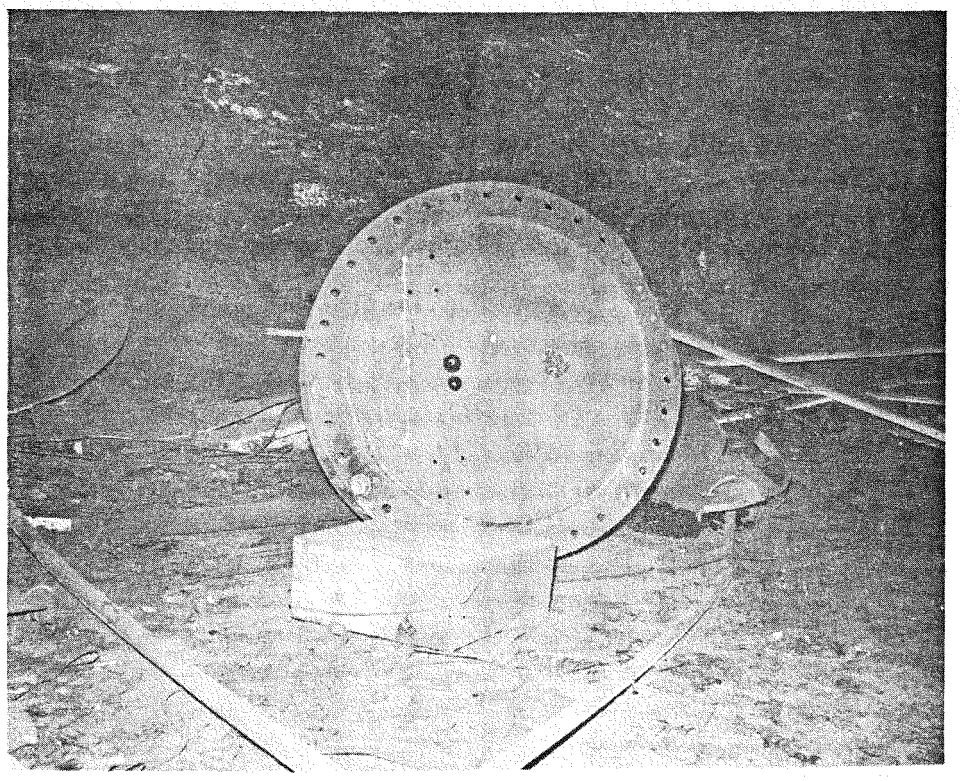


FIGURE 46. After Shot 14. Large cylindrical plug on north side of Drift B

Seismic Stations 1, 2, and 3 were abandoned at their locations, as directed by AEC. An H&N purchase order was issued to H. E. Gorham Company, for clean-up as directed of Stations 4 through 11. At each station location, the sandbags were emptied and scattered, the bag material either removed or buried, the concrete slabs and instrument pits left in place, and the buildings disposed of as directed by the property owners in accordance with the original AEC agreements. This work was complete and approved by H&N and AEC on 22 April.

Return of Leased Equipment

Mobile radio units, base stations, and antennae located at the Carey water tower and Many, Louisiana, were removed by a representative of RCA. The equipment was disposed of by RCA as provided in their original purchase order.

Rental of the teletype machine obtained from Southern Bell Telephone was terminated 13 April.

All telephone instruments were removed except one retained for Project Plowboy.

Rented furniture and office equipment were returned to the owner. AEC furniture was shipped to Project Gnome at Carlsbad, New Mexico. The office building was released to the owner on 19 April, and the H&N Field Office trailer was then utilized during the final week of Roll-Up. Local hires were terminated 26 April.

Preparations for Future Activity

Equipment and material retained at the site for future use required about 60% of the existing warehouse space. Since the warehouse owner was unwilling to lease a portion of the space at an equitable rental rate, another warehouse was leased by AEC with a substantial savings in annual rent.

The new warehouse was owned by H. E. Gorham, Winnfield, and was located on North Court Street. Under the property control system established, material movements into or out of the warehouse were, until the completion of Plowboy, acknowledged by representatives of AEC, H&N, and Mr. Gorham; and AEC retained exclusive authority for withdrawal. Materials were stored in the new warehouse on 28 March, and the first warehouse was returned to the owner on 5 April 1960 after securing his release from all claims for further compensations.

Disposal

The Los Angeles Office provided assistance at the Jobsite in disposing of material and equipment which was not reserved for Project Plowboy. A joint inspection of all government property, rental equipment and leased facilities was made by the H&N representative and the Chief, Property Management Branch, ALO. The purpose of this inspection was to coordinate and establish a program of disposal that would meet with the satisfaction of the Commission and be in accordance with AEC Manual provisions. Part of the equipment, including the Government-owned trailer, occupied by H&N, was shipped to Project Gnome, and equipment not required at Gnome was returned to NTS.

All supplies and materials purchased for the Vacuum and Gas System, and required for future experiments, were stored in the Winnfield warehouse. Certain items of equipment were sold to Carey on a negotiated sale basis, in accordance with the provisions of Chapter 5180-252, AEC Manual.

Unserviceable equipment was surplused to (1) the GSA Office in Shreveport, (2) the Louisiana Surplus Property Office in Baton Rouge, and (3) the Salvage Disposal Section at England AFB in Alexandria. Government property of a non-capital nature, considered excess to the needs of the contract and not required by other AEC contractors, was disposed of through GSA and the State of Louisiana Educational Office.

The automotive equipment, provided by AEC for the use of USC&GS, was checked at a Winnfield garage for minor repairs and shipped by rail to Carlsbad, New Mexico. All but one of the vehicles on loan from GSA were returned to Baton Rouge and to the Fort Worth GSA center. The vehicle move was completed 27 April 1960. One vehicle was retained at the site for use during Project Plowboy.

The various scientific agencies disposed of apparatus for which they were responsible.

VI ADMINISTRATION

A MANAGEMENT

Agency Responsibilities

Overall project administration was the responsibility of the AEC Project Manager with a Project Officer (subsequently changed to Support Director) representing the Project Manager in the field. Planning, coordination, and execution of technical projects were the responsibility of the LRL Technical Director. The Support Coordinator, LRL, maintained logistical coordination between the technical program units and the AEC. The Support Director was responsible for the coordination and execution of required engineering, logistical support functions, and construction.

H&N Responsibilities

H&N provided architect-engineer service, procurement service in certain categories, and overall logistical and field support. Under the direction of the Manager, Engineering & Construction, the senior H&N representative at Jobsite (Project Engineer) performed the overall administration, management, and coordination of these services and support functions.

H&N provided administration of purchase orders, including inspection, preparation of reports, payment estimates, and accounting services. Final inspection of a completed facility was made jointly by the Project Officer, OTO, (or the Support Director, OTO) in company with the Project Engineer, H&N, and the constructor. Acceptance and final payment were accomplished by H&N, as approved by the Chief, Los Angeles Branch, AEC.

Work Order procedures for CPFF construction, support, and miscellaneous services were established by H&N in accordance with the requirements contained in AEC Operations Order 3-59. Details of implementation appear in the section on Jobsite Engineering.

H&N was accountable custodian for all AEC property at the Jobsite except special items of technical equipment brought in by Users and equipment purchased by Carey. Numbered property tags were used to identify all accountable property items except the property items obtained on M/R Loan or by lease.

B. PROCUREMENT

Equipment Inspection

At the inception of the Project, an H&N representative inspected Government controlled mining and construction equipment in the Washington, D.C. area for possible utilization. The equipment available was (1) either in poor condition or (2) could not be repaired and rehabilitated. This information was relayed to AEC/ALO. At AEC request, equipment in both categories was shipped to Winnfield. Other equipment was acquired from NTS and Badger Ordnance Plant.

Equipment Rentals

By H&N Purchase Order 70653, six 600 cfm air compressors and one 5-ton hydraulic crane were rented from Louisiana Industrial Services. One Eimco crawler mounted mucker was rented on Purchase Order 70654.

Procurement Activity

To permit maximum time for the procurement and delivery of materials and equipment, H&N issued Advance Material Estimates as soon as preliminary engineering design indicated firm requirements. This AME action was followed immediately by the preparation of requisitions.

Unusual procurement actions included the following:

a. To meet the schedule, it was necessary to split an order for 30 tons of steel plate required to fabricate the plugs and liners among three of the twelve steel suppliers contacted.
b. Only two bids were received from invitations sent to ten known manufacturers of complex motor-operated control valves for the vacuum and gas system. In order to meet delivery requirements, the successful supplier was authorized to proceed with production on an overtime basis.
c. All components of the vacuum and gas system were required to be wire-brushed, pickled, neutralized, and flushed with acetone. Pipe openings and valves were to be treated with silica gel and plugged for pro-

tection. Because of the rigid and unusual requirements, and short delivery time, many firms were unable to submit quotations. Two bids were received and award was made to Avondale Marine Ways on the basis of low bid. An H&N inspector was assigned to the vendor's plant to insure compliance with specifications.

From 724 requisitions received, 347 purchase orders and 172 revisions to purchase orders were issued. Materials shipped to Jobsite included 16,532 pounds of air freight, 2193 pounds of rail express, 332,215 pounds of rail freight and 722,800 pounds of truck freight. These amounts do not include approximately 1,544,000 pounds of miscellaneous supplies shipped by vendors in or near the Winnfield area.

Major Purchase Orders

On 20 July 1959, Invitation to Bid No. AEC-HN-60-1, for drilling and casing a 36-inch diameter ventilation shaft, was mailed to 20 prospective bidders. Quotations were solicited on five "Schedule A" work items representing various activities required to complete the project, and on eleven "Schedule B" work items representing auxiliary services and contingencies created by circumstances which were not the contractor's responsibility. Six bids were received and H&N Purchase Order 70860 was awarded 21 August, on the basis of low bid for the Schedule A items, $97,731, to Modern Foundation Company, Shreveport.

Revision No. 1, issued on 13 November, brought about no change in the total estimated amount. Revision No. 2, issued 6 January 1960, for increases in previously estimated quantities and new work items not included in the original estimate, increased the total amount to $244,507.62. Revision No. 3, issued 22 February 1960, to cover additional work and increases in estimated quantities increased the total estimated cost to $366,775.32. Revision No. 4 issued 21 April 1960. increased the total cost to $402,257.35. Revision No. 5, issued 2 August 1960, re-stated all line items included in the original purchase order and in prior revisions, and added new work and additional requirements, for a revised total purchase order price of $430,569.93.

Invitation to Bid No. AEC-HN-60-2, for installation of the vacuum and gas system, was mailed to ten prospective bidders on 30 September. The four bids received were opened on 16 October and all were rejected on the basis of variance in bidding and excessive costs. The bid was readvertised on 30 October under Invitation No. AEC-HN-60-4 and the rebids were opened on 9 November. The second lowest bid was recommended since the low bidder had qualified his bid on two items, rendering it impossible to evaluate. With AEC approval, H&N Purchase Order 71480 was awarded to Barnet Brezner on 13 November, in the amount of $95,960. In order to meet an accelerated schedule for the test program, the contractor in early December was authorized to proceed on an overtime basis. In addition to work covered by the original purchase order, Brezner installed thousands of feet of cable and wire necessitated by the accelerated program and changes to original criteria. Purchase Change Order No. 1, dated 15 February 1960, covered this additional work and increased the total purchase order price to $219,033.13.

Invitation to Bid No. AEC-HN-60-3, for fabrication and installation of plugs and liners, was mailed to 18 prospective bidders on 30 September. Only three firms responded and H&N Purchase Order 70047 was awarded to the low bidder, Farnsworth & Chambers, Inc., Houston, Texas. The original amount of the purchase order was $116,173.00; however, changes in User criteria during the course of fabrication and additional costs incurred as a result of the accelerated program increased the purchase order to $159,517.38.

By AEC direction, H&N Purchase Order 71679, in the amount of $18,000, was issued 8 December to the Transicold Corporation, Los Angeles, for two dehumidification units. Since delivery at Jobsite was required 12 December, overtime production and air transportation from Los Angeles to the project site were necessary. Revision No. 1 added one dehumidification unit which was delivered by truck on 17 December, and increased the purchase order to $27,100. Revision No. 2 decreased the unit price and reduced the purchase order total to $23,274.25.

H&N Purchase Order 72062, in the amount of $52,083.00, was issued to Kraloy Plastic Pipe Co., Inc., Los Angeles, to fabricate plastic platforms and platform supports for the high explosive detonations. Revision 1 provided additional assemblies and incorporated design changes and increased the purchase order to $60,554.39.

H&N Purchase Order 72118 was issued to Paramount Plastic Fabricators, Downey, California, for a 48-inch plastic sphere and sphere support to be used in a 2000-pound high explosive detonation. Total amount of this purchase order was $3,390.00.

H&N Purchase Order 72466 was issued to Ray

Products, Inc., Alhambra, California, for a 60-inch plastic sphere and sphere support for use in a 4000-pound high explosive detonation. Total amount of the purchase order was $3,664.85.

C. PERSONNEL

General

A majority of the H&N key personnel were temporarily assigned to the Winnfield Office from the H&N Los Angeles Office and other sites. A system of rotating these key employees, based on a four-to six-week period was adopted. This rotation system was similar to that used by AEC, LRL, and some other agencies. Since these three major groups did not necessarily coordinate their rotations with each other, continuity of administrative control was lacking and did not afford the best of managerial services.

Statistics

During the active period of Project Cowboy, H&N transferred 23 employees from Los Angeles and other sites to Winnfield for permanent or temporary assignments in the following classifications:

Classification	No. of Personnel
Administrative Assistant	2
Ass't Project Engineer	1
Auditor	1
Buyer	1
Chief Auditor	1
Chief Clerk	1
Design Specialist	1
Engineer	2
Estimator	1
Field Engineer	3
Materials Coordinator	1
Project Engineer	3
Senior Accountant	1
Senior Draftsman	1
Senior Engineer	2
Senior Estimator	1
Total	23

By AEC request, H&N hired construction laborers to provide temporary assistance to WES. This was an expedient which was discontinued as soon as practicable.

H&N hired 41 employees at Winnfield whose classifications are listed below.

Classification	No. of Personnel
Chainman	2
Janitor	1
Laborers	30
Messenger-Driver	2
Receiving Clerk	2
Stenographer	1
Typist Clerk	3
	41

Wage Schedule

Wage rates in general conformed to the H&N On-Continent wage schedule. Rates for manual classifications (not included in the H&N schedule) were based on the Secretary of Labor's decision relative to Davis-Bacon construction rates, and were approved by AEC.

On 17 August, the Test Manager authorized an extended workweek of 54 hours (six 9-hour days) for all participating agencies except Carey which was authorized a 56-hour workweek (seven 8-hour days). Carey began working six 8-hour days per week on 22 August but never worked the seventh day because of conflict with its labor union agreement. All participants returned to a 40-hour week effective 7 March 1960.

Carey initiated work on the basis of one 8-hour shift five days per week. As recruiting and training of personnel progressed, Carey activity inincreased as follows: two 8-hour shifts, five days per week commenced 6 August 1959; two 8-hour shifts, 6 days per week commenced 22 August; and three 8-hour shifts 6 days per week commenced 24 September.

Modern Foundation Company worked on a 24-hour day, 7 days per week schedule. In general, constructors of other major features of the work adopted a 10-hour, 6 days per week schedule.

D. SECURITY

Criteria

In the initial security action pertaining to Project Cowboy, security and classification criteria for the project were determined following discussions between H&N and the Security Coordinator, OTO. Basic classification guidance was distributed in memorandum form on 27 August 1959.

Clearances

In view of the early classification directive pertaining to size of HE charges, a total of twenty "L" personnel security clearances were processed for Carey employees. This was a precaution in the event support labor was required for loading HE in the spheres and shot holes.

On 21 September 1959, the Security Coordinator, OTO requested H&N to establish special procedures for reporting personnel clearance information concerning H&N employees assigned to Jobsite. Clearance processing for local hires was initiated at Jobsite and completed at the Los Angeles Office for submission to ALO. Thereafter, a weekly report was sent to OTO on initial requests for clearances, reinstatements, terminations, and clearance grants. Visitor control processing followed normal procedures, using AEC Form 277 or teletype directed to the Security Coordinator, OTO.

Classified Material

The Security Coordinator, OTO, approved arrangements made by H&N for a classified mail channel and storage at Winnfield of documents classified no higher than Confidential-DI.

Revised classification guidance as approved by the USAEC was issued on 19 January 1960, primarily for the purpose of declassifying information regarding the size of individual HE charges and the reports indicating the results of these investigations performed during Project Cowboy.

All information concerning H&N activity was processed in accordance with Company, Division, and AEC policy.

Cessation

By instruction from the Security Coordinator, OTO, the weekly personnel clearance reports were discontinued 25 February 1960, and subsequently, clearance processing was discontinued for personnel hired only for local employment.

The Security Coordinator, OTO, deleted the security interest at Project Cowboy on 26 April 1960 by letter, symbol TA:RWM 1633. On this date all continuing visitor approvals and the classified mailing address were abolished.

Publicity

The Office of Information, ALO, assisted the Project Manager in carrying out the responsibility for conducting Project Cowboy public information. The project was officially announced with a public statement issued 10 July 1959. After that time, Winnfield area news media, public officials, and employees of Carey were kept informed through brief statements of Cowboy construction progress and high explosive shots. On request, AEC representatives delivered short talks to several Winnfield community organizations, utilizing previously released Project Cowboy material.

E. FISCAL

Financial Plans

The interim Financial Plan for H&N was issued 9 September 1959 and included $539,000 for the project. This amount was increased to $589,000 in the Initial Financial Plan for FY 1960, issued 18 September 1959.

Changes in Project Cowboy scope necessitated various changes in estimated costs, increasing the total allowance to $861,000 which was included in a Revised Financial Plan dated 1 December 1959.

Changes continued to enlarge requirements, and a new allocation totaling $1,636,000 was arranged in January 1960. At the same time, the factor of capital equipment was segregated from operations; the separate budget being established at $31,000, and designated as Equipment Not Included in Construction Costs.

On 19 April 1960, the Financial Plan for H&N was again revised upward to provide operation funds in the amount of $1,947,000 plus $39,000 for Equipment Not Included in Construction Costs.

The final adjustment of the Fiscal Year 1960 Financial Plan was dated 24 June 1960 and was entitled Change No. 2. This revision allotted $2,035,000 for Cowboy Operations and $80,000 for Equipment Not Included in Construction Costs.

Cost Accounting

Costs were incurred under the ALO 3000 Program and reported under Special Test Activities. Cost-Budget reporting consisted of Test Construction and Support Costs under sub-category No. 3843.102, and Equipment Not Included in Construction Costs under sub-category 3910.

The AEC/ALO Chart of Accounts was issued on 28 July 1959 and later revised on 8 December 1959. Project costs as of 30 June 1960 are detailed on Pages 66 and 67.

F. REPORTS

Progress Reports

From information provided by H&N functional components the Reports Section presented monthly progress status in the Monthly Narrative Report, Special Projects.

Special Projects

The Reports Section wrote (from assembled data) and published the following reports for Project Cowboy:

a. Operational Plan for Engineering, Construction & Support
b. H&N Managerial Account (Report of the Manager – Part III)
c. Completion Report

COSTS INCURRED – PROJECT COWBOY

From Inception to June 30, 1960

COST	DESCRIPTION	SUPPORT	CONSTRUCTION	TOTAL
61.2	Sphere – Phase I	$ 21,120.67	$ 14,126.78	$ 35,247.45
61.3	Plug – Phase I	8,291.51	95,487.38	103,778.89
61.5	Vacuum Gas – Phase I	38,859.10	101,858.27	140,717.37
61.99	Common	8,707.78		8,707.78
62.2	Sphere – Phase II	20,010.95	56,507.10	76,518.05
62.3	Plug – Phase II	18,255.05	89,243.34	107,498.39
62.5	Vacuum Gas – Phase II	38,859.11	101,858.28	140,717.39
63.3	WES (Vent Shaft)	21,777.41		21,777.41
64.1	Seismic Stations	4,837.85	17,987.43	22,825.28
65.1	Trailer Park		7,000.00	7,000.00
65.2	Utilities	151.98		151.98
69.1	Vent Shaft Drilling		450,634.04	450,634.04
69.3	Vent Shaft Grouting	12,476.38	86,083.78	98,560.16
69.99	Common	1,456.47		1,456.47
81.1	Engineering – LA Direct & Support	132,810.67		132,810.67
81.2	Engineering – Field – Direct	75,094.45		75,094.45
81.2	Engineering – Field – Support	96,140.75		96,140.75
81.2	Survey & Consultant Services	100,958.47		100,958.47
81.3	Oper. & Maint. Scient. Stas. & Facil.	79,860.49		79,860.49
81.4	Procurement	9,714.37		9,714.37
81.5	Transportation – Air Lines & Auto Rental	29,330.13		29,330.13
81.6	Communications – Cable	25,409.17		25,409.17
81.7	Rent – Warehouse & Office	6,015.00		6,015.00
81.99	Remodel Warehouse – LRL	2,877.67		2,877.67
81.99	WES Support	9,268.14		9,268.14
81.99	E. G. & G. Support	139.76		139.76
81.99	USC&GS Support	1,524.99		1,524.99
81.99	LRL Support	1,549.89		1,549.89
81.99	Sandia Support	2,478.68		2,478.68
81.99	U. S. Bureau of Mines	41.95		41.95
81.99	Stanford Research Institute Support	377.90		377.90
81.99	Construction Sandia Bunker	652.09	1,913.61	2,565.70
81.99	Construction – LRL Bunker	236.65	2,536.74	2,773.39
81.99	United Kingdom Support	1,077.32		1,077.32
81.99	Common	2,316.81	11,118.00	13,434.81
82.99	Lean-to- Existing Machine Shop		1,550.33	1,550.33
82.99	Rental of Air Compressor, Cranes, Front End Loaders, Drills, Shovels & Misc. Items	146,762.82		146,762.82
82.99	Power Distribution Equipment	34,272.36		34,272.36
82.99	EIMCO Machine Maintenance	10,250.59		10,250.59
82.99	Transfer from Jobsite	18,323.27		18,323.27
82.99	Common	27,529.11		27,529.11
	TOTAL H&N OPERATIONS COST	$1,009,817.76	$1,037,905.08	$2,047,722.84
	Other Construction Costs (Footnote 1)		405,891.00	405,891.00
	Total Construction Costs		$1,443,796.08	
	TOTAL OPERATIONS COSTS	$1,009,817.76	$1,443,796.08	$2,453,613.84

Footnote #1. Construction performed by Carey Salt Co. of $194,199 and C of E (WES) of $211,692 as reported in AEC Report of The Manager dated June 1960, for which engineering and support services were furnished by Holmes & Narver.

PROJECT COWBOY

EQUIPMENT NOT INCLUDED IN CONSTRUCTION PROJECTS

As of June 30, 1960

		TOTAL
3900	Weapons Equipment Not Included in Construction Projects	
3910	Equipment Acquisition or Fabrication	
	710 – Heavy Mobile Equipment	$ 6,110.40
	725 – Motor Vehicles and Aircraft	570.00
	799 – Miscellaneous Equipment	74,077.43
	Total H&N Equipment Costs	80,757.83
	TOTAL COWBOY	$2,534,371.67

MEMO:

Project Cowboy – Nevada, Hobo Wells and Rock Mechanics, have incurred engineering costs to date of $3,926.57 and $12,896.26 respectively. These costs are not reflected on the cost code report.

[redacted]

N

STATE POPULATION
2,683,516

CITY POPULATION
- 100,000 AND OVER
- 25,000 TO 100,000
- 5,000 TO 25,000
- 1,000 TO 5,000
- UNDER 1,000

STATE CAPITOL IS SHOWN WITH STAR-CENTERED SYMBOL.

PARISH SEAT IS SHOWN WITH DOT-CENTERED SYMBOL.

METROPOLITAN DISTRICTS ARE ENCLOSED BY DASHED LINES.

OFFICIAL USE ONLY

REVISIONS				
NO.	DATE	DESCRIPTION	CH'K'D	APP.

U. S. ATOMIC ENERGY COMMISSION
ALBUQUERQUE OPERATIONS OFFICE

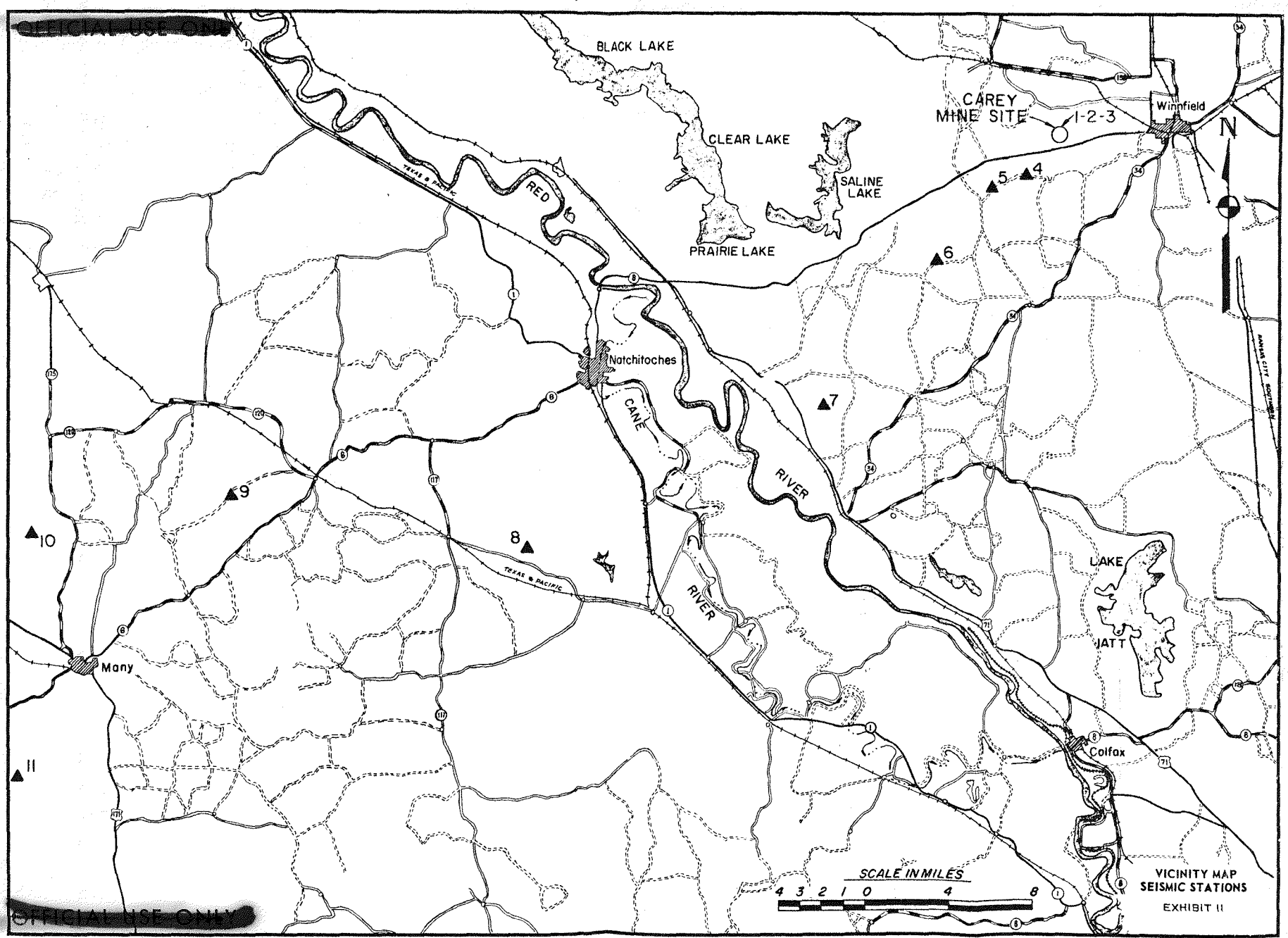
HOLMES & NARVER, Inc.
ENGINEERS—CONSTRUCTORS
828 SO. FIGUEROA STREET LOS ANGELES 17, CALIFORNIA

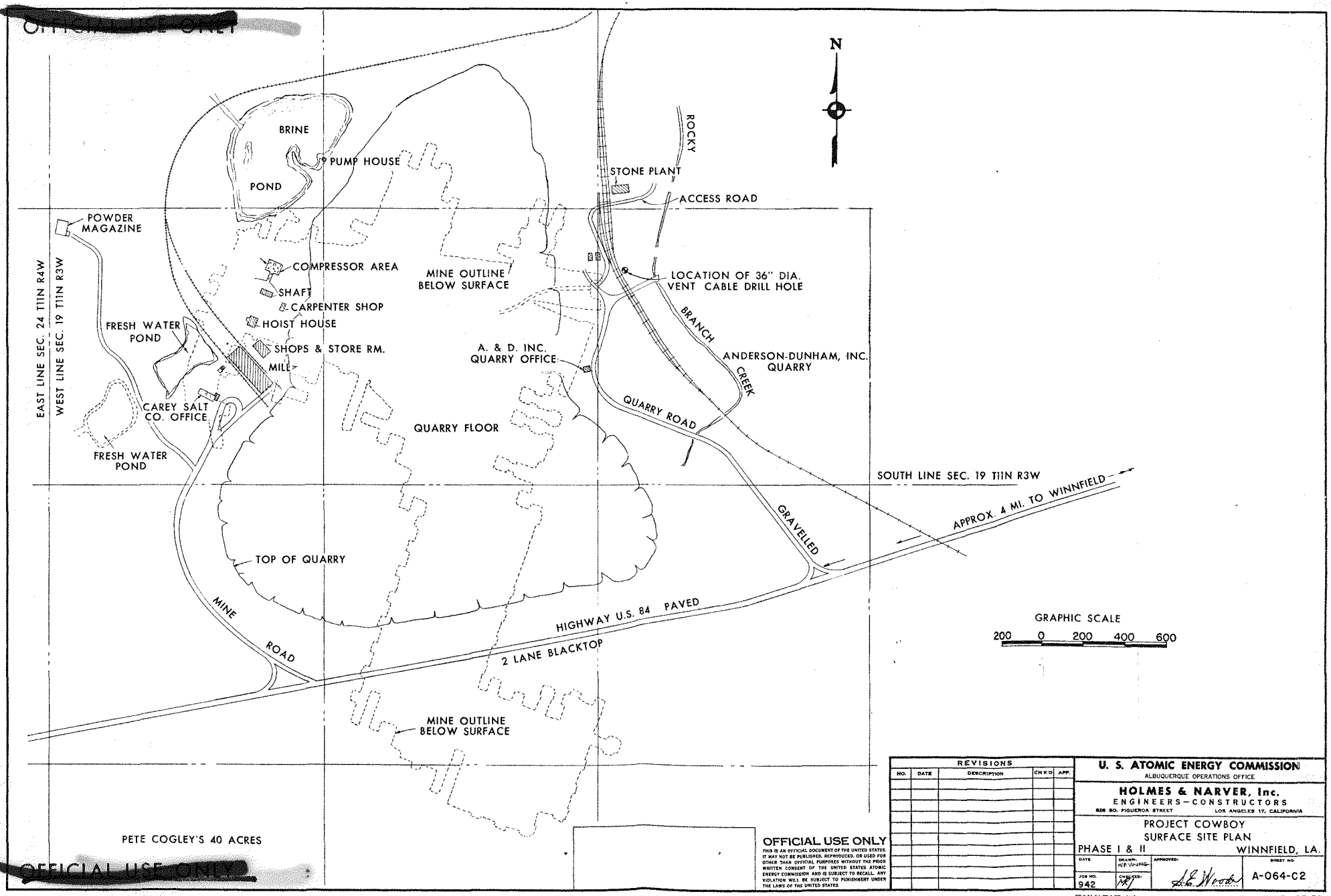
PROJECT COWBOY
LOCATION PLAN
PHASE I & II WINNFIELD, LA.

DATE	DRAWN:	APPROVED:	SHEET NO.
JOB NO. 942	PHOTO CHECKED:	S.E. Woods	A-064-C1

EXHIBIT I

[redacted]





REVISIONS				
NO.	DATE	DESCRIPTION	CH'K'D	APP.

U. S. ATOMIC ENERGY COMMISSION
ALBUQUERQUE OPERATIONS OFFICE

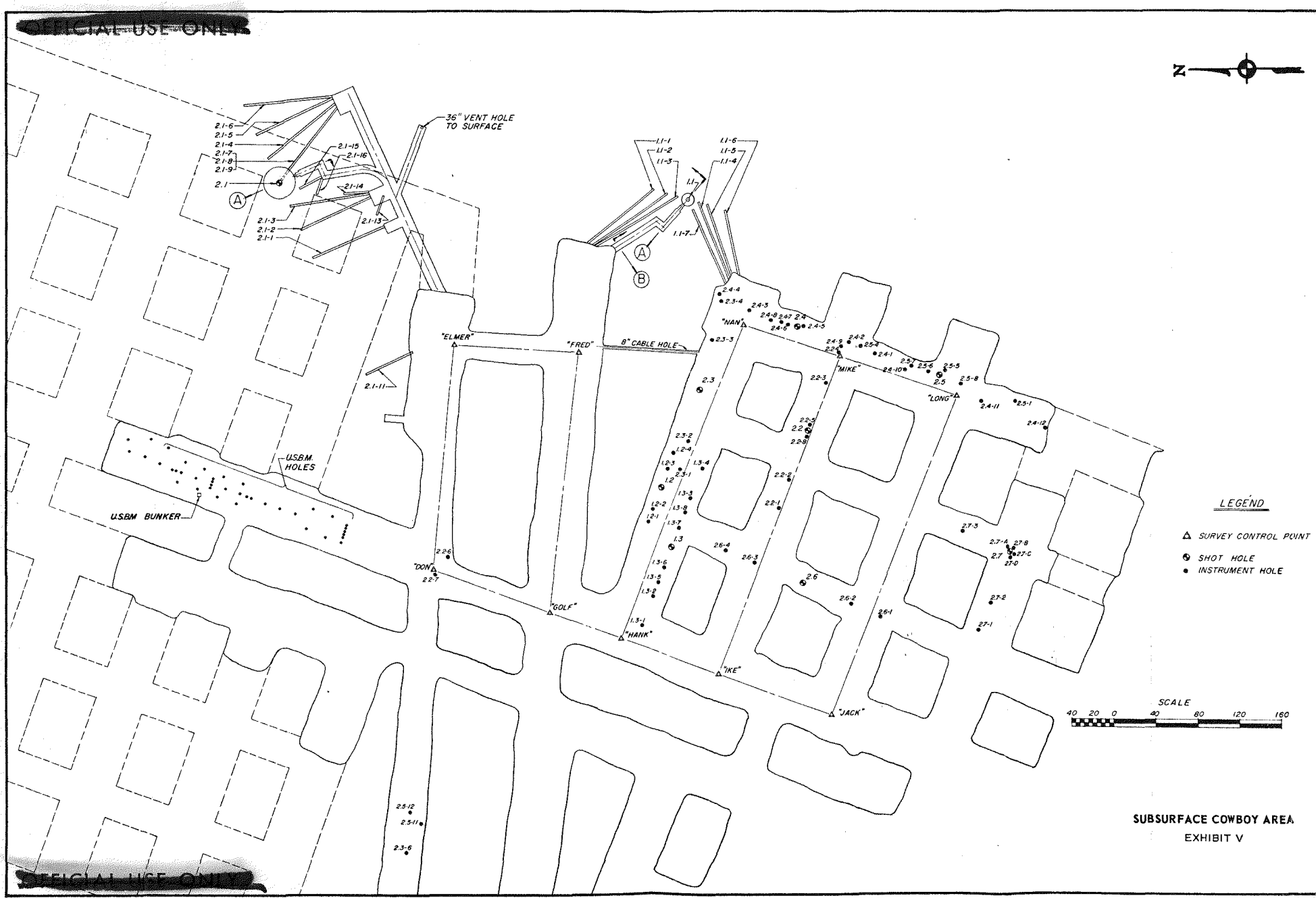
HOLMES & NARVER, Inc.
ENGINEERS—CONSTRUCTORS
828 SO. FIGUEROA STREET LOS ANGELES 17, CALIFORNIA

PROJECT COWBOY
SURFACE SITE PLAN
PHASE I & II WINNFIELD, LA.

DATE | DRAWN: W.P. YOUNG | APPROVED: L.E. Woods | SHEET NO. A-064-C2
JOB NO. 942 | CHECKED: WP

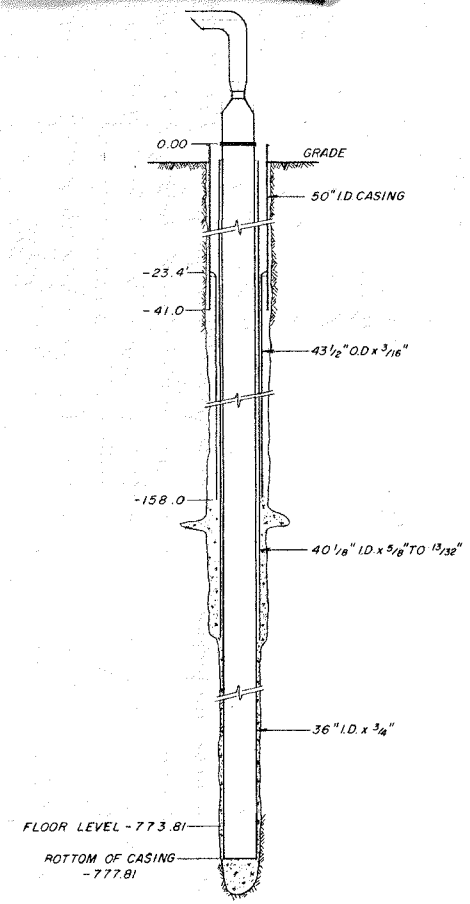
SUBSURFACE SITE PLAN

EXHIBIT IV

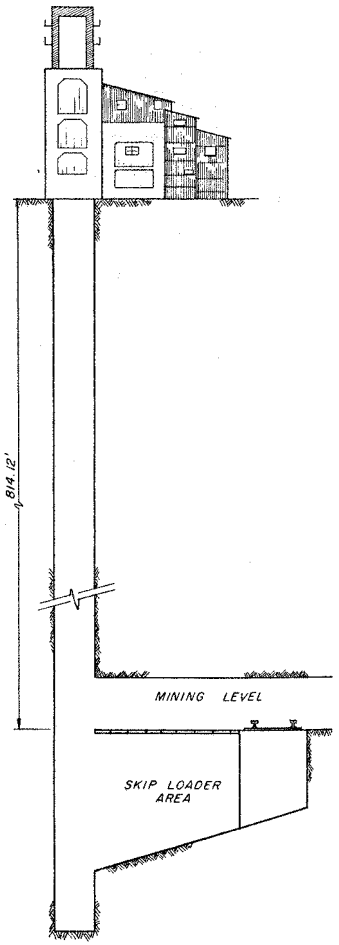


SUBSURFACE COWBOY AREA

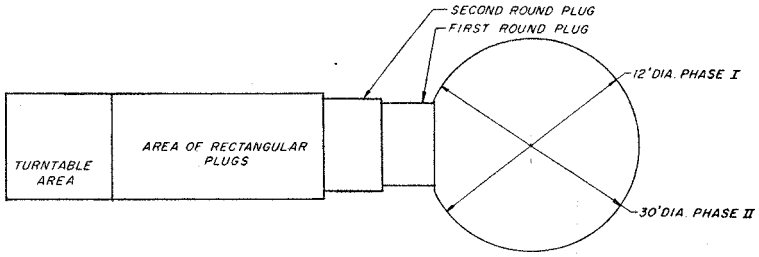
EXHIBIT V



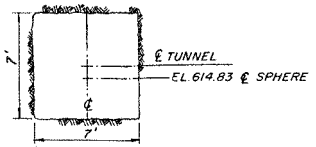
VENT HOLE
NO SCALE



MAIN SHAFT
NO SCALE

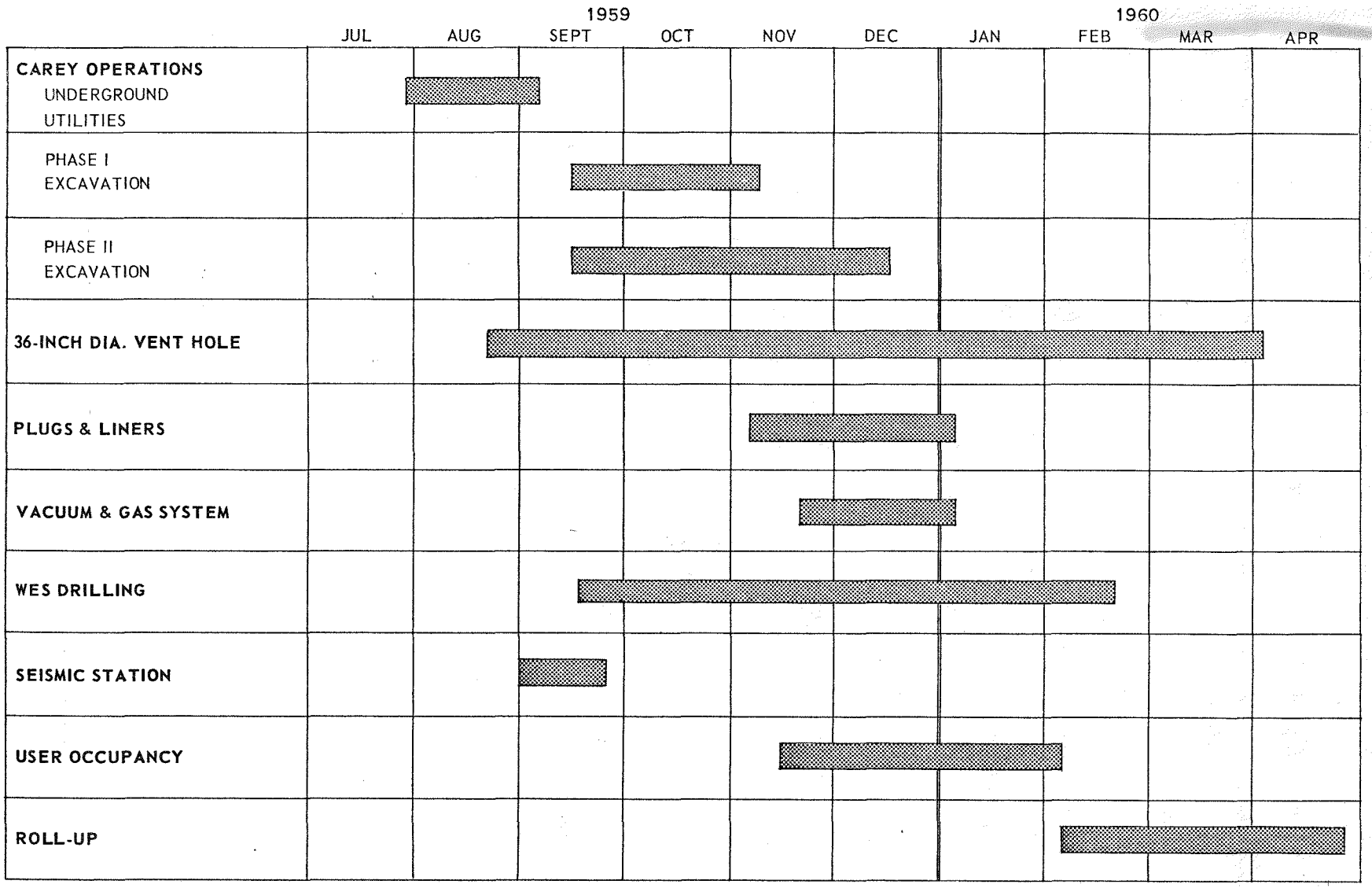


SECTION (A)
NO SCALE



SECTION (B)
NO SCALE

SECTIONS AND DETAILS
EXHIBIT VI



PROJECT COWBOY CONSTRUCTION SCHEDULE

EXHIBIT VII

WORK AUTHORIZATION SUMMARY

NO.	DESCRIPTION	ESTIMATED COST	BEGINNING DATE	SCHEDULED COMPLETION DATE	ACTUAL COMPLETION DATE
1	Receiving – receive construction materials, transport to mine level work site	$14,945.00	7/31/59	continuous	
2	Equipment – disassemble at surface – reassemble at mine work site	1,914.00	7/31/59	ASAP	8/27/59
3	Compressed Air System – construct according to Drawing A-067-M1	2,023.00	7/31/59	ASAP	9/5/59
4	2.4 KV Electrical Distribution System – construct according to Dwgs. A-080-E1 thru E9	19,027.00	7/31/59	ASAP	9/8/59
5	Vent Shaft Materials – deliver salt to vent shaft for WES grouting operation	1,749.00	8/14/59	9/4/59	11/28/59
6	Vent Shaft Labor Support – labor to support WES grouting at vent shaft	1,215.00	7/31/59	9/4/59	9/9/59
7	General Support – miscellaneous work defined by subsequent buck slip	10,500.00	7/31/59	continuous	
8	Mine Shaft Instrumentation – install USC&GS seismometers in mine shaft	326.00	8/3/59	ASAP	8/25/59
9	Mine Ventilation – construct according to Dwgs A-092-M2 and M3	1,839.00	8/3/59	ASAP	9-8/59
10	WES Support – labor support for underground drill crews	94,361.00	9/29/59	continuous	
11	Field Phone Installation – install underground phone system	438.00	8/11/59	8/13/59	8/19/59
12	Experimental Hole – move WES drill and provide power and compressed air for drill rig	420.00	8/13/59	8/14/59	8/18/59
13	Phase II Excavation – construct according to Dwgs. A-090-C1 and S1	45,370.00	8/17/59	10/20/59	12/14/59
14	Phase I Excavation – construct according to Dwgs. A-090-C2 and S1	16,333.00	8/17/59	10/20/59	11/7/59
15	Experimental Adit – test low yield HE excavation and hand tools for excavation	500.00	8/21/59	8/27/59	10/21/59
16	Shaft Safety – provide topside cager – control personnel movement in shaft cage	6,652.00	8/25/59	8/28/59	4/26/60
17	Mine Floor Cleaning – remove salt debris for SRI program	6,610.00	11/2/59	1/5/60	1/9/60
18	Salt crete Material – stock pile salt crete materials at work area	6,531.00	10/2/59	12/16/59	1/9/60
19	Roll-up – prepare government equipment for shipping – restore mine area	15,000.00	11/6/59	11/6/59	4/26/60
20	Dial Telephone – install underground wire and telephone booth	426.00	11/9/59	11/16/59	10/16/59
21	Cage Cable – replace hoist cage cable	1,200.00	11/19/59	11/21/59	10/22/59
22	US Bureau of Mines Program – provide power and labor support for program	615.00	11/24/59	12/5/59	12/5/59
23	Quarry Road Relocation – construct according to Dwg. A-002-C3	1,347.50	12/1/59	1/1/60	deleted
24	75 KVA Substation – rent station complete from Louisiana Power Co.	550.00	12/29/59	1/3/60	1/3/60
25	Photographic Support – to United Kingdom and USC&GS	600.00	1/27/60	4/26/60	4/26/60