FOR OFFICIAL USE ONLY

HISTORICAL REPORT

DET #3 SITE ACTIVATION TASK FORCE

BEALE AF BASE, CALIFORNIA

PERIOD

1 January 1961 through 31 December 1961

FOR OFFICIAL USE ONLY

XVIII-20-4

BEALE AREA

ARMY ENGINEERS

BALLISTIC MISSILE CONSTRUCTION OFFICE

HISTORICAL SUMMARY

October 1959 - March 1962

CORPS OF ENGINEERS
BALLISTIC MISSILE
CONSTRUCTION OFFICE
CEBMCO

BEALE AIR FORCE BASE
BEALE, CALIFORNIA

FOR OFFICIAL USE ONLY

HISTORY

OF

CORPS OF ENGINEERS

ACTIVITIES

AT

BEALE AIR FORCE BASE

OCTOBER 1959 --- MARCH 1962

Respectfully Submitted By:

Joseph H. Sherrard
JOSEPH H. SHERRARD
Lt. Col, CE, Area Engineer

Beale Area, United States Army
Corps of Engineers Ballistic Missile Construction Office

UNITED STATES ARMY
CORPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE
LOS ANGELES 45, CALIFORNIA

WS-107 A-2 TECHNICAL FACILITIES
BASE T-5
COMPLEX 1A, 1B and 1C
BEALE AIR FORCE BASE
CALIFORNIA

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INTRODUCTION

This history is a factual summary of contract and construction activities encountered by the Corps of Engineers during the construction of the three complex, Titan I Squadron at Beale Air Force Base, California.

It provides a concise history of construction progress, a detailed review of contract administration actions and will furnish a background of experience for consideration in solving similar problems and development of techniques for future ICBM construction.

This history includes, but is not limited to, the following areas of interest - scope of work, personnel and organization at Area Office and SATAF, delays, construction procedures and problems, unusual and unforeseen events, accident prevention, total costs, relations with SATAF, conclusions and recommendations.

Also included are 89 photographs and 12 charts.

There were four main agencies involved in the construction and installation of this missile program; two military and two civilian. Each had a definite and unique function:

1. U. S. Army Corps of Engineers Ballistic Missile Construction Office (CEBMCO) directly supervised the construction of the launch facilities through the Prime Contractor (Peter Kiewit Sons Co.), and several support facilities by other contractors.

2. USAF Site Activation Task Force (SATAF) Ballistic Missile Division "Purchasing or Using" Agency, was responsible for the following:

a. Approval of changes in plans and specifications of technical facilities.

b. Waivers to specifications.

c. Approval for substitution of materials.

3. Peter Kiewit Sons Co., the Prime Contractor, physically constructed that portion of the launch structures and facilities described in the construction section of this history, excluding the installation of the missile and numerous other installation items.

4. The Martin Co. designed the Titan I ICBM, was designated as integrating contractor for installing the missiles and other items, and installed the missiles after completion of the construction phase.

This history covers paragraph 1 above completely, and paragraphs 2 and 3 only to the extent necessary for a complete report. A discussion of paragraph 4 is not considered pertinent to this summary.

PART I

ADMINISTRATION

U. S. ARMY

1. CORPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE (CEBMCO)

ESTABLISHMENT AND FUNCTION

The new Corps of Engineers Ballistic Missile Construction Office was opened in Los Angeles, California on 1 August 1960. The office was established to streamline, strengthen and expedite ICBM site construction. ICBM construction consisted of Atlas, Titan and Minuteman squadron sites at various bases, as well as certain testing facilities at Vandenburg AFB, California and Cape Canaveral, Florida.

The Commanding Officer of the Corps of Engineers Ballistic Missile Construction Office (CEBMCO) was Colonel T. J. Hayes, and the Directorate of Titan I was Col. Whitesell who also was the Contracting Officer for the contracts administered by the Beale Area Office.

CEBMCO, through the various "Construction Directorates", controlled the overall missile site construction program and furnished the Area Offices guidance, ie: Construction, Electrical, Mechanical, Engineering, P.L.S., Administration, etc. Numerous visits were made by CEBMCO representatives to the Areas, thus assuring CEBMCO of continual "up-to-date" information on what was occurring in the field.

The organization chart (Figure 1) shows the five directorates

under CEBMCO, with a further breakdown of the Titan I Directorate, showing its five areas.

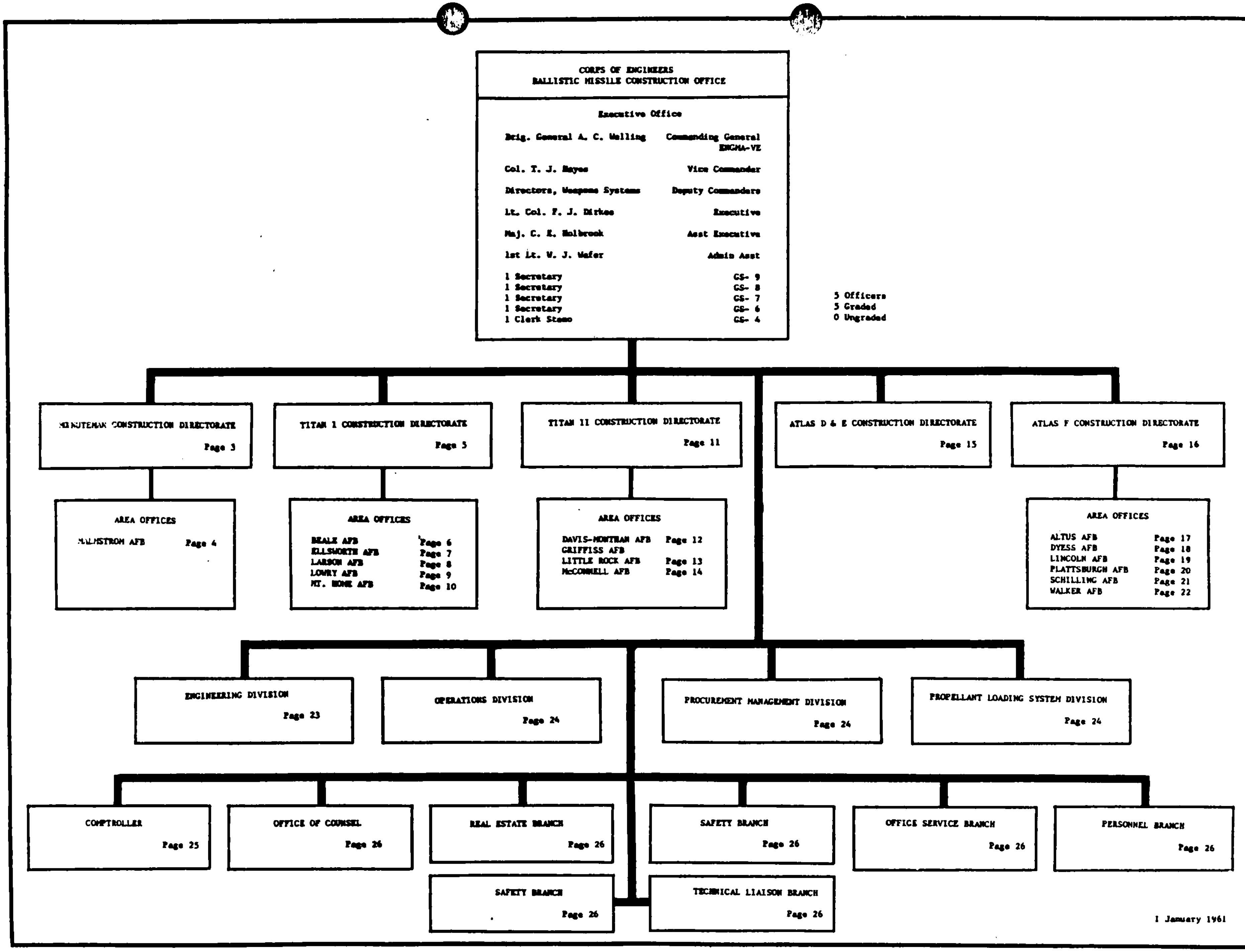

CORPS OF ENGINEERS
BALLISTIC MISSILE CONSTRUCTION OFFICE
Executive Office
Brig. General A. C. Welling — Commanding General ENGMA-VE
Col. T. J. Hayes — Vice Commander
Directors, Weapons Systems — Deputy Commanders
Lt. Col. F. J. Dirkes — Executive
Maj. C. E. Holbrook — Asst Executive
1st Lt. W. J. Wafer — Admin Asst
1 Secretary GS- 9
1 Secretary GS- 8
1 Secretary GS- 7
1 Secretary GS- 6
1 Clerk Steno GS- 4
5 Officers
5 Graded
0 Ungraded
MINUTEMAN CONSTRUCTION DIRECTORATE Page 3
AREA OFFICES
MALMSTROM AFB Page 4
TITAN I CONSTRUCTION DIRECTORATE Page 5
AREA OFFICES
BEALE AFB Page 6
ELLSWORTH AFB Page 7
LARSON AFB Page 8
LOWRY AFB Page 9
MT. HOME AFB Page 10
TITAN II CONSTRUCTION DIRECTORATE Page 11
AREA OFFICES
DAVIS-MONTHAN AFB Page 12
GRIFFISS AFB
LITTLE ROCK AFB Page 13
McCONNELL AFB Page 14
ATLAS D & E CONSTRUCTION DIRECTORATE Page 15
ATLAS F CONSTRUCTION DIRECTORATE Page 16
AREA OFFICES
ALTUS AFB Page 17
DYESS AFB Page 18
LINCOLN AFB Page 19
PLATTSBURGH AFB Page 20
SCHILLING AFB Page 21
WALKER AFB Page 22
ENGINEERING DIVISION Page 23
OPERATIONS DIVISION Page 24
PROCUREMENT MANAGEMENT DIVISION Page 24
PROPELLANT LOADING SYSTEM DIVISION Page 24
COMPTROLLER Page 25
OFFICE OF COUNSEL Page 26
REAL ESTATE BRANCH Page 26
SAFETY BRANCH Page 26
OFFICE SERVICE BRANCH Page 26
PERSONNEL BRANCH Page 26
SAFETY BRANCH Page 26
TECHNICAL LIAISON BRANCH Page 26
1 January 1961

Fig. 1

2. BEALE AREA ORGANIZATION

ESTABLISHMENT OF AREA OFFICE

The Valley Area Office (Mil.) was established as a field unit of the Sacramento District by District Order No. 59-51, dated 30 September 1959. This Area Office was subsequently given the responsibility for supervising construction of ICBM facilities and Titan I Missile Launch Complexes in the vicinity of Beale Air Force Base. District Order No. 59-52, dated 1 October 1959, assigned Mr. Olaf Lein as Area Engineer of the Valley Area Office. District Order No. 58, dated 30 September 1960, effective 3 October 1960, assigned Lt. Col. Joseph H. Sherrard as Area Engineer and Mr. Olaf Lein as Deputy Area Engineer and changed the name of the Area Office to Beale Area Office.

On 1 November 1960, by Memorandum of Understanding by CEBMCO and Sacramento District dated 28 October 1960, the Beale Area Office was placed under the control of CEBMCO and was removed from the control of the Sacramento District.

MISSION

The mission of the Beale Area Office was to perform the contract administration and construction supervision functions delegated by the Titan I Directorate of the Corps of Engineers Ballistic Missile Construction Office, to the Beale Area Office. The contracts to which this mission applied were those under the WS-107 A-2 Technical Facilities, Complex 1A, 1B and 1C,Base T-5 for Beale Air Force Base,California Project and the related support facilities. Administrative and logistical support was

provided the Area by CEBMCO and the Sacramento District to the extent indicated in the "Memorandum of Understanding".

INDOCTRINATION & TRAINING

Rocketry Familiarization Training

In October 1959 when the Sacramento District was alerted to its impending participation in the missile program, arrangements were made for Rocketry orientation of key personnel of the District. Ten training sessions (a total of 15 hours) were presented by specialists from Aerojet General Corporation and Douglas Aircraft. Forty nine persons were selected and attended this training. Selection was based on a need-to-know basis and the general belief that every key employee involved in the missile program would do a better job if he knew something about the history and make-up of rockets and rocket facilities. The orientation consisted of the following:

Date	Session	Title
Oct. 19	1	History of Rockets
Oct. 20	2	Solid Rocket Motors
Oct. 21	3	Liquid Rocket Engines
Oct. 22	4	Metals and Plastics
Oct. 23	5	High Energy Fuels
Oct. 26	6	Guidance Systems
Oct. 27	7	Missile Launching and Facilities
Oct. 28	8	Ground Support Equipment
Oct. 29	9	Trajectory and Orbital Problems
Oct. 30	10	Rocketry Tomorrow

Training

Personnel from the Sacramento District and the Beale Area Office attended the following training sessions in preparation for this project:

Date	Location	Title	No. Hours	Personnel Attended
13 Oct. 59	Inglewood	Ballistic Missile Orientation	16	1
18 Nov. 59	Denver	Shock Requirements	16	3
7 Dec. 59	Vandenburg	Propellant Loading System	40	2
18 Jan. 60	Omaha	Propellant Loading System	15	4
26 Jan. 60	Vandenburg	Propellant Loading System	24	2
29 Feb. 60	Vandenburg	Propellant Loading System	40	2
7 July 60	Vandenburg	Titan Operation	16	3
24 Nov. 60 to 12 Dec. 60	Denver	Propellant Loading System	40	22
9 Dec. 60	Vandenburg	Propellant Loading System	40	5

In addition to the above, training at the Area Office level was provided as follows:

6 hours of PLS training at the Area Office in Sept. 1960 for Area staff personnel.

6 hours of PLS training at each complex for Government inspection personnel.

Military Training

All military personnel assigned to the Beale Area Office completed "on the job" training as part of their assigned duties. The training objective was to thoroughly study the contract drawings and specifications, the techniques of preparing government estimates and the conducting of negotiations with the contractor.

"On the job" training for Resident Office personnel was provided to acquaint them with TEMPCO type reporting procedures and use.

Meetings were held weekly in the Area Office during the months of January, February and March 1961 with mechanical personnel at the Area Office and the three complexes, to present problems anticipated and to review the contract requirements.

The Resident Engineers conducted "on the job" training of inspection personnel as the work progressed.

AREA ORGANIZATION AND FUNCTIONS

The Sacramento District Valley Area Office was initially responsible for supervision and construction of the ICBM facilities at Beale Air Force Base. Organization Chart, Fig.2, shows the organization under Mr. Olaf Lein, the Area Engineer, from 1 October 1959 to 3 October 1960. Lt. Col. Joseph H. Sherrard was designated Area Engineer, with Mr. Lein as Deputy, effective 3 October 1960.

On 1 November 1960 the Valley Area Office was transferred to CEBMCO and the name of the office was changed to Beale Area. Immediately after take-over by CEBMCO, the organization was

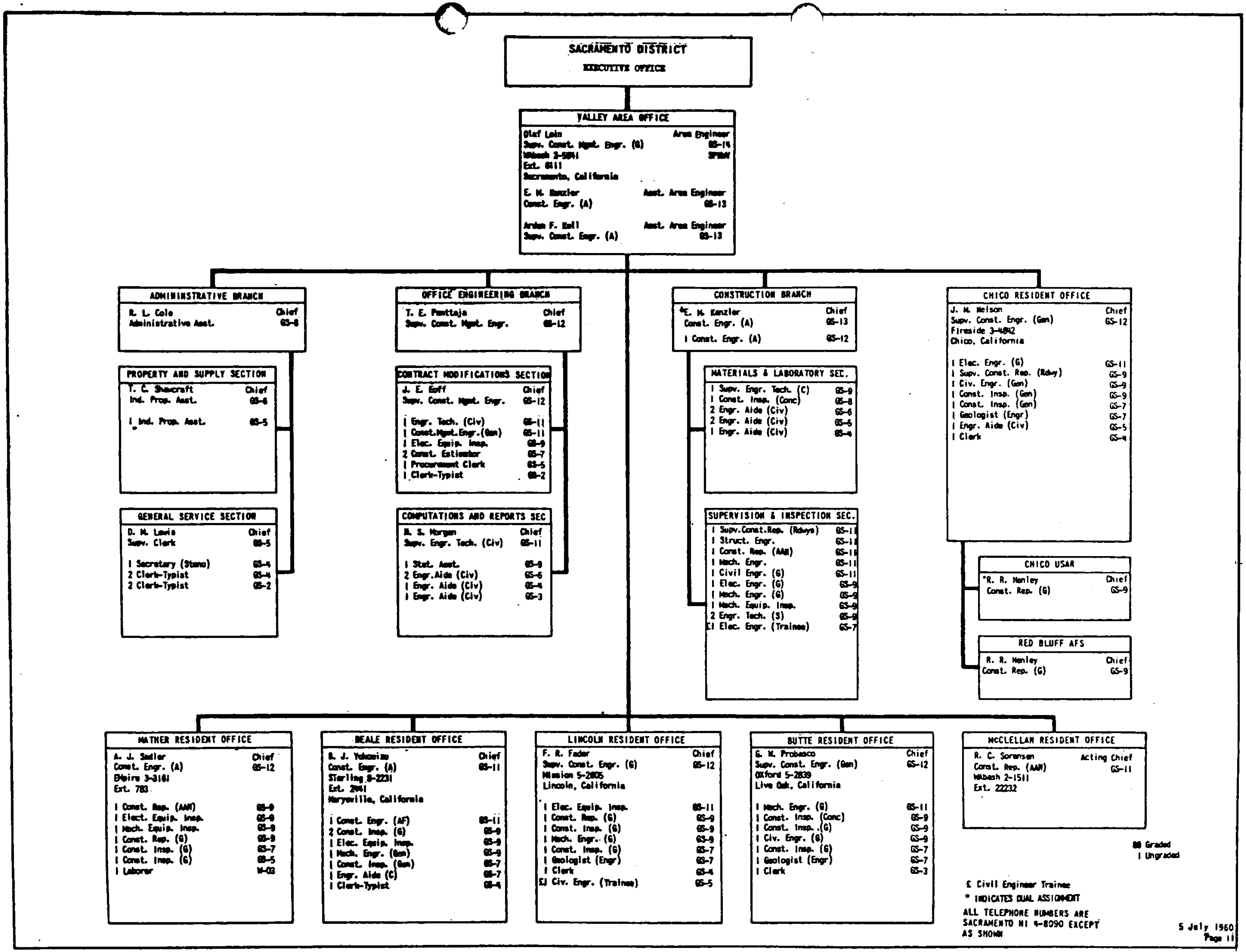

SACRAMENTO DISTRICT
EXECUTIVE OFFICE
VALLEY AREA OFFICE
Olaf Lein Area Engineer
Supv. Const. Mgmt. Engr. (G) GS-14
WAbash 2-5841 SPKKV
Ext. 6411
Sacramento, California
E. M. Kenzler Asst. Area Engineer
Const. Engr. (A) GS-13
Arden F. Kell Asst. Area Engineer
Supv. Const. Engr. (A) GS-13
ADMINISTRATIVE BRANCH
R. L. Cole Chief
Administrative Asst. GS-8
PROPERTY AND SUPPLY SECTION
T. C. Shawcraft Chief
Ind. Prop. Asst. GS-6
1 Ind. Prop. Asst. GS-5
GENERAL SERVICE SECTION
D. M. Lewis Chief
Supv. Clerk GS-5
1 Secretary (Steno) GS-4
2 Clerk-Typist GS-4
2 Clerk-Typist GS-2
OFFICE ENGINEERING BRANCH
T. E. Penttaja Chief
Supv. Const. Mgmt. Engr. GS-12
CONTRACT MODIFICATIONS SECTION
J. E. Eoff Chief
Supv. Const. Mgmt. Engr. GS-12
1 Engr. Tech. (Civ) GS-11
1 Const.Mgmt.Engr.(Gen) GS-11
1 Elec. Equip. Insp. GS-9
2 Const. Estimator GS-7
1 Procurement Clerk GS-5
1 Clerk-Typist GS-2
COMPUTATIONS AND REPORTS SEC
M. S. Morgan Chief
Supv. Engr. Tech. (Civ) GS-11
1 Stat. Asst. GS-9
2 Engr. Aide (Civ) GS-6
1 Engr. Aide (Civ) GS-4
1 Engr. Aide (Civ) GS-3
CONSTRUCTION BRANCH
*E. M. Kenzler Chief
Const. Engr. (A) GS-13
1 Const. Engr. (A) GS-12
MATERIALS & LABORATORY SEC.
1 Supv. Engr. Tech. (C) GS-9
1 Const. Insp. (Conc) GS-8
2 Engr. Aide (Civ) GS-6
2 Engr. Aide (Civ) GS-5
1 Engr. Aide (Civ) GS-4
SUPERVISION & INSPECTION SEC.
1 Supv.Const.Rep. (Rdwys) GS-11
1 Struct. Engr. GS-11
1 Const. Rep. (AAM) GS-11
1 Mech. Engr. GS-11
1 Civil Engr. (G) GS-11
1 Elec. Engr. (G) GS-9
1 Mech. Engr. (G) GS-9
1 Mech. Equip. Insp. GS-9
2 Engr. Tech. (S) GS-9
£1 Elec. Engr. (Trainee) GS-7
CHICO RESIDENT OFFICE
J. M. Nelson Chief
Supv. Const. Engr. (Gen) GS-12
Fireside 3-4842
Chico, California
1 Elec. Engr. (G) GS-11
1 Supv. Const. Rep. (Rdwy) GS-9
1 Civ. Engr. (Gen) GS-9
1 Const. Insp. (Gen) GS-9
1 Const. Insp. (Gen) GS-7
1 Geologist (Engr) GS-7
1 Engr. Aide (Civ) GS-5
1 Clerk GS-4
CHICO USAR
*R. R. Henley Chief
Const. Rep. (G) GS-9
RED BLUFF AFS
R. R. Henley Chief
Const. Rep. (G) GS-9
MATHER RESIDENT OFFICE
A. J. Sadler Chief
Const. Engr. (A) GS-12
EMpire 3-3161
Ext. 783
1 Const. Rep. (AAM) GS-9
1 Elect. Equip. Insp. GS-9
1 Mech. Equip. Insp. GS-9
1 Const. Rep. (G) GS-9
1 Const. Insp. (G) GS-7
1 Const. Insp. (G) GS-5
1 Laborer W-03
BEALE RESIDENT OFFICE
R. J. Yokomizo Chief
Const. Engr. (A) GS-11
STerling 8-2231
Ext. 2441
Marysville, California
1 Const. Engr. (AF) GS-11
2 Const. Insp. (G) GS-9
1 Elec. Equip. Insp. GS-9
1 Mech. Engr. (Gen) GS-9
1 Const. Insp. (Gen) GS-7
1 Engr. Aide (C) GS-7
1 Clerk-Typist GS-4
LINCOLN RESIDENT OFFICE
F. R. Fader Chief
Supv. Const. Engr. (G) GS-12
Mission 5-2805
Lincoln, California
1 Elec. Equip. Insp. GS-11
1 Const. Rep. (G) GS-9
1 Const. Insp. (G) GS-9
1 Mech. Engr. (G) GS-9
1 Const. Insp. (G) GS-7
1 Geologist (Engr) GS-7
1 Clerk GS-4
£1 Civ. Engr. (Trainee) GS-5
BUTTE RESIDENT OFFICE
G. W. Probasco Chief
Supv. Const. Engr. (Gen) GS-12
OXford 5-2839
Live Oak, California
1 Mech. Engr. (G) GS-11
1 Const. Insp. (Conc) GS-9
1 Const. Insp. (G) GS-9
1 Civ. Engr. (G) GS-9
1 Const. Insp. (G) GS-7
1 Geologist (Engr) GS-7
1 Clerk GS-3
McCLELLAN RESIDENT OFFICE
R. C. Sorensen Acting Chief
Const. Rep. (AAR) GS-11
WAbash 2-1511
Ext. 22232
88 Graded
1 Ungraded
£ Civil Engineer Trainee
* INDICATES DUAL ASSIGNMENT
ALL TELEPHONE NUMBERS ARE SACRAMENTO HI 4-8090 EXCEPT AS SHOWN
5 July 1960
Page 11

Fig. 2

expanded to seven branches: Administrative, Construction, Engineering, Contract Administration, Propellant Loading System, Safety, and Office of Counsel, as shown on Organization Chart, Fig. 3.

Resident Offices were established at each of the complexes, and one at Beale Air Force Base to supervise the construction of the support facilities. The Propellant Loading System (PLS) was a separate branch for approximately one year before becoming a section under the Construction Branch. The Organization Chart for SATAF, Fig. 4, is included for reference.

The functions of the branches at the Beale Area Office were as follows:

AREA ENGINEER

The Area Engineer, who was the Contracting Officer's representative for contracts administered by the Beale Area Office, enforced the contract provisions and directed and coordinated the Area Branch activities.

DEPUTY AREA ENGINEER

Assisted the Area Engineer, and acted as the Area Engineer during his absence.

Provided direction to the technical, advisory and administrative staff in all matters of a technical nature.

EXECUTIVE OFFICER

Assisted the Area Engineer and the Deputy Area Engineer in a staff capacity in delegated matters not requiring the immediate or personal attention of those officials, normally assumed duties

which included coordination, review or approval of matters where guidelines of action were clearly defined, served as focal point in all matters relating to the Administrative and Advisory Staff, coordinated matters of organization, personnel staffing and space allocation, served as the principal Administrative Assistant to the Area Engineer, coordinated in those matters relating to overall administration where executive action was required, supervised the preparation of transfer documents, and participated in the formal transfer of completed construction to the Using Agency. Supervised military personnel administration as directed and performed additional duties as specifically assigned.

ADMINISTRATION BRANCH

Provided administrative assistance to all branches of the Area Office. Distributed and dispatched incoming and outgoing mail. Maintained area correspondence files and directed the records retirement program. Furnished instructions to clerical personnel and provided stenographic and typist assistance to other branches of the area. Maintained control of all required periodic reports not assigned to other branches. Provided office service including: supply, communication, reproduction and transportation. Directed civilian personnel actions and maintained records including: time and attendance, leave and travel orders.

U. S. ARMY, CORPS OF ENGINEERS
BALLISTIC MISSILE CONSTRUCTION OFFICE
TITAN I CONSTRUCTION DIRECTORATE

BEALE AREA OFFICE

Lt. Col. J. E. Sherrard	Area Engr
O. Lein	Asst Area Engr GS-15
Maj. C. C. Baldwin	Exec Officer
Maj. V. S. Adkins	Liaison Officer
1 Secretary	GS-5
1 Clerk-Steno	GS-5

COUNSEL & LRO BRANCH

1 Advisor Counsel	GS-12
*1 Labor Relations	GS-12

SAFETY BRANCH

1 Safety Engr	GS-12

ADMINISTRATION BRANCH

Vacancy	Chief GS-11

PROPERTY & SUPPLY SECTION

1 Admin Asst	GS-9
2 Ind Prop Asst	GS-6

GENERAL SERVICE SECTION

1 Supr Clerk	GS-8
1 Supr Clerk	GS-5
2 Secretary (Steno)	GS-4
3 Clerk-Typist	GS-4
7 Clerk-Typist	GS-3
1 Teletypist	GS-4
1 Chauffeur	WB-4

CONSTRUCTION BRANCH

E. M. Kenzler	Chief
Supr Constr Mgmt Engr	GS-14
1 Civil Engr	GS-13

ENGINEER CONTROL SECTION

*1 Constr Mgmt	GS-12
2 Mech Engr	GS-11
2 Elect Engr	GS-11
1 CME	GS-11
1 Supr Engr Tech (C)	GS-11
*1 Engr Tech (C)	GS-11
1 Civil Engr	GS-11

LABORATORY SECTION

*1 Engr Tech	GS-11
1 Supr Engr Tech(C)	GS-9
1 Engr Aid (G)	GS-7
3 Engr Aid (G)	GS-5

SURVEY SECTION

2 Surv Tech	GS-9

CONTRACT ADMINISTRATION BRANCH

T. E. Panttaja	Chief
Supr Const Mgmt Engr (G)	GS-13
1 Asst Supr CME	GS-12

CONTRACT MODIFICATION SEC

1 Supr CME	GS-12
1 Supr Engr Tech (C)	GS-11
3 CME (G)	GS-11
1 Engr Tech (Mech)	GS-11
1 Constr Est (Elect)	GS-9
2 Constr Est	GS-9
1 Proc Clerk	GS-6

PROGRESS & REPORTS SECTION

1 Supr Prog & Rpts Off	GS-12
1 CME	GS-9
1 Stat Asst	GS-11
1 Constr Est	GS-7
1 Engr Draftsman	GS-7

COST & PAY EST SECTION

1 Supr Engr Tech (C)	GS-11
1 Engr Aid (C)	GS-7
1 Cost Clerk	GS-7

ENGINEERING BRANCH

R. R. Owens	Chief
Constr Mgmt Engr	GS-13

OFFICE ENGR SECTION

1 Struct Engr	GS-11
1 Constr Mgmt Engr	GS-9
1 Engr Aid (C)	GS-7
2 Engr Draftsman	GS-5

TECH REVIEW SECTION

1 Civil Engr Gen	GS-12
2 Mech Engr	GS-11
3 Struct Engr	GS-11
1 Elect Engr	GS-11
1 Elect Engr	GS-7

PLS BRANCH

Maj. B. R. Huetter	Chief
1 Mech Engr	GS-13
1 Mech Engr	GS-11
1 Mech Engr	GS-9

BEALE INSPECTION OFFICE

1 Mech Engr	GS-12
1 Supr Engr Tech (C)	GS-12
1 Constr Repr (G)	GS-9
3 Mech Equip Control	GS-9
1 Mech Equip Control	GS-7
2 Constr Control	GS-8
2 Constr Control	GS-7
1 Engr Aide	GS-6
1 Constr Insp	GS-6
1 Clerk-Typist	GS-3

COMPLEX A (LINCOLN)

1 Supr Constr Engr (G)	GS-12
1st Lt F. H. MacDonald	Complex Off
1 CME	GS-11
1 Elect Equip Control	GS-11
2 Mech Engr	GS-11
1 Mech Engr	GS-9
3 Constr Control	GS-9
1 Constr Control	GS-7
1 Geologist (Engr)	GS-9
1 Civil Engr	GS-9
1 Clerk-Typist	GS-4

COMPLEX B (BUTTE)

1 Supr Constr Engr (G)	GS-12
1st Lt K. E. Wiersema	Complex Off
2 Mech Engr	GS-11
2 Mech Engr	GS-9
1 Elect Engr	GS-11
1 Civil Engr	GS-11
2 Constr Control	GS-9
2 Constr Control	GS-7
1 Geologist (Engr)	GS-9
1 Clerk	GS-3

COMPLEX C (CHICO)

1 Supr Constr Engr (G)	GS-12
Capt M. R. Cohn	Complex Off
1 Elect Engr	GS-11
2 Mech Engr	GS-11
1 Mech Engr	GS-9
1 Constr Repr (G)	GS-9
1 Civil Engr (G)	GS-11
2 Constr Control	GS-9
1 Constr Control	GS-7
1 Geologist (Engr)	GS-9
1 Clerk	GS-4

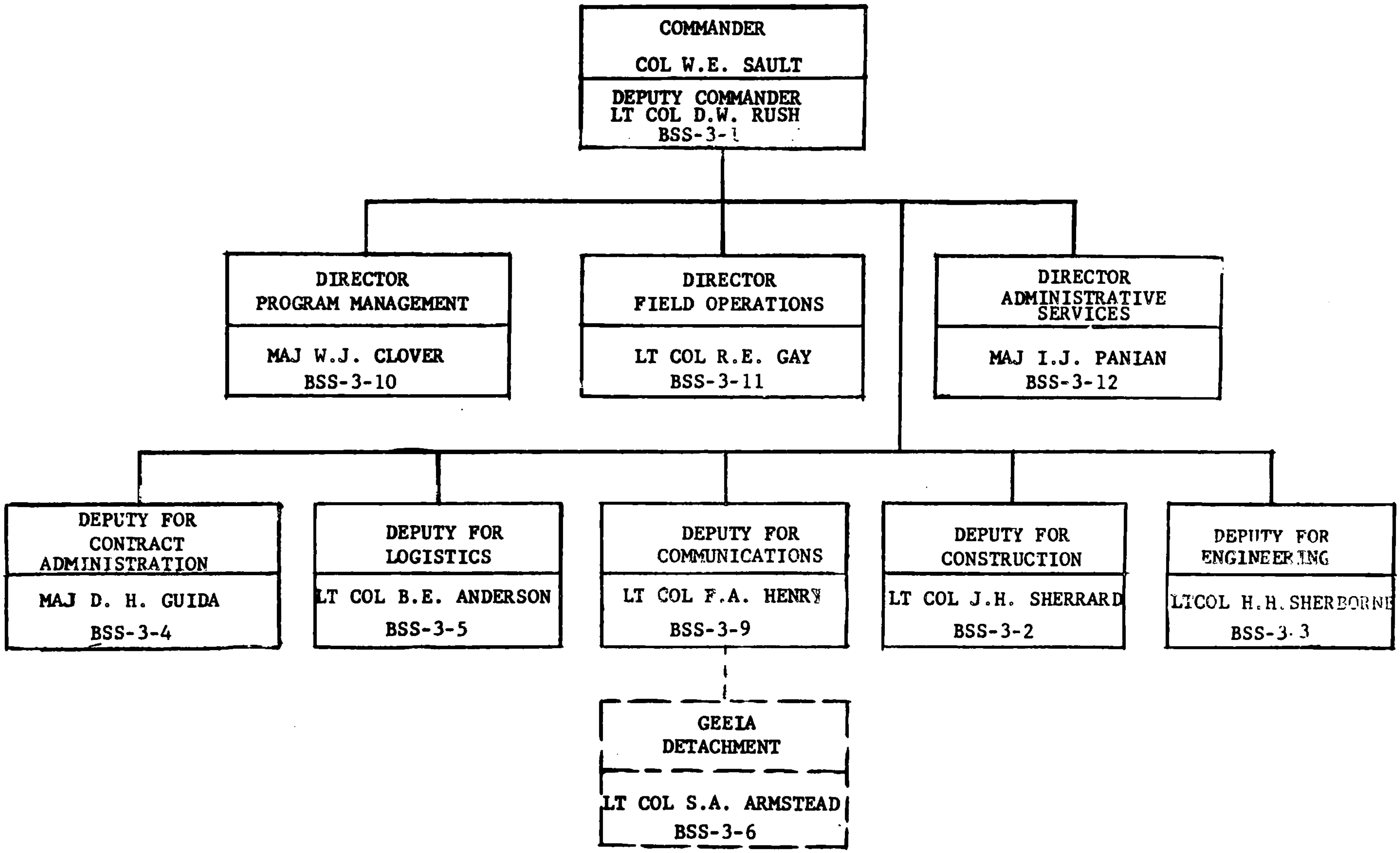
* Dual Assignment

7 Officers
133 Graded
1 Ungraded

1 JANUARY 1961

Fig. 3

SITE ACTIVATION TASK FORCE



DATE: 17 November 61

Fig. 4

Property Section

Property Section was responsible for furnishing and maintaining records of all office furniture and inspection equipment utilized in the area. The contract specifications required the contractors to submit purchase orders for all materials purchased for the project. This was for the purpose of allowing Government follow-up and expediting assistance when necessary. Property Section coordinated the review of the purchase orders and issued inspection requisitions when needed.

This Section checked incoming Government furnished and standardized equipment while enroute to, or at warehouse or railhead. In connection with some Liquid Oxygen tanks, it was necessary for a Government representative to ride the trains to insure that these items were not side tracked or humped enroute. There were in excess of 250 vouchers of incoming Government furnished items that had to be checked in, reviewed for damage and transferred to the contractor. Items received in a damaged condition were photographed and visual damage report prepared. A large portion of the Government furnished property arrived 10 April 1960 through 21 April 1961, total cost of which was in excess of $5,000,000.

Test equipment for testing the PLS systems started arriving 5 April 1961. Most of the test equipment was mounted on semi-trailers with accessories, 17 filters and spare elements. There were 37 of these trailers transferred from the Air Force and

utilized by the contractor during testing of the PLS. At the conclusion of the PLS testing, all equipment was transferred back to the Air Force. Total value of testing equipment was in excess of $1,200,000.

Property Section prepared for signature, and distributed all Eng. Forms 290, including installed property lists for both Government furnished property and contractor furnished equipment. There were 92 Eng. Forms 290 required to transfer the three complexes. Government and contractor installed property lists required several visits to construction sites to obtain complete nomenclature of all items of equipment. Contractors were contacted for the unit prices of all contractor furnished equipment listed with the Eng. Forms 290.

ENGINEERING BRANCH

The Engineering Branch was composed of a Technical Review Section and an Office Engineering Section. The function of the branch was to provide technical support and guidance to the Area Engineer and to the Construction Branch.

Function of Technical Review Section

The Technical Review Section's prime responsibility was to check shop drawings, contractors' construction lift drawings, and mechanical and electrical layouts; contractors were advised of results. Necessary liaison between the Architect-Engineers and various components of the Beale Area Office was a responsibility of this section. This involved presenting design and field problems to the Architect-Engineers for review and after receipt of their

reply, analysis and distribution of this information to those concerned.

Support was given to the Contract Administration Branch by Engineering Branch in the preparation and negotiation with the contractor, of large, complex modifications.

Function of Office Engineering Section

This Section worked closely with the U. S. Air Force SATAF Deputy for Engineering so far as revisions to contract plans and specifications were concerned. The drawings and specifications were revised by Office Engineering Section and prints issued to the contractor and other agencies involved. "Marked-up" prints of "as-built" drawings were prepared and forwarded to the Architect-Engineers for final posting on the tracings. Engineering Branch maintained up-to-date sets of plans and specifications for all concerned and had files of all approved shop drawings, lift drawings and standardized equipment drawings.

When requested by the Area Engineer or Construction Branch, Engineering Branch performed inspections of construction to insure that the design intent had been accomplished.

Shop Drawings

The contractor submitted 980 shop drawing transmittals. Each transmittal contained an average of four sheets, all of which required checking. The items were structural, mechanical and electrical. In addition, there were 200 mechanical layout transmittals with an average of ten sheets each, and 100 electrical layout transmittals of approximately six sheets each.

The checking of these shop drawings was accomplished

either by Corps of Engineer forces or by those of the Architect-Engineer.

Construction Lift Drawings

Three hundred sixty construction lift drawings were submitted by the contractor for approval. This required highly skilled checking to insure that the configuration of structure was correct and that each embedded item was in place. Speed as well as accuracy was required since each drawing had to be checked before the concrete could be poured.

CONTRACT ADMINISTRATION BRANCH

Advised area personnel on contractual matters. Processed progress schedules from contractors, reviewed same with cooperation of Construction Branch, and initiated action for revision or approval. Furnished information, coordinated activities and distribution of "TEMCO" report, and prepared associated progress reports. Furnished Engineering Branch with comments for changes on plans and specifications. Maintained budget control of Government costs, construction contract costs, and prepared revised current cost estimates as required. Monitored proposed change orders within the area office and initiated change order action with the contractors. Prepared Government cost estimate for changes, conducted modification negotiations, and prepared and distributed modification documents. Researched all claims submitted by the contractor and furnished area counsel information and recommendations for preparation of findings of fact for contracting officer's decision.

PROPELLANT LOADING SYSTEM BRANCH

Provided engineering and technical assistance to area personnel on the PLS. Reviewed PLS shop and layout drawings for conformance to the contract plans and specifications. Resolved field conflicts and design inadequacies of the PLS and furnished this information to Engineering and Technical Branch for initiation of change order action. Performed engineering inspections of PLS construction to insure adequate construction standards and the compliance of material and equipment to design criteria. Directed the conduct of final field acceptance testing of the PLS. Provided Contract Administration with information for pay estimates of contract modifications and claims negotiations.

CONSTRUCTION BRANCH

Supervised and conducted continuous inspection of construction activities. Directed the job-level Training Program. Reported to Engineering Branch conflicts and design inadequacies occurring in the plans and specifications. Assisted in the negotiations for change orders and reviewed proposed changes for construction feasibility. Provided Contract Administration Branch with information for pay estimates and progress reports. Maintained a set of contract prints showing as-built conditions. Provided Property Section with data for Eng. Forms 290 and other transfer documents. Established and furnished construction completion and acceptance dates to Contract Administration Branch. Reported work stoppages to area Labor Relations representative.

SAFETY BRANCH

Worked under the general supervision of the Area Engineer. Duties included the administration and operation of the Area Accident Prevention Program. Reviewed contractors' pre-work accident prevention proposals. Advised on technical aspects of contractors construction work methods, detection of hazards, and recommended corrective action. Implemented regulatory controls, Safety Standards and Codes. Developed or reviewed design of safety guards, scaffolds, ventilating systems, etc. Was responsible for fire prevention and protection. Insured adequate and prompt reporting procedures were in effect.

Due to the difficulties in recruiting a competent Safety Engineer, this position was filled only for a few months during the later stages of construction. For the time that this position was not filled, the Assistant Chief of Construction Branch assumed the duties of this branch.

Experience

From January to October 1960 the overall safety program was supervised by the District safety engineer. After that time the District safety engineer continued to serve in an advisory capacity and performed periodic inspections of the job sites. The Area office continued the safety program instituted by the District safety officer. Figure 5 shows the Area safety program.

The Beale Area safety experience from the start of the project through February 1962, as compiled by CEBMCO Safety

Branch is as follows:

Man hours worked	3,895,049
Disabling injuries	26
Fatalities	1
Days lost	6,696
Frequency rate	6.68
Severity rate	1.72

Considering the nature of the work, the contractor had a good safety record. There was one fatality which was the only major injury during the course of the work. The fatality occurred when an end loader operator backed over a steep slope in a stockpile area. The vehicle overturned and crushed the operator. As the operator was alone in the area, the exact cause of the accident could not be determined. It was concluded that the operator lost control of the loader while backing over windrowed embankment material and could not stop in time to avoid going over the bank. The loader flipped over backwards and pinned the operator underneath.

As will be noticed in the area safety program, each resident engineer was directly responsible for effective safety implementation. This policy proved to be very effective.

BEALE AREA OFFICE SAFETY PROGRAM

1. The Valley Area Office Safety Council will be composed of the following:

Area Engineer
Assistant Area Engineers
Resident Engineer, Lincoln T-5
Resident Engineer, Beale Air Force Base
Resident Engineer, Buttes T-5
Resident Engineer, Chico T-5

2. Council Meetings will be held once a month or more often if considered necessary by the Area Engineer. The regular monthly meetings will be held on the first Monday of each month at 9:30A.M.

3. Meeting Procedure

a. Review of accidents or near accidents occurring during preceding month.

b. Written report from each Resident Engineer evaluating each contractor's performance during the past month. At this time Resident Engineers will present the reports prepared by the Resident Safety Inspector as described in paragraph below.

c. General discussion of Safety Program and suggestions for improving program. Resident Engineers should present at this time any suggestions or comments which may have been presented at the monthly resident meeting described in paragraph below.

4. Resident Offices:

a. Every inspector shall be thoroughly indoctrinated in accident prevention. Each inspector shall be made fully aware of his responsibilities in connection with administration of the

Fig. 5

safety program.

b. Each Resident Engineer shall conduct a scheduled safety meeting with all inspectors monthly. Additional meetings shall be held if conditions warrant. Each Resident Engineer shall establish the time for the monthly meetings and shall advise the Area Office of the time established. The following subjects should be covered, but not limited to, at the resident meetings:

(1) Interest and cooperativeness of contractor's management.

(2) Effectiveness of contractor's indoctrination of supervisory personnel.

(3) Effectiveness of indoctrination at workman level. Is each workman safety conscious?

(4) Condition and adequacy of the contractor's safety equipment and materials.

(5) Inclusion of safety in contractor's planning of work operations.

(6) Effectiveness of program in connection with sub-contractor activities.

(7) Discussion of the monthly safety inspector's report as prepared according to paragraph below.

c. Designate for each contract the inspector responsible for meeting with the prime contractor's superintendent and subcontractor's representatives prior to start of the subcontractor's activity and when there is a change of supervisors for either the prime contractor or subcontractors, report compliance

corrective action has not been taken, an explanation will appear in the log. The acting safety inspector will report orally at the monthly Resident Office Safety Meeting on his findings, problems and pending violations. A copy of inspection logs will be presented to the Area Office Safety Council at each monthly meeting of the council by the Resident Engineer.

h. Resident Engineers will evaluate the performance of employees under their supervision, for compliance and application of the Safety Program and shall consider this in determining the annual performance rating of the inspector.

5. Reports of the Safety Council Meetings, and evaluation follow-up by Area Office Staff and Resident Safety Inspectors' logs will be forwarded to the Safety Engineer after each council meeting.

Fig. 5

or (noncompliance in red) in daily log.

d. Engineers and inspectors will include in their daily logs their activities pertinent to the application of the Safety regulations, programs and mutual understandings, noting in red all deficiencies. A follow-up of all deficiencies will also be recorded in the log.

e. All reportable accidents will be thoroughly investigated, and follow-up, to be assured that prescribed reports are properly prepared and submitted promptly. Be prompt in making verbal report of accidents to Area Office. Prepare a supplementary report for all contractors reportable accidents.

f. Check to see that corrective action indicated on accident reports is put into effect on the job. One copy of the accident report will be retained by the Resident Engineer for follow-up purposes.

g. Resident Engineers will assign one member of their staff on a monthly rotation basis as an acting safety inspector to check all operations, equipment and materials. Appointments will in no way relieve other staff members of their safety responsibilities. Development of the procedure and assignment of responsibilities will be accomplished locally. Acting safety inspectors will be required to prepare a log (pencil or ink), listing date of inspections; building, structure, equipment, material or operation inspected; findings; and name of person responsible for corrective action. The date corrective action was taken will be entered in the log opposite the deficiency involved. When

OFFICE OF AREA COUNSEL

Advised the Area Engineer and his staff on administrative actions where legal questions were involved and as to the Government's rights and obligations under construction contracts. Considered claims under construction contracts, made recommendations to the Area Engineer, and drafted findings of fact and decisions for consideration by the Contracting Officer. Advised personnel assigned to contract administration duties on legal problems confronting them during the administration of contracts requiring interpretation of contract clauses and/or technical provisions of contracts. Also provided advice on problems that arose via labor relations.

PERSONNEL

Personnel functions were administered by the Sacramento District during the entire duration of the job. Prior to the establishment of CEBMCO the Area Office was under the Sacramento District, and after CEBMCO's establishment the Sacramento District provided Administrative support to the Area on personnel matters.

The Valley Area Office was established in November 1959 to supervise all military construction assigned the Sacramento District. This construction included the ballistic missile construction work which was new to the District at that time. Since the normal military construction work was decreasing, it was possible for the District to staff for the construction of missile projects through gradual reassignment of current personnel. There was a shortage of mechanical and electrical engineers and inspectors.

These needs had to be met to a large extent through training of surplus personnel possessing the best potential for these specialized jobs, since all missile construction projects were recruiting for similar personnel in nearly all sections of the United States.

At the time of transfer of missile construction to CEBMCO, 1 November 1960, there were 95 employees assigned to the work in the field and a substantial part of the productive time of the Construction Branch was devoted to this work. Coincident with the transfer the name of the area was changed to Beale Area Office. Strength increased to 112 in December and to 122 in February 1961. From February through June, strength remained constant. There was a gradual decrease in personnel after July 1961 and on 20 December 1961 the strength of Beale Area Office was 101.

The Personnel Branch provided complete personnel services to Beale Area Office, including recruitment, in-service placement, training assistance, classification and wage, etc. The Area also was serviced by the Incentive Awards Committee and represented in the Civilian Welfare Council. The phase-out of personnel required much attention of the Personnel Branch after July 1961. The separation of employees was particularly complicated by the fact that approximately 90 employees had administrative reemployment rights with Sacramento District. Most of these employees had field experience and at the same time the District was undergoing reduction in force of personnel with similar backgrounds. Placement was further aggravated by the fact that other missile projects were phasing out, too, resulting in far more

surplus personnel than needed for vacancies throughout the CEBMCO organization.

PART II

CONSTRUCTION HISTORY

3. SCOPE OF WORK

GENERAL

The Beale T-5 Project consists of a 3 x 3 configuration of one squadron of TITAN ICBM Facilities, comprised of three complexes of three missiles each. The three sites are located near the cities of Lincoln (Complex 1A), Live Oak (Complex 1B), and Chico (Complex 1C) in Northern California and are arranged in a pattern around Beale Air Force Base near Marysville, which is the support base for technical, administrative and logistical support. All site investigations, topographic explorations and surveys were performed by the Sacramento District. Design of the launcher facilities was performed by an Architect-Engineer under the guidance of the Air Force Ballistic Missile Division. The Sacramento District accomplished the design of access roads and constructed the water wells at Complexes 1B and 1C. The combined bid documents were reviewed in the District and subsequently advertised and awarded by the District. The low bid received was submitted by the Peter Kiewit Sons' Company, in the amount of $30,157,150.50, of which one-third is attributable to each of the three sites. In addition, approximately $5,000,000 worth of Government furnished equipment was also involved in the construction. Completion of construction was scheduled to allow phase occupancy by the Air Force with the latest increment completed 1 February 1962. Construction was initiated on 22 January 1960.

TITAN MISSILE COMPLEX

The Intercontinental Ballistic Missile (ICBM) facility described herein is one of three such complexes constructed by the Corps of Engineers Beale Area Office for the Air Force. The several sites are located in the vicinity of Lincoln, Sutter Buttes and Chico. Essentially each of these are the same.

Each complex includes three missile silos with attendant propellant and equipment terminals; a control center; a powerhouse; two antenna silos; entry portal; and a system of tunnels, which connect the various elements. The attached diagram and sketch show the relative locations and configurations of the various components which comprise the complex.

The missile silos are approximately 155 feet in depth and have an inside diameter of 40 feet. The concrete walls of the silos have a thickness of from 2 to 3 feet. The top of each silo is covered with two horizontal leaf concrete doors weighing 125 tons each. The interior of the silo is fitted with an elevating mechanism which raises the missile into firing position.

The propellant terminals are cylindrical subsurface structures which contain the liquid fuels of the missile, in high pressure bottles, until the missile is to be readied for firing. This component is approximately 25 feet in diameter, approximately 25 feet in depth and covered by about 18 feet of earth.

The equipment terminals are also cylindrical subsurface structures having a diameter of 40 feet, a depth of 60 feet and covered by 16 feet of earth. This feature provides for housing

air conditioning equipment, work shop space and space for certain types of technical equipment.

Both the power house and the control center are hemispherically shaped subsurface structures. The power house contains four diesel electric generators and accompanying switchgear, thus allowing the entire installation to be independent of outside sources of power. The control center contains that equipment which is required to be the nucleus of operations within the complex.

Radar detection equipment is housed and operated from two antenna silos. These silos are 25 feet in diameter and are 65 feet in depth. Elevating mechanisms raise the radar detectors above the ground surface when this equipment is in use.

All of the structures in the complex are connected by a system of tunnels. In general, the tunnels are approximately 9 feet in diameter and about 30 feet below the surface of the ground.

To protect the structures and the equipment contained within them from the shock of atomic blast, protective construction requirements were designed into the project. Some of these requirements include the provision of "rattle space" for all floor slabs, and the shock mounting of all piping, equipment and fixtures.

MISSILE COMPONENT CONTRACTORS

The following associate contractors worked under the supervision of SATAF to develop the missile component indicated:

Martin Company	- furnishing the air frame including assembly and test of the missile
Bell Telephone Company	- radio guidance system
Remington-Rand-UNIVAC	- computer system
A. C. Spark Plug	- initial guidance system
Aerojet General Corp.	- propulsion system
Avco Corp.	- re-entry vehicle
American Machine and Foundry	- launcher system
A. D. Little	- propellant loading system

UTILITIES

The utilities during construction (as required by the specifications) were provided by the contractor. Commercial power was available at all three complexes.

Water at Complex 1B and Complex 1C was available from the water wells at the sites provided by contracts completed prior to award of the launcher contract. Water at Complex 1A was available from the city of Lincoln main located adjacent to the complex.

ACCESS TO SITES

The three launch sites have all-weather access roads from existing county or state roads. Road construction to the sites was one of the first scheduled items of work and was required to start during winter and inclement weather conditions.

Lincoln Site. The Lincoln site had temporary access over a rancher's cattle road for approximately three months, during which time the permanent access road was constructed. The permanent route, consisting of approximately 2,700 lineal feet

of road, was constructed from State Route No. 91 to the site property line.

Buttes Site. The Buttes site had no temporary means of access and required accelerated construction of the permanent road. This permanent access road, consisting of approximately 7,100 lineal feet, was constructed from an existing paved county road to the site property line.

Chico Site. The Chico site has two means of access by road. To the south of the site, a double bituminous surfaced road was constructed, which connected the site with a county road, Cohasett Road. This access road followed an existing dirt road to the site property line. This access road is still being used because of the shorter distance from the town of Chico.

The permanent access road to the Chico site was constructed and consists of 3,314 lineal feet of road from a county road, Kieffer Lane, to the site property line.

The nearest railroad facilities to the sites are located at Lincoln, Live Oak and Chico.

VICINITY MAP

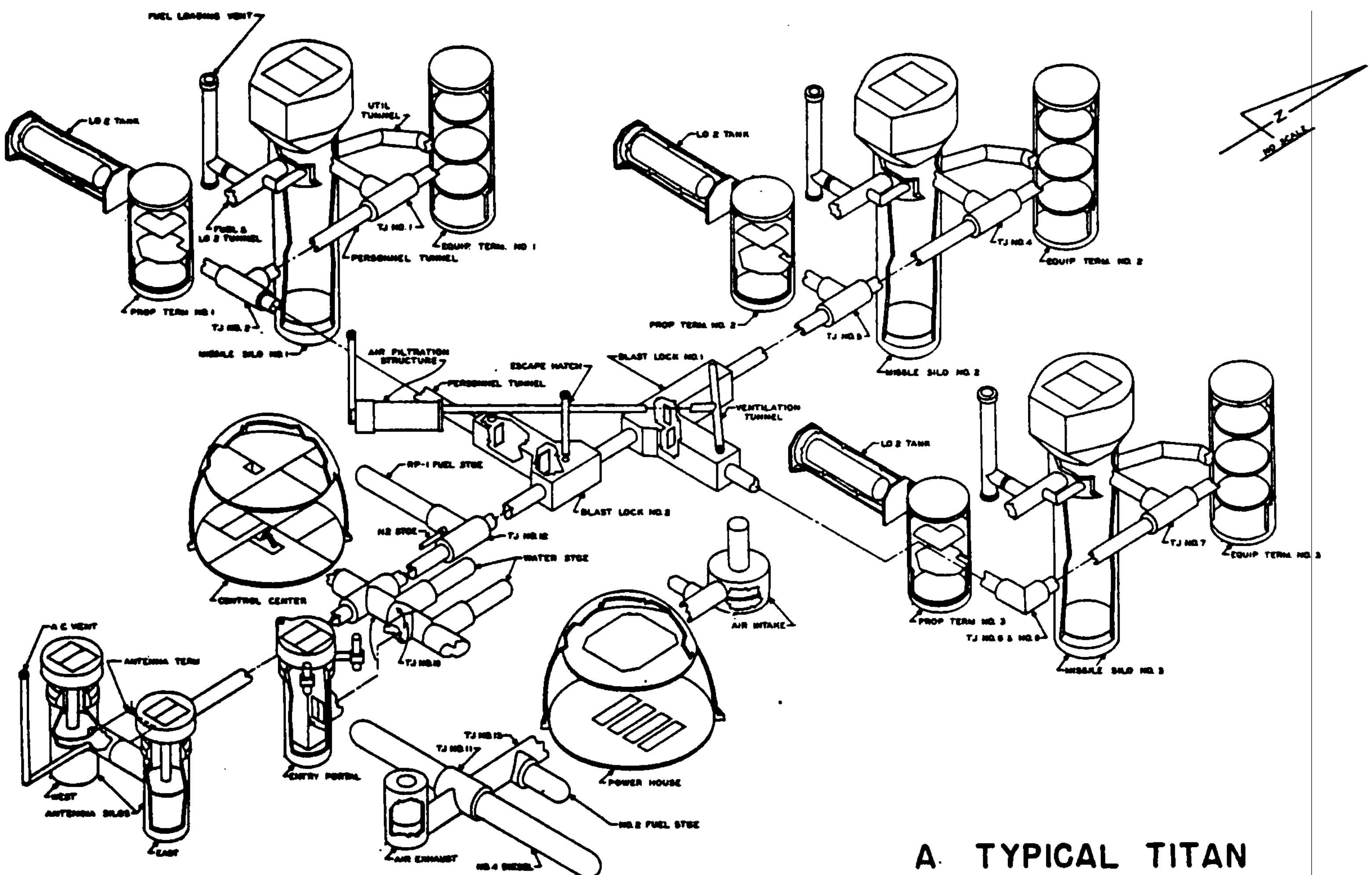
Figure 8 is a map showing the locations of the three complexes: 4A, Lincoln, 4B, Buttes and 4C, Chico, respectively.

These launcher sites are all within a sixty mile radius of Beale Air Force Base.

WEATHER

The yearly mean temperature in this area is 61°F, varying from a maximum of about 110°F to a minimum of about 25°F.

The mean monthly temperatures vary from about 44°F in January to 79°F in July. The mean monthly precipitation is a minimum of 0 in July and a maximum of 5.8 in December. Freezing is rare and there is no snowfall. (See Figure 9)



A TYPICAL TITAN SITE

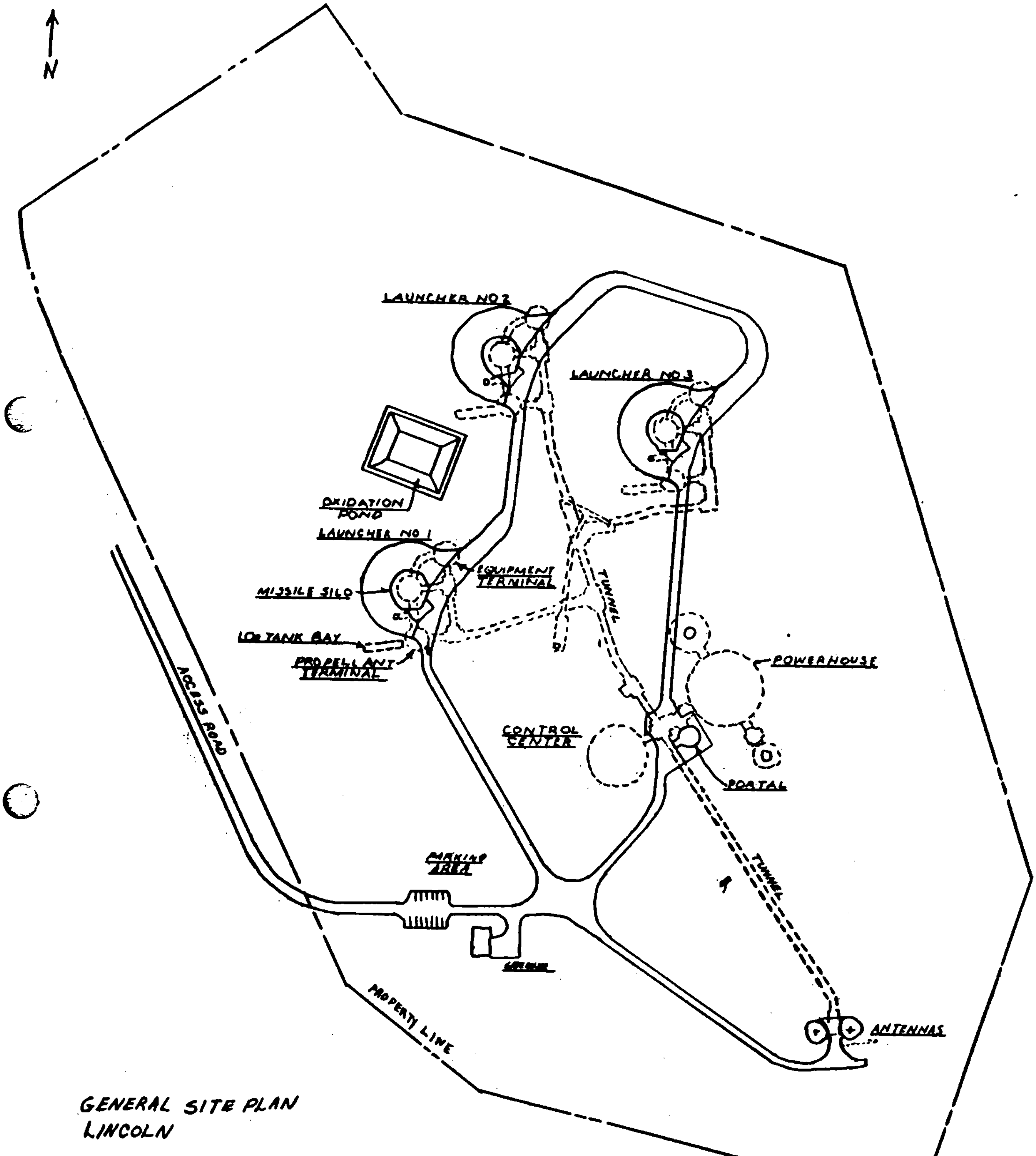
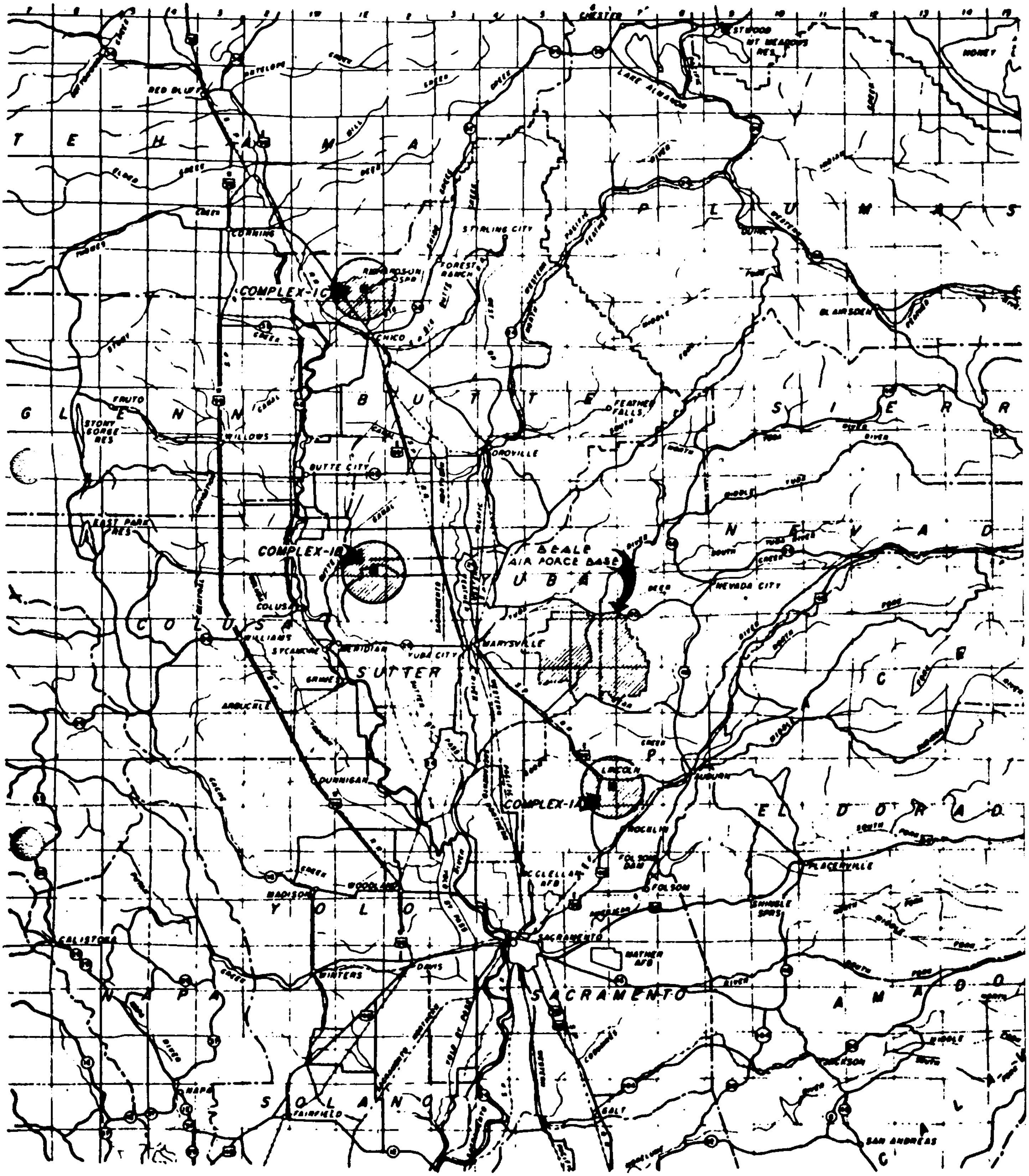

N
LAUNCHER NO 2
LAUNCHER NO 3
OXIDATION POND
LAUNCHER NO 1
EQUIPMENT TERMINAL
MISSILE SILO
TUNNEL
PROPELLANT TERMINAL
POWERHOUSE
CONTROL CENTER
ACCESS ROAD
PORTAL
PARKING AREA
TUNNEL
PROPERTY LINE
ANTENNAS
GENERAL SITE PLAN
LINCOLN

Fig. 7



VICINITY MAP
SCALE 1" = 8 MILES

Fig. 8

TAB 3-C

BEALE

TABULATION OF PRECIPITATION AND TEMPERATURES

AT CHICO, CALIFORNIA

PRECIPITATION (30 YEAR PERIOD)

	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.
NORMAL	.09	.19	1.59	2.62	5.78	4.67	4.22	3.44	2.30	1.10	.44	.01	.09	.19	1.59	2.62
1960-61	.0	.04	.44	5.44	2.10	4.55	3.47	3.70	.99	.66	.44	.01	.10	.40	.23	3.55

TEMPERATURE (20 YEAR PERIOD)

NORMAL	76.3	72.5	63.0	52.6	45.7	44.4	48.4	52.9	58.9	65.9	72.3	78.6	76.3	72.5	63.0	52.6
1960-61	77.0	73.5	63.1	52.7	44.9	42.9	50.9	52.5	59.3	63.0	77.4	79.5	78.6	70.6	63.1	51.1
AVG.MAX.	96.1	92.1	78.6	62.6	53.0	49.8	60.9	62.4	74.8	77.5	95.8	100.3	95.7	88.3	79.9	64.3
AVG.MIN.	57.9	54.8	47.6	42.8	36.8	36.1	41.0	42.5	43.8	48.5	58.9	58.6	61.8	52.9	46.4	38.0

YEARLY MEAN TEMPERATURE = 61.0° F.

NOTE: CHICO EXPERIMENT STATION CONSIDERED REPRESENTATIVE OF WEATHER PATTERN AT ALL THREE SITES.

Fig. 9

4. GEOLOGY OF THE SITES

SITE 1A - LINCOLN

The site is in the foothills of the Sierra Nevada about 40 to 50 feet higher than the adjacent Sacramento Valley. The area has rolling topography with an irregular drainage pattern to the west and southwest. The ground surface was strewn with occasional quartz cobbles and had a thin cover of native grass and oak trees with scattered outcrops of granite on the eastern edge of the site.

The site was underlain by a medium grained granite with a thin cover of overburden. The rock was granodiorite, referred to as granite. The overburden ranged from 4 to 18 feet which graded into a highly decomposed granite in thickness from 24 to 38 feet. The granite became progressively harder with depth, and was fresh, sound rock from 60 to 70 feet. The overburden was composed of a red, brown, sandy silt with subrounded gravels and occasional cobbles.

Ground water was encountered at about 20 to 30 feet below the ground surface. The approximate flow from a Missile Silo was 10 gallons per minute.

SITE 1B - BUTTES

The site is on the crest of one of the radial ridges on the north side of Sutter Buttes. The Sutter Buttes are nearly a circular cluster of hills about ten miles in diameter, which rise

abruptly from the floor of the Sacramento Valley. They are the remnants of an extinct volcano. Drainage of the site is to the north and east. The ground surface at the site was strewn with cobbles and boulders of andesite. There was scant cover of native grass and oak trees. Average ground slope was about 3½ degrees to the north.

The site was underlain by a nearly homogeneous mixture of silt, sand, gravel, cobbles and boulders, all of volcanic origin with a predominence of tuffaceous silt and sand.

Ground water was encountered at 100 to 120 feet below ground surface. The approximate flow from a Missile Silo was 400 gallons per minute.

SITE 1C - CHICO

This site is located in the foothills of the Sierra Nevada range and is about 100 feet higher than the adjacent Sacramento Valley floor. This location is approximately six miles northeast of Chico, California. The immediate area is quite flat with a gradual slope to the west. Drainage on the north and south sides of the site is carried off by creeks flowing almost due west. The ground surface of the area is covered with cobbles from 2 inches to 12 inches in diameter. Lava outcroppings are prevalent throughout the adjacent areas. Oak trees are clustered throughout the areas in the near vicinity.

The site was covered with a gravelly, sandy silt to an average depth of six feet. This was heavily cemented and consolidated. The next ten to twelve feet consisted of lava

(andesite) grey, hard, fractured with clay in the joints. The material in the lava cap consisted of various layers of mixed lenses of gravelly, sandy silt and sandy silt. This generally was from eighteen feet to fifty five feet. Below fifty five feet the material consisted of agglomerate, grey brown, fine to medium grained sand matrix with angular volcanic fragments, moderately to well cemented.

Ground water was encountered at 140 feet below the ground surface. The approximate flow from a Missile Silo was 500 gallons per minute.

5. EXCAVATION AND BACKFILL

EXCAVATION

The contractor elected to use the open cut method of excavation for the tunnels and as a partial excavation for the Launcher structures and the Antenna Silos. Finished open cut depths were approximately 40 feet in the Launcher areas, 55 feet in the Powerhouse-Control area and 40 feet in the Antenna Silos area. (See Figure 10 . These depths varied in accordance with existing ground elevations. The open cut for the tunnels was taken to 12 feet above the tunnel invert. A tunnel cut was made with bottom width of 8 feet and top width of 21 feet. The width at limit of open cut excavation was 41 feet, leaving 20 feet for roadway. (See Figure 11) Ramps were constructed out of each Launcher area, the Control Center-Powerhouse area and the Antenna Silos area. All ramps had maximum 12 per cent slopes.

Parish Bros. of Benicia, California was the subcontractor for the open cut excavation at Site 1A. At Sites 1B and 1C, Murphy Bros. of Spokane, Washington was the subcontractor.

Parish Bros. utilized DW 20's, DW 21's, DW 10 Side Dumps, D8 Cat Dozers, one with ripper, a D9 dozer with ripper, motor patrol, and a Northwest 80 shovel. (See Figure 12) Their operation was on a 10 hour, six day a week basis. Start of operations was on 22 January 1960 and completion on 27 June 1960. At Site 1B, Murphy Bros. utilized Euclid TD 24's and TD 18's, D8 Cat Dozers, two with rippers, and motor patrol. (See Figure 13) Their operation was on two 9 hour shifts, six days per week basis.

Start of operations was in February 1960 and completion in May 1960.

At Site 1C, Murphy Bros. utilized Euclid TD 24's, TD 18's, D8 Dozers, two with rippers, Euclid Dump Trucks and Huff Loaders. (See Figure 14) Their operation was on two 9 hour shifts, six days a week basis. Start of operations was in March 1960 and completion in May 1960.

During the early stage of the open cut excavation at Site 1A, operations were slowed because of the muddy ground conditions. After pioneer excavation this condition was lessened and operations proceeded normally. At Site 1B the mud was not as extensive as at Site 1A and the excavation operations were not severely hampered. At Sites 1A and 1B considerable overrun for excavation of the access road occurred because of the saturated condition of the subgrades. However, at Site 1A, placement of the select sub-base proceeded rapidly due to the fact that the decomposed granite from the open cut was utilized for the select material. The short haul, together with the excellent compaction characteristics of this material, compensated considerably for the time lost because of over-excavation.

At Site 1A, a changed condition of the foundation occurred during the open cut excavation of the Power House area. (See Figure 15) Information as shown on the contract drawings indicated the hardened granite would start occurring near bottom grade of the open cut excavation. However, this granite, especially in the easterly part of the area, appeared at elevations considerably above that indicated. The contractor was required to drill and blast to remove rock. In the launcher areas only a few rounds of

blasting were needed for rock removal.

Four significant slides occurred at Site 1A. Two of these slides happened in the tunnel cut from Blast Lock #1 to Launcher #2 (See Figure 16), one in the Blast Lock #1 cut and one on the east Powerhouse cut. There were numerous smaller slides and potential slide areas. These slides and potential slide areas were stabilized by berms, flattening of slopes and by shoring. (See Figures 17 and 18)

At Site 1B no unusual problems were encountered during the open cut excavation. Due to the type of soil, severe muddy conditions did not prevail. The in-place material was stabile and no sloughing of the cut slopes occurred.

At Site 1C a muddy condition existed which slowed excavation until pioneering had been accomplished. The removal of the lava cap, approximately 6 feet below existing ground surface and approximately 12 feet in depth required drilling and blasting. Approximately 150,000 cubic yards of rock was removed. Below the lava cap to bottom of open cut excavation, no unusual problems occurred. (See Figure 19) There was no sloughing of the cut slopes.

Ground water did not present a problem at any of the three sites during the open cut operations.

SHAFT EXCAVATION

The excavation of the shafts for the Missile Silos, Equipment Terminals and Propellant Terminals was part of the Prime Contractor's work. The operation was carried out on a 3 shift, 6 day a week basis at all three sites. Equipment used at each site consisted of a

Fig. 10

Excavation of Launcher #1, Site 1A

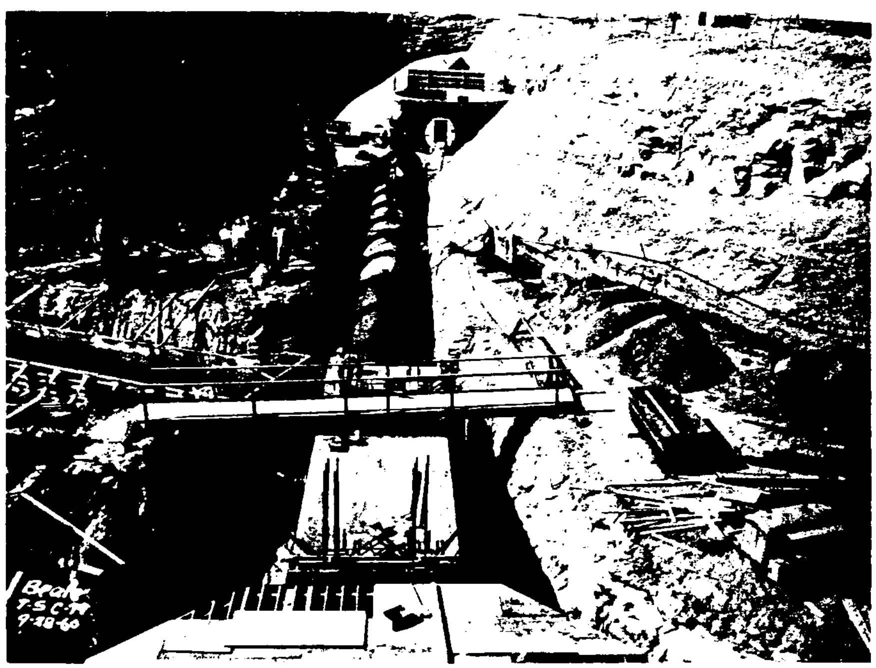


Fig. 11

Tunnel Excavation, Site 1C

Fig. 12

Excavation of Launcher #1, Site 1A

Fig. 13

Open Cut Excavation, Site 1B

Fig. 14

Open Cut Excavation Showing Huff Loader,
Launcher #2, Site 1C

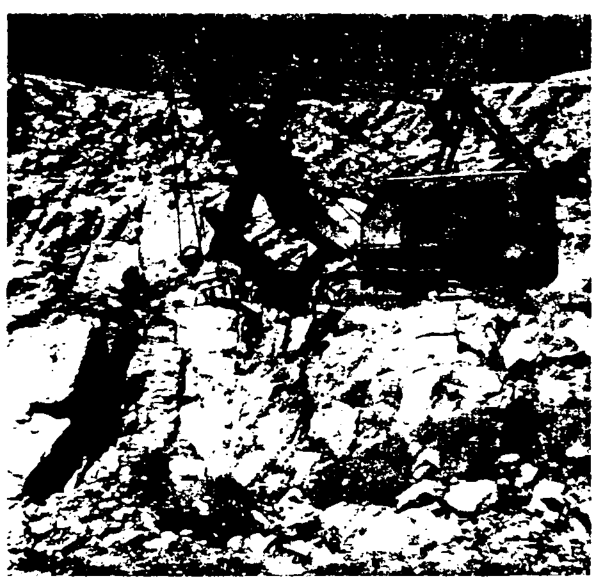


Fig. 15

Excavation-Powerhouse Area Showing Rock, Site 1A

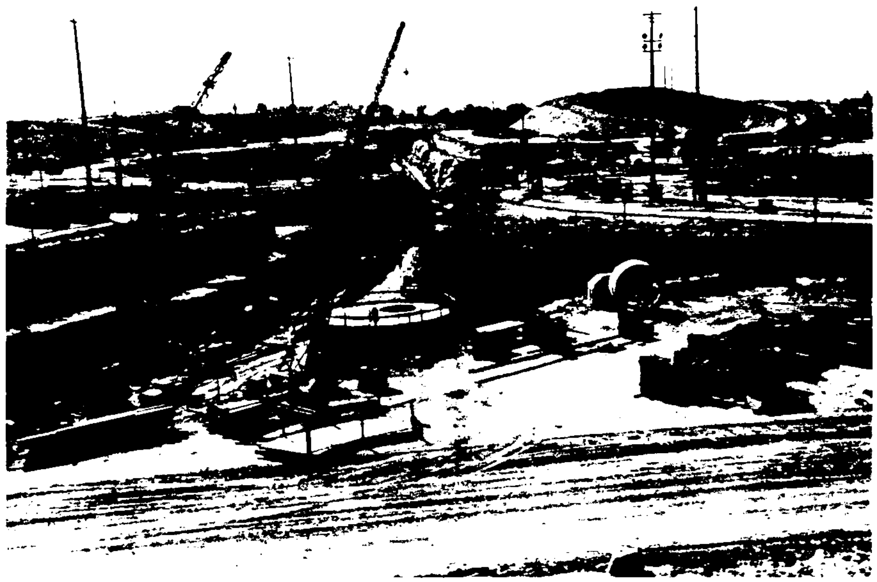


Fig. 16

Launcher #2, Site 1A, Showing Slide

Fig. 17

Open Cut Excavation Showing Berm,
Launcher #2, Site 1A

Fig. 18

Antenna Silos Open Cut Excavation,
Shoring of Slope, Site 1A

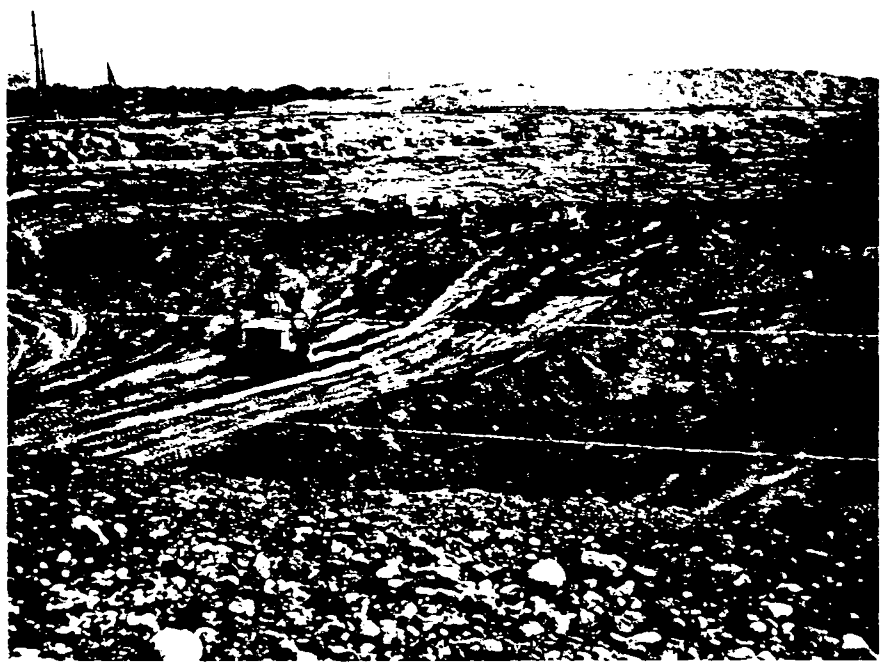


Fig. 19

Open Cut Excavation of Powerhouse,
Control Center Showing Lava Cap, Site 1C

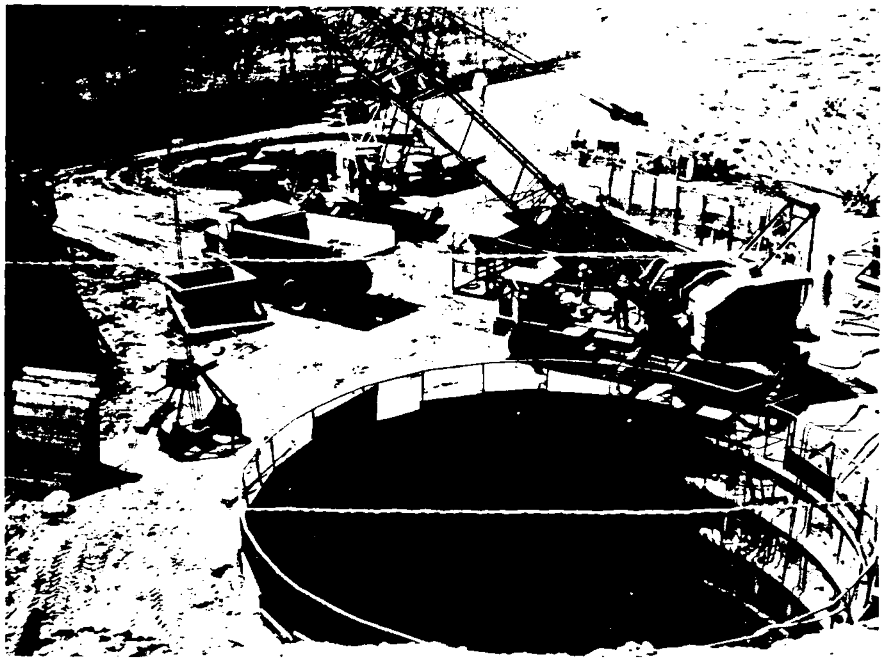


Fig. 20

Shafting Operations Showing Equipment,
Launcher #1, Site 1A

Fig. 21

Rock Bolt Hole Drilling, Site 1A

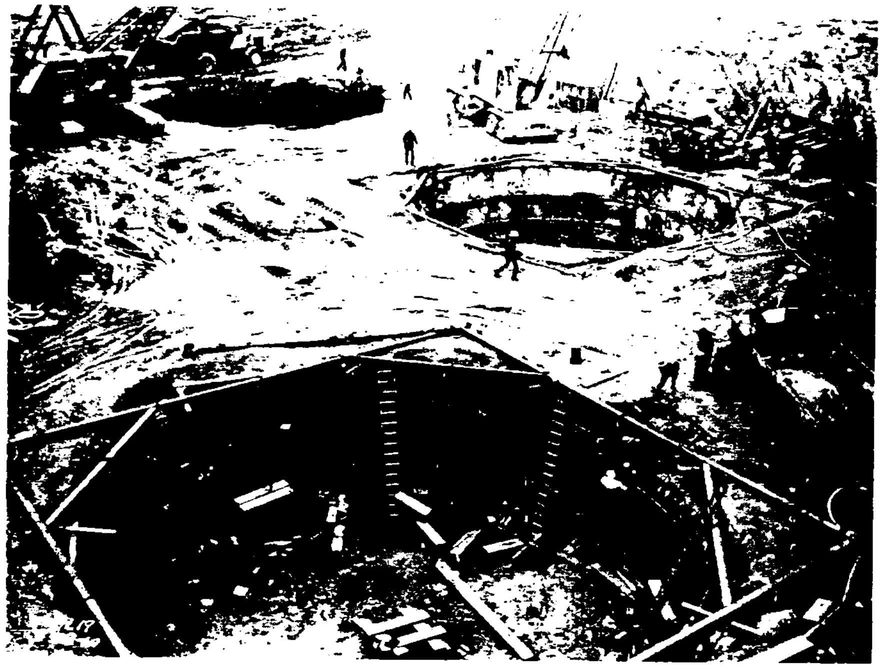


Fig. 22
Shafting Operations Showing Steel Ring Beams, Gunite, Launcher #1, Site 1A

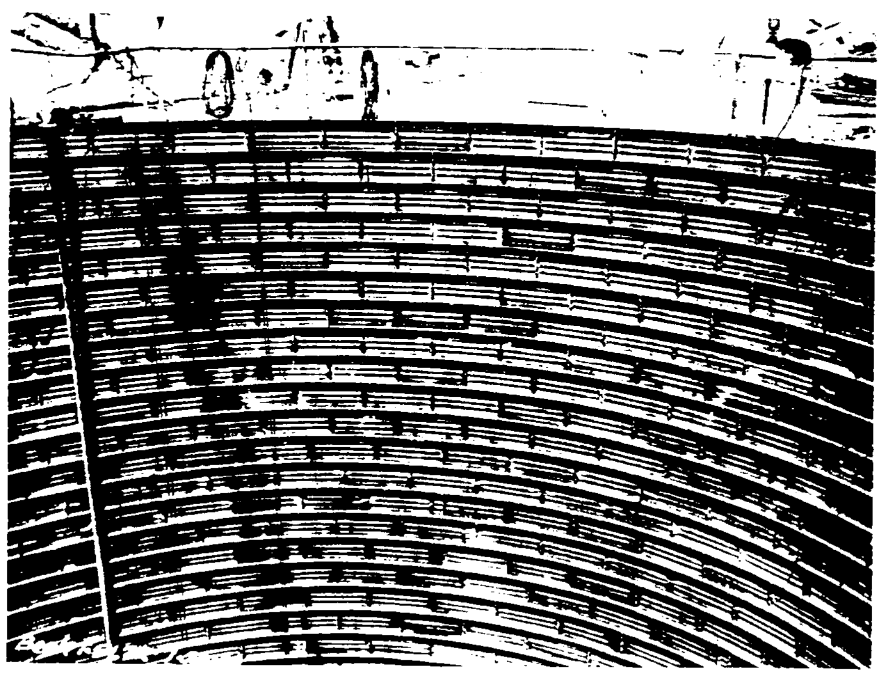


Fig. 23
Liner Plate, Missile Silo #2, Site 1A

Manitowoc 60 ton crawler type crane, two American 40 ton truck cranes and a Cat 977 loader with ripper. (See Figures 10and 20) At Sites 1A and 1C, Gardner-Denver and Ingersoll-Rand air tracks were used for rock bolt hole drilling. (See Figure 21) A nine cubic yard loading bucket was used in lifting muck from shafts. (See figure 22) Euclid end dump trucks were used to haul muck to waste piles.

At Site 1A the hardened granite appeared at start of shafting operations. Sequence of operations was drilling, loading and blasting, mucking, and setting of steel ring beams. At Site 1A ring beams used with wood lagging, wire mesh and gunite were part of the contractor's method of shoring. (See Figure 20) At Sites 1B and 1C, steel ring beams on 5'2" centers with wire mesh and gunite were used in accordance with a design prepared by the contractor and made a part of the contract by change order. At Site 1A the contractor proposed the use of a sectional liner plate which was used by modification to contract (See Figure 23) in lieu of the smooth plate. The sectional liner plate joints required sealing with Products Research Company's 250 rubber calk or equal. The smooth liner plate required welding at the seams.

Changed conditions of the foundation rock in Missile Silo #2, Site 1A, resulted in a design change of the foundation slab. The change consisted of eliminating the rock bolts and increasing reinforced concrete slab thickness to 9 feet. The reason for the change was that the granite was considered unsuitable to provide

adequate anchoring of the rock bolts. At Site 1A rock bolts were required to anchor the foundation slabs of all other structures in order to compensate for hydrostatic pressure. (See Figures 24 and 25 and 26) In the Missile Silo, one hundred rock bolts were required. These were 2 3/4" round bolts, 28 feet 6 inches long, 27 feet of which were grouted into the hole with non-shrink grout. The end embedded into the concrete had upset end to 3" diameter. Rock bolts for other structures were 2" round bolt, with lengths of 22', 23' 6" or 28'6". (See Figure 27) All rock bolts were threaded at each end. The bottom nut was tack welded and at top end washers were used with the nut.

At Site 1A in Missile Silo #1, steel ring beams were used to 30 feet below top of shaft. In Missile Silos #2 and #3, the softer granite extended to greater depths than in Missile Silo #1. The ring beams in Missile Silo #2 were set to the bottom of the shaft and the spacing of a portion changed to 2 feet 6 inches. In Missile Silo #3 ring beams were set to 70 feet below top of shaft. A portion of the ring beams was spaced at 2 feet 6 inches.

During installation of the liner plate at Site 1A, buckling of the plate caused some delay. (See Figure 28) The buckling apparently was caused by grout shrinkage which allowed water to enter behind liner plate, thus creating hydrostatic pressure of sufficient force to buckle the plates.

Shafting operations began at Site 1A on 10 March 1960. Initial work was done in Launcher #1 and final work, completed on 25 June 1960, was done in Launcher #3.

The sequence of operations was the same at Sites 1B and 1C as at Site 1A, except that at Site 1B only occasional drilling and blasting were needed to remove boulders. Some minor buckling of the liner plate occurred at Site 1C.

The start of shafting operations at Site 1B was on 19 April 1960 and completion on 27 June 1960. The start of shafting operations at Site 1C was in June 1960 and completion in August 1960.

BACKFILL

The backfilling was accomplished by the Prime Contractor. Operations began in September 1960 at Sites 1A and 1B and in October 1960 at Site 1C. At all sites the stockpile materials from the open cut excavation furnished sufficient backfill material. DW 21's and D8 Dozer with Sheepsfoot Roller were heavy equipment used. Around the structures gasoline motor powered vibratory compactors were used. (See Figure 29)

Few problems were encountered. The greatest difficulty was in the handling of over optimum material during inclement weather. Close construction control was maintained to insure that contractor obtained the required 90 per cent of maximum density at optimum moisture content in the fill or the 95 per cent of maximum density adjacent to structures.

One specification requirement was changed, in that rock up to 20 inches was allowed in the fill material with the exception that within 4 feet of structures, material had to meet original specification requirements. (See Figure 30) The specifications required that rock be reduced to a maximum size of 2/3 the thickness

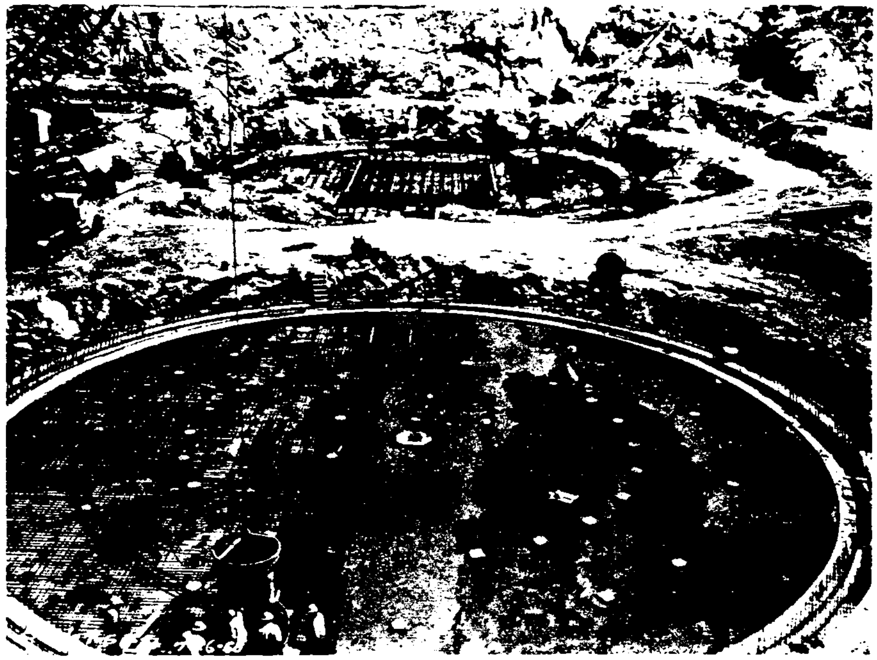


Fig. 24

Rock Bolts, Control Center, Site 1A

Fig. 25

Rock Bolts, Control Center, Site 1A

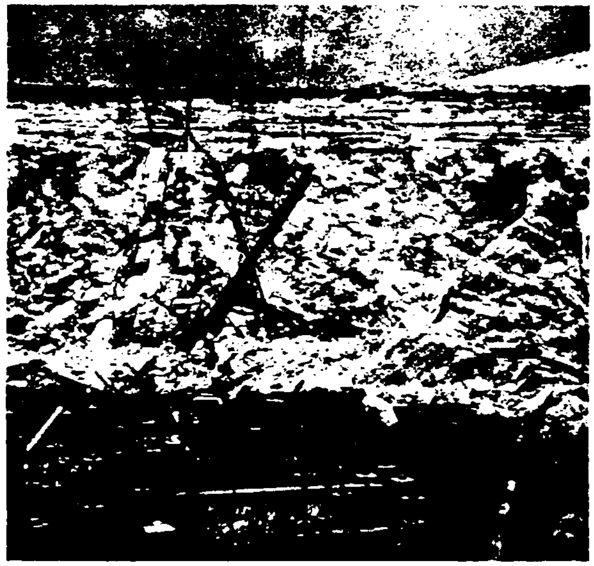


Fig. 26

Rock Bolts, Site 1A, Control Center

Fig. 27

Rock Bolts, Site 1A

Fig. 28

Buckled Liner Plate, Site 1A, Missle Silo

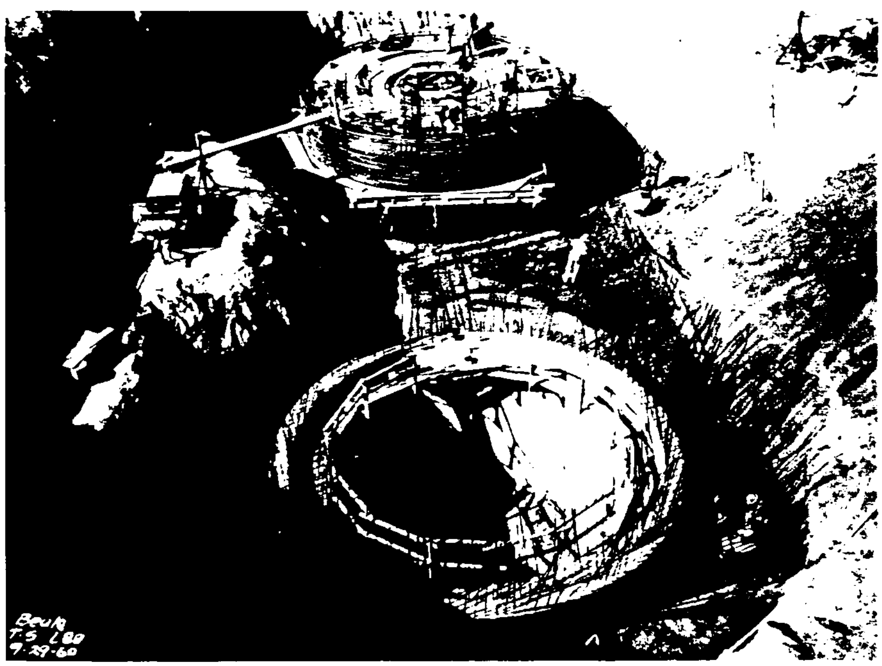


Fig. 29

Compacting Backfill Antenna Silos, Site 1A

Fig. 30

Backfill Showing Rock, Site 1C

Fig. 31

Tunnel Backfill, Site 1A,
Between Tunnel Junction #10 and Antenna Terminal

of the layer in which the rock was placed. Layer thickness was specified as not to be placed in layers exceeding 8" in thickness.

At Site 1C the quantity of rock excavated from the open cut excavation was much greater than that excavated at Sites 1A and 1B. Much of this rock was utilized in the backfill.

The specification requirements for tunnel backfill were waived at Sites 1A and 1B, in that at Site 1A (See Figures 31 and 32) sand backfill was used underneath and up to spring line and at Site 1B, because of the suitability of the granular material, sand was not used. Specifications required that sand be backfilled beneath, above and on each side of structures.

Fig. 32

Tunnel Backfill, Site 1A

Fig. 33

Concrete Batch Plant, Site 1A

6. CONCRETE OPERATIONS

CONCRETE PLANT

The Prime Contractor accomplished all of the concrete work.

At each site a portable, automatic-controlled Noble Batch Plant with an 850 barrel storage cement silo was set up. (See Figure 33) The capacity of the plant was 80 cubic yards per hour. The sand and aggregate were dumped into the weighing batch hopper by means of conveyor belt. From the weighing hoppers, the sand, gravel and cement were dumped onto a conveyor belt and conveyed to the loading hopper. Water was metered by volume from scale room and piped to loading hopper. The air entraining agent was measured into a cylinder and by air, released into the loading hopper.

During concrete placement there were one to eleven transit mix trucks used on pours. An average of three to four trucks was used per pour.

Cranes using concrete buckets were utilized in placing concrete. (See Figures 34 and 35)

CONCRETE MATERIALS

Approximately 90,000 cubic yards of concrete were used. The specifications required strengths of 5000,3750,3000,2500 and 2000 pounds per square inch. Maximum sizes of aggregate used were 1½" and 3/4".

The source of fine and coarse aggregates depended upon the location of the sites. At Site 1A aggregates were supplied by Richter and Harms from their Bear River plant near Sheridan,

California. At Site 1B aggregates were furnished by Matthews Ready Mix Inc. from their Feather River plant at Gridley, California. At Site 1C sand was furnished by Richter and Harms from their Dry Creek plant near Pintz, California and coarse aggregate was supplied by Mack Rock and Sand Company near Stony Creek.

The aggregates were hauled to the sites by truck, and stock-piled.

The Calaveras Cement Company, San Andreas, California, supplied the cement. All cement was Type II and was hauled to the site by cement trucks.

The air entraining agent and curing compound, Edoco, were supplied by Edoco Technical Products Company, Long Beach, California.

Ice for cooling concrete mixtures was supplied by local ice companies. An ice storage room was built at each batch plant.

The Corps of Engineers South Pacific Division Laboratory designed the concrete mixes. The Class A designs are listed. Most of the concrete was Class A.

SITE 1A

	1 1/2" Maximum
Cement	4.99 sacks/cu.yd.
Sand	33% by volume
Gravel	67% by volume
Air	4.0% by volume
Water	5.5 gal/sack

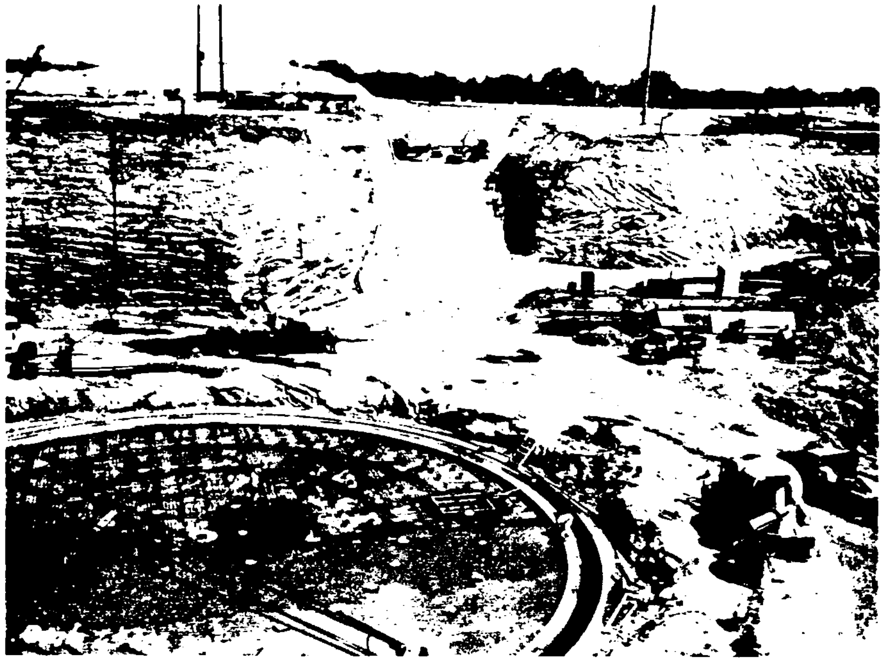


Fig. 34
Concrete Placement, Control Center, Site 1A

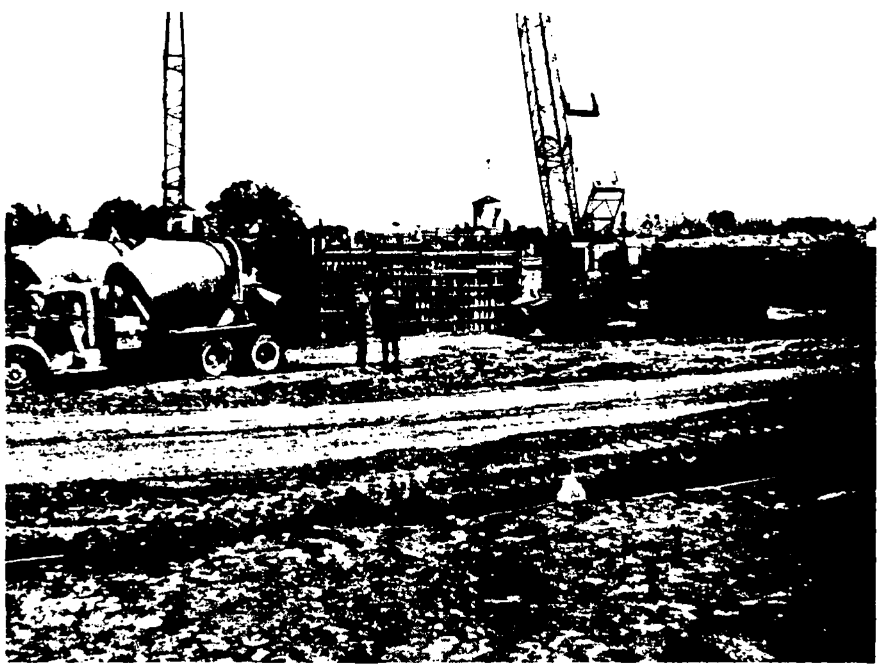


Fig. 35
Concrete Placement,Missile Silo #2, Site 1A

SITE 1A (Continued)

	3/4" Maximum
Cement	4.7 sacks/cu.yd.
Sand	40% by volume
Gravel	60% by volume
Air	4.0% by volume
Water	6.5% gal/sack

SITE 1B

	1 1/2" Maximum
Cement	5.71 sacks/cu.yd.
Sand	31% by volume
Gravel	69% by volume
Air	4.0% by volume
Water	5.0 gal/sack

	3/4" Maximum
Cement	5.57 sacks/cu.yd.
Sand	36% by volume
Gravel	64% by volume
Air	4.0% by volume
Water	5.50 gal/sack

SITE 1C

	1 1/2" Maximum
Cement	5.76 sacks/cu.yd.
Sand	30.5% by volume
Gravel	69.5% by volume
Air	4.0% by volume
Water	5.25 gal/sack

3/4" Maximum

Cement	5.81 sacks/cu.yd.
Sand	38.5% by volume
Gravel	61.5% by volume
Air	4.0% by volume
Water	6.0 gal/sack

At each site a construction control laboratory was built for both soil and concrete work.

FORMS

At each site three types of forms were used. The conventional type forms were used for all structures with the exception of the Control Center and Power House domes and the Missile Silo walls up to 16 feet from top.

The conventional type forms were built in accordance with standard construction practices. Material used was 2" thick tongue and groove board with 3/8" thick plywood lining. (See Figures 36, 37, 38, 39, 40)

The forms for the Control Center and the Power House domes were movable steel forms. (See Figures 41, 42 and 43)

For each structure, there were two opposed orange peel forms 1/8 of the diameter of the structure, mounted on track and supported by structural members to center pivot post. (See Figures 42 and 43) Concrete placement was made simultaneously in each form, and forms were moved at same time. These forms first

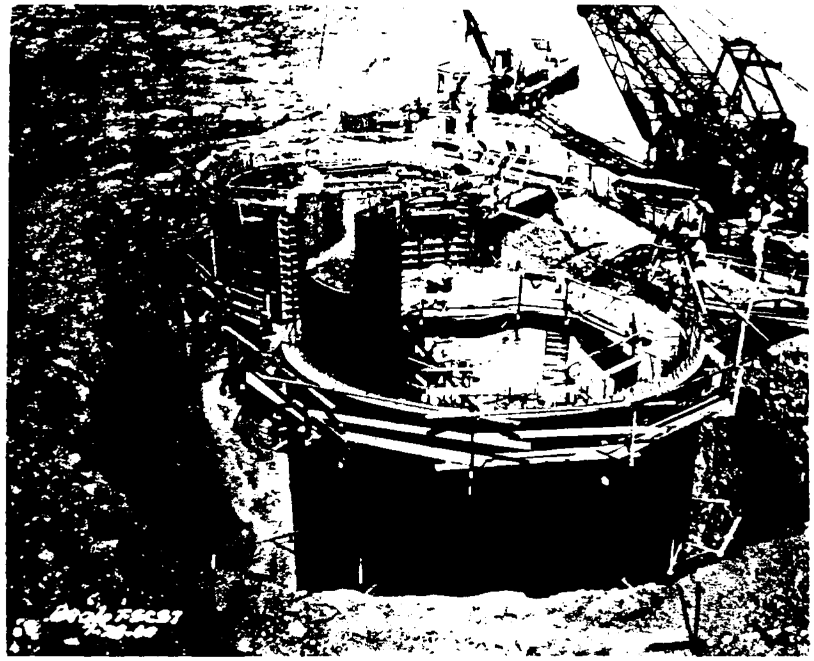


Fig. 36

Setting Forms, Antenna Silos, Site 1C

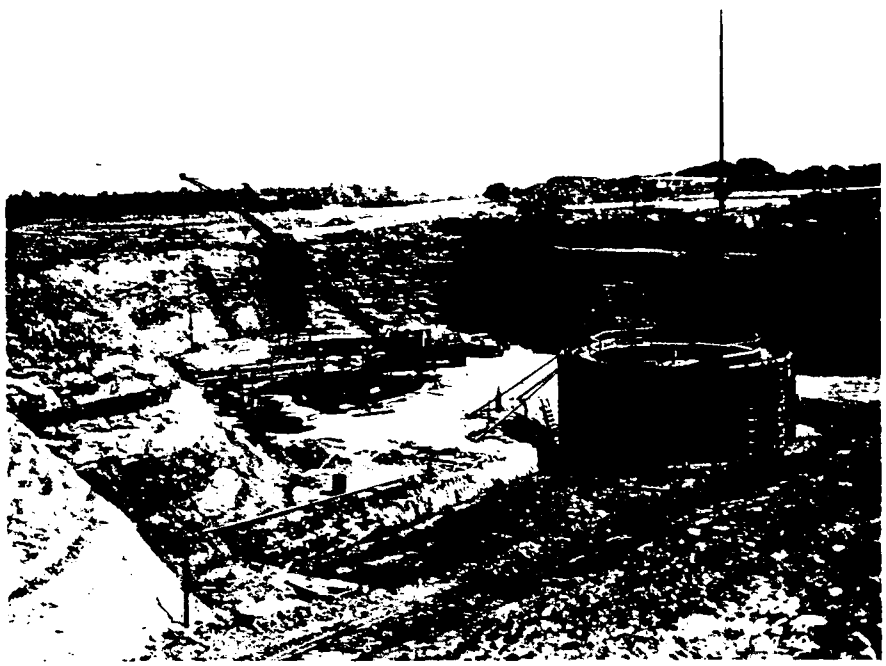


Fig. 37

Form Propellant Terminal, Site 1C

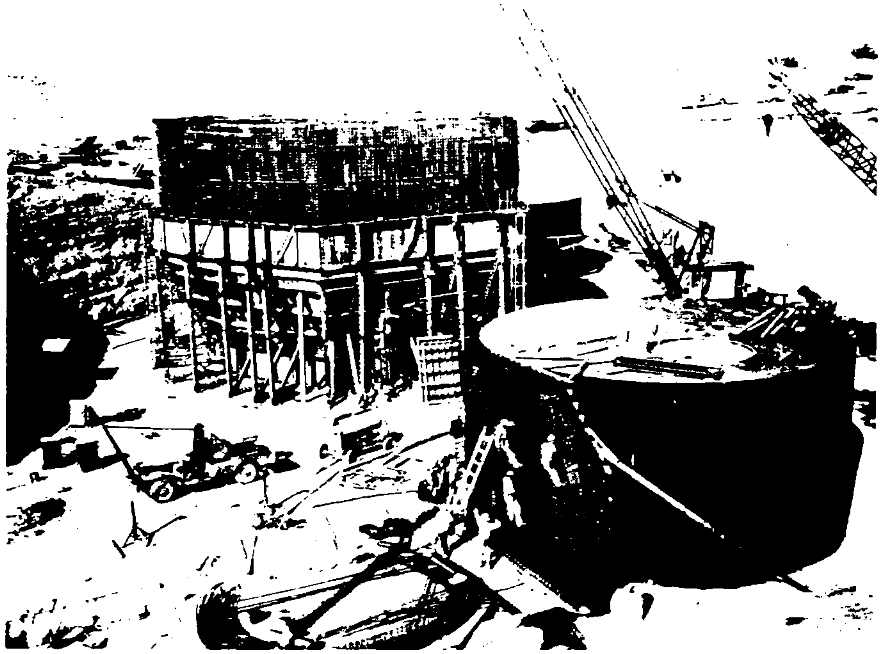


Fig. 38

Form Missile Silo #2, Site 1A

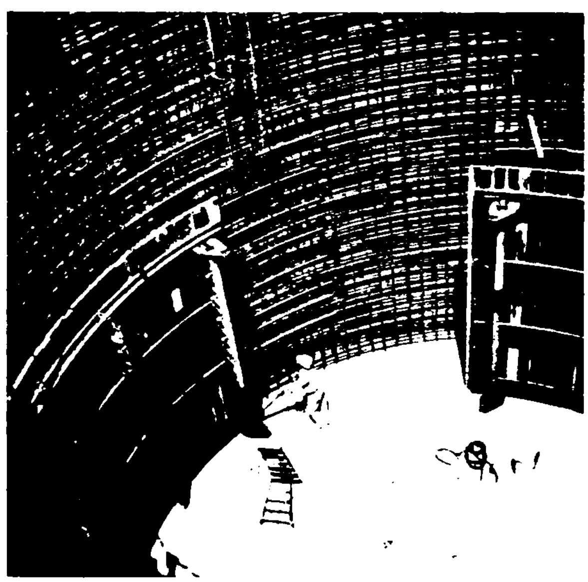


Fig. 39

Form, Site 1A, Equipment Terminal Wall

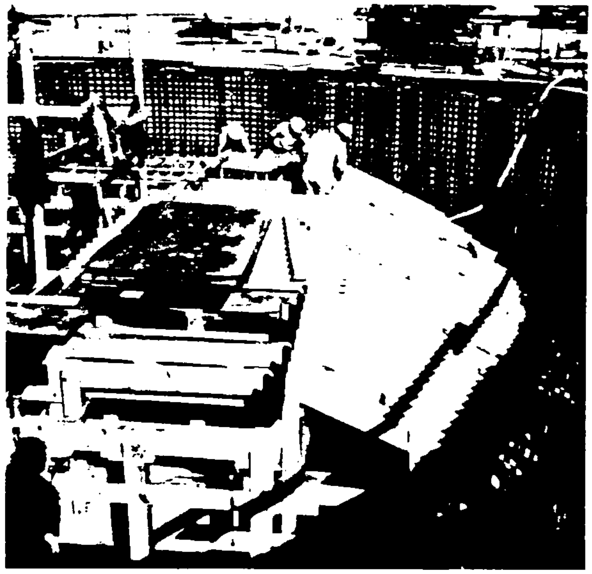


Fig. 40

Form, Site 1A, Missile Silo Top Slab

Fig. 41

Movable Steel Forms, Control Center, Site 1A

Fig. 42

Movable Steel Forms, Control Center, Site 1A

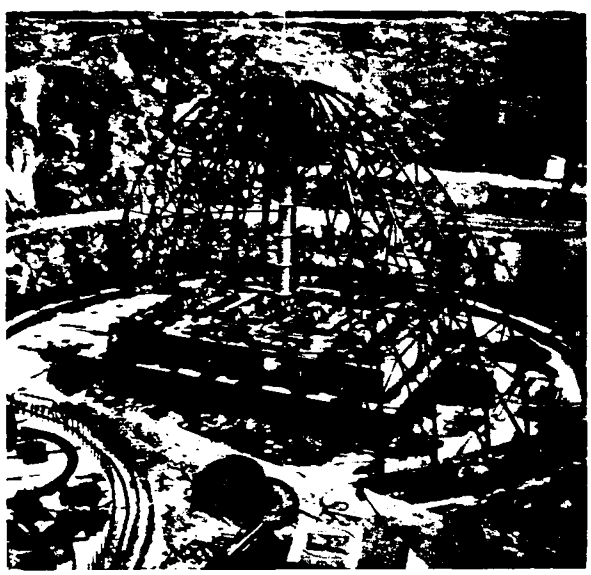


Fig. 43

Movable Steel Forms, Powerhouse, Site 1A

were used at Site 1B, secondly at Site 1A and final use was at Site 1C. During the first placement at Site 1B it was discovered that an additional row of windows was needed near top of form. The spacing between the top row and the one below was too great to permit adequate vibrating. After this correction, only minor problems were encountered.

The slip forms used for the Missile Silo wall pours were the third type of forms used. As with the conventional forms, materials were 2" tongue and groove board and 3/8" plywood lining. The first slip form used at Site 1A had three platforms. (See Figures 44 and 45) The top platform was for material storage, and concrete hopper. (See Figure 46) The middle platform was working platform for concrete placement and the final work on embedded items. The bottom platform was for operating the hydraulic jacks and for the concrete finishers. After the first Missile Silo at Site 1A was slipped, the upper platform, except for the hopper, was discarded. Thirteen hydraulic jacks were used on the first slipping. Due to the additional strain imposed by the weight of concrete and hopper, two additional hydraulic jacks were added under the hopper for the remaining slipping. The hydraulic jacks were manually operated from a central control station. The overall length of the vertical face was six feet. The form was operated to keep it slightly higher than the freshly placed concrete. The slipping was continuous with an average rate of progress slightly over a foot an hour. During the slip form operations the greatest difficulty encountered was in controlling

the roundness of the form. The roundness of the concrete wall was checked from four control wires, one at each quadrant intersection, stretched from point near top of silo to the bottom. In all silos the form became out of round, resulting in numerous embedded items, notably the unistruts, not being flush with the concrete. (See Figure 47) Additional cables were added across the forms and attempts made to force form back into position. However, out of roundness still occurred for all slipping. Contributing factors for this condition were the unequal expansion of the wooden platform due to moisture absorption and also the bulging of the steel reinforcement. (See Figure 48)

Slip forming at Site 1A and 1B was concurrent. Start of operations was on 26 August 1960 and completion on 29 October 1960. At Site 1C start was on 7 November 1960 and completion on 11 December 1960.

A form fabrication yard was established at Site 1A. Forms for the three sites were built at this yard and transported by truck to Sites 1B and 1C. Many of the forms were used from site to site.

<u>STEEL REINFORCEMENT</u>

The steel reinforcement work was done by Yuba Erectors of Emeryville, California.

Resteel sizes ranged from No. 5 through No. 18. The No. 18 bars were used in the Missile Silo top pours, in the Air Intake and Air Exhaust structures and Missile Silo Foundations at Silos 1B and 1C. (See Figure 49) Difficulty was encountered in placing concrete in many of the pours due to quantity of resteel

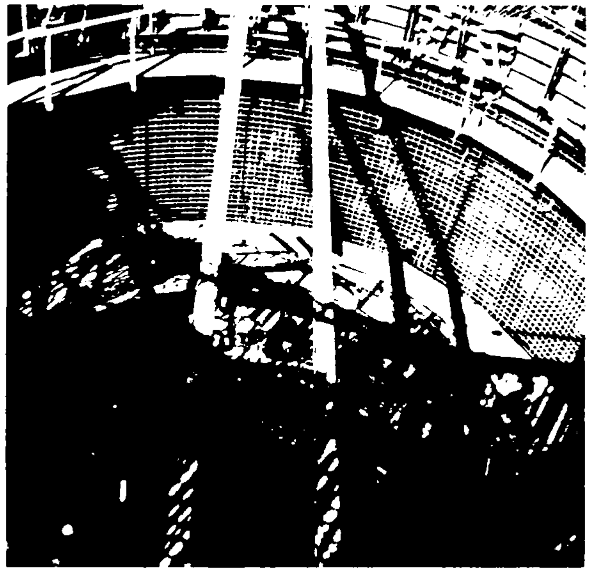


Fig. 44

Slip Form, Missile Silo #1, Site 1A

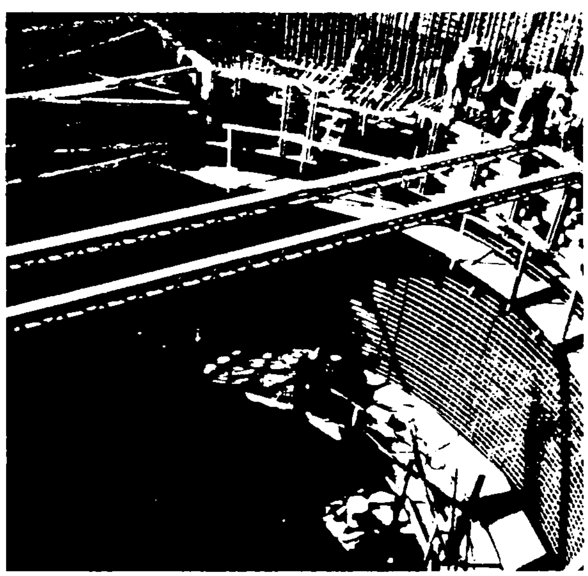


Fig. 45

Slip Form, Missile Silo #1, Site 1A

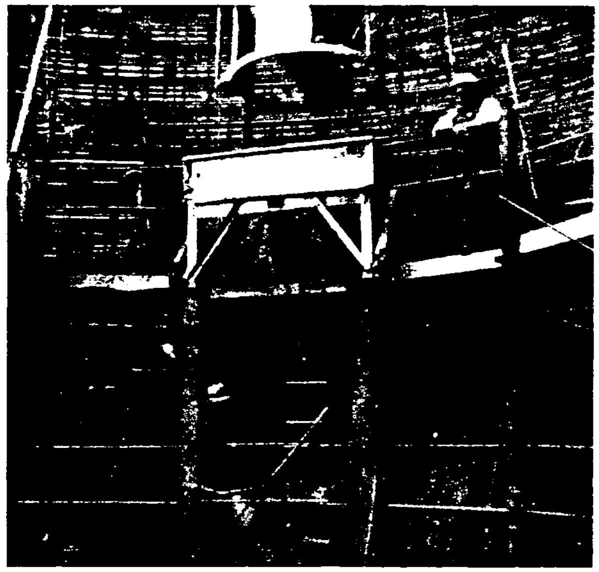


Fig. 46

Slip Form, Missile Silo #1, Site 1A
Buggie, Hopper and Hoist Bucket

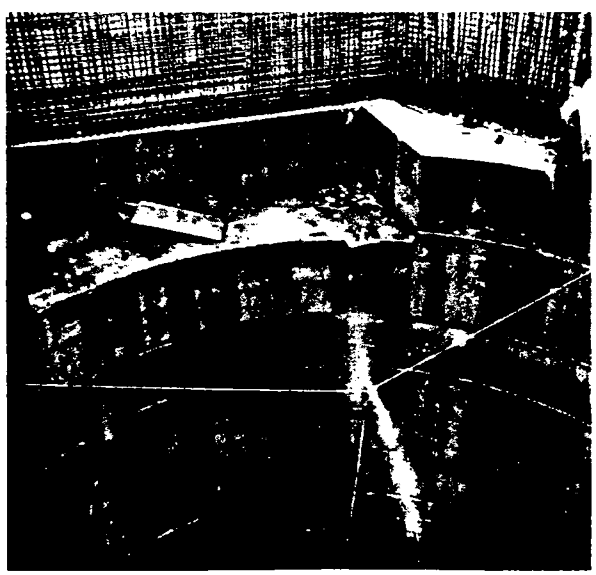


Fig. 47

Concrete Wall Finish Missile Silo #1, Site 1A

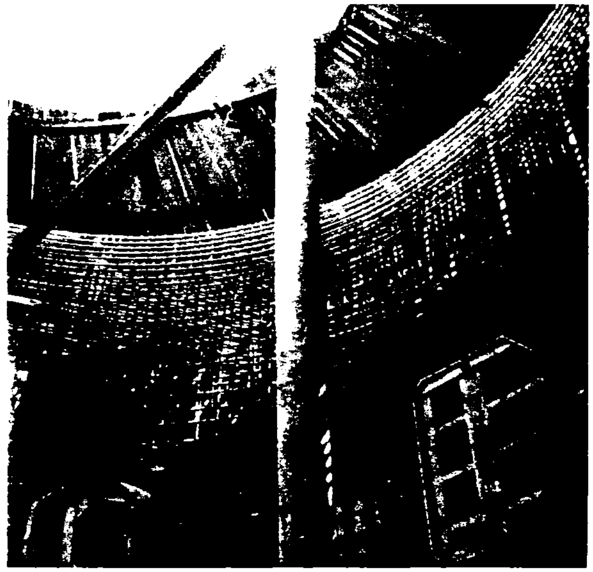


Fig. 48

Reinforcement Steel, Missile Silo #1, Site 1A
Also LOX and Heating and Ventilating Tunnel Openings

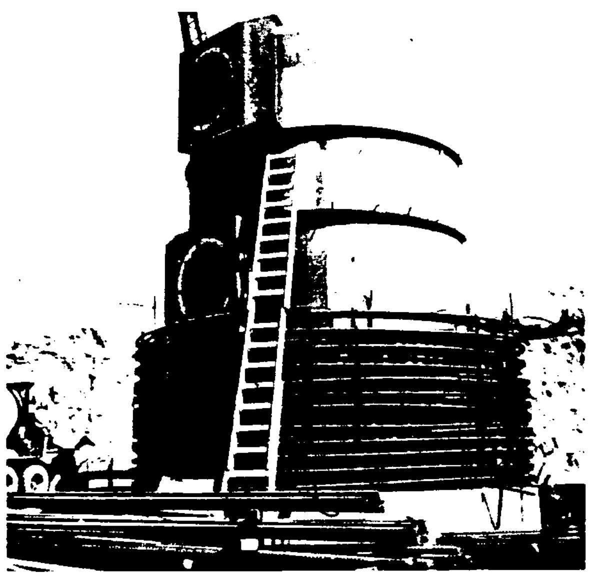


Fig. 49

Reinforcement Steel, Air Exhaust, Site 1A

used.

Resteel was placed in accordance with normal construction practices. (See Figures 50, 51, 52, 53 and 54) For the placing of the wall resteel in Missile Silos, swinging platforms, one a single deck and the other with four decks, (See Figure 55) were used. These platforms were raised and lowered by crane.

The most serious problem encountered was bulging of the resteel in the Missile Silo walls during slip forming. Certain sections were forced back to allow clearance. Only minor problems were encountered in the placing of resteel for the other structures. In the Missile Silos and Equipment Terminals all reinforcing steel was bonded for electrical continuity by welding splices and a portion of intersection where layers of steel crossed at right angles. The steel walls were also connected electrically with grounding matting beneath each structure.

CONCRETE PLACEMENT

With the exception of the slip form operations and Power House foundation slab pours, cranes were utilized in placing concrete. (See Figures 57 and 58)

During the slip form operations, concrete was dumped from transit mix trucks into a chute. (See Figure 56) The chute dumped the concrete into a cubic yard bucket. This bucket was raised and lowered along guides by hoist, and dumped into a hopper above the work platform. From the hopper the concrete was dumped into hand buggies and placed where required.

In the placing of the Power House spring beam supported slabs,

transit mix trucks dumped concrete into hoppers. From the hoppers the concrete was dumped into power buggies and dumped from them where needed. (See Figure 57)

Concrete vibrators were used in all concrete placement. One to three cranes were used. During placement of the Missile Silo tops, two to three cranes were used. Two cranes were used on the Control Center and Power House dome pours. Concrete buckets of $1\frac{1}{2}$ cubic yard capacity were used. (See Figure 58)

Ice was used during the hot weather to cool the concrete mixes below 80° F. The ice was added at the batch plant. At Site 1A the ice was crushed, weighed, dumped on conveyor and into truck from loading hopper. At Sites 1B and 1C, the ice was weighed, crushed and by means of blower, transmitted to the loading hopper into the truck mixer.

FINISHING AND CURING

The walls of the Missile Silo were form finished. Rough areas were smoothed with wood float and some areas required patching. A rainmaker was supported below the bottom platform by light cable. This rainmaker supplied full water coverage to the walls.

All unformed surfaces that were not to be covered by additional concrete or backfill had either a wood float finish or steel trowel surface. Floor slabs were steel trowel finished. Top slabs of Missile Silos, except for buttresses which were steel troweled, Entry Portal and Antenna Silos were wood float finished. Missile Silo, Antenna Silo and Entry Portal Doors were wood float finished. (See Figure 59)

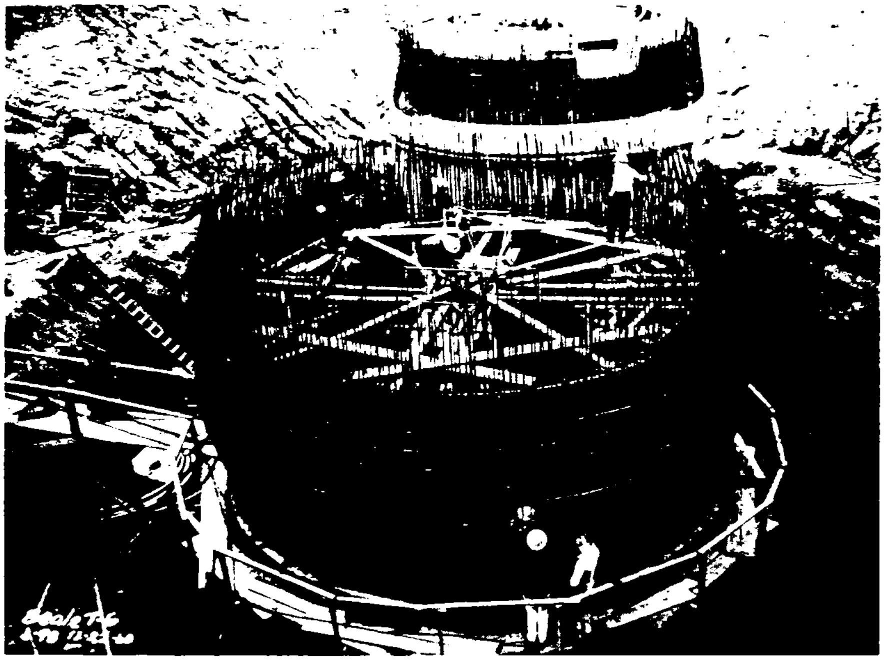


Fig. 50

Reinforcement Steel, Antenna Silos, Site 1A

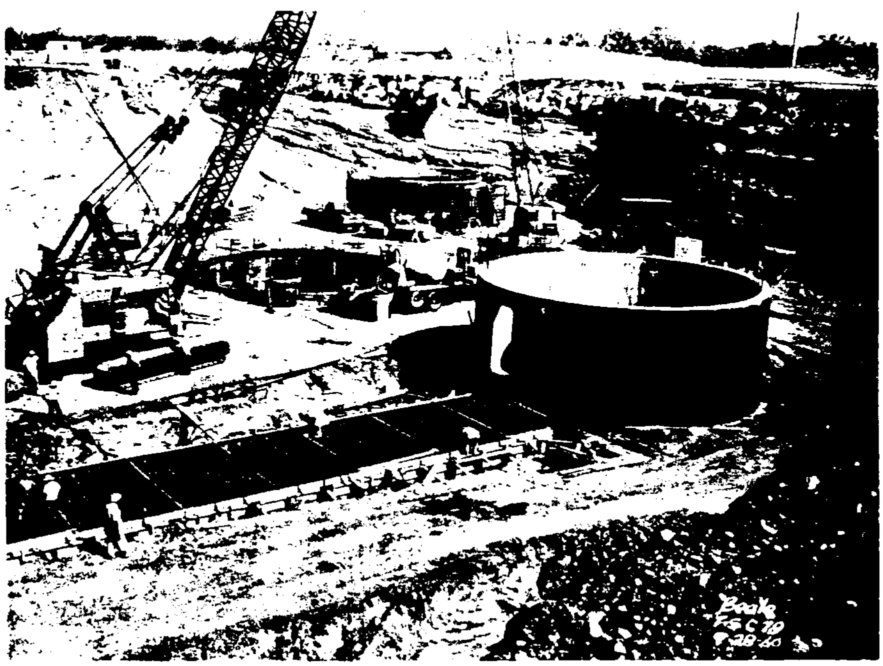


Fig. 51

Reinforcement Steel, Foundation for Liquid Oxygen Tank, Site 1C

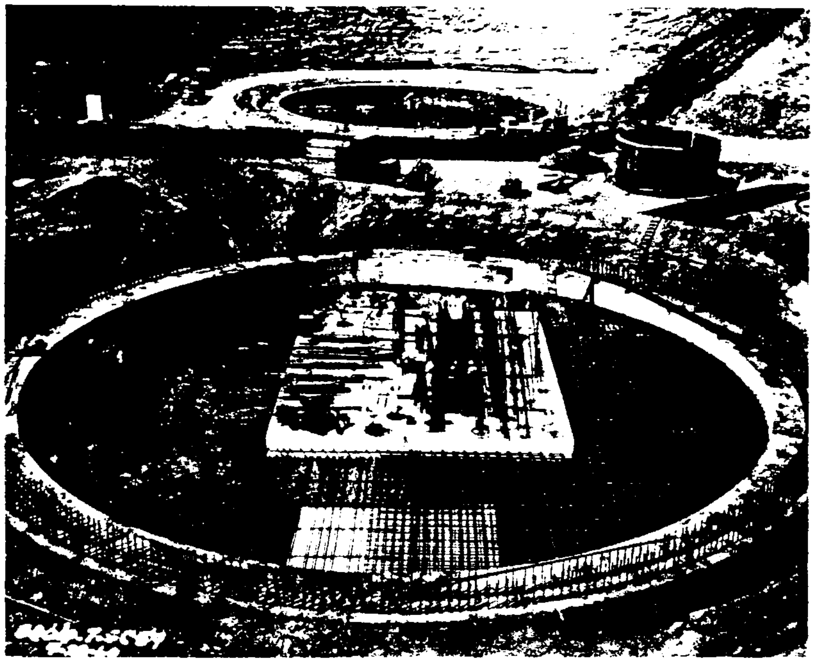


Fig. 52
Reinforcement Steel Foundation,Powerhouse, Site 1C

Fig. 53
Reinforcement Steel For Door, Missile Silo #1, Site 1A

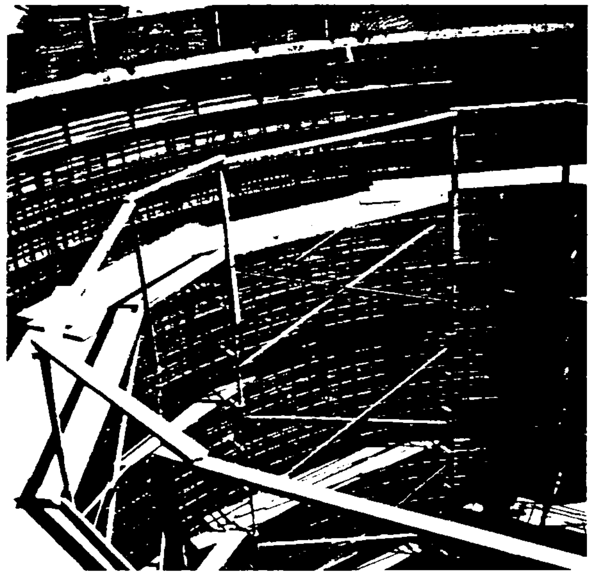


Fig. 54
Reinforcement Steel, Equipment Terminal, Site 1A

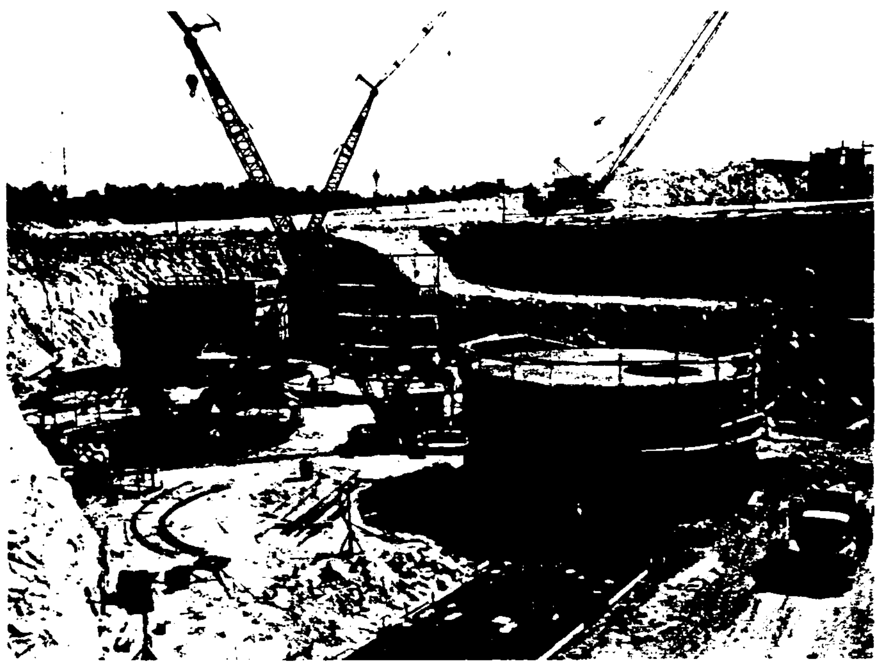


Fig. 55
Four Deck Scaffold, Steelworkers,
Missile Silo #2, Site 1A

Fig. 56

Concrete Placement, Missile Silo #1, Site 1A

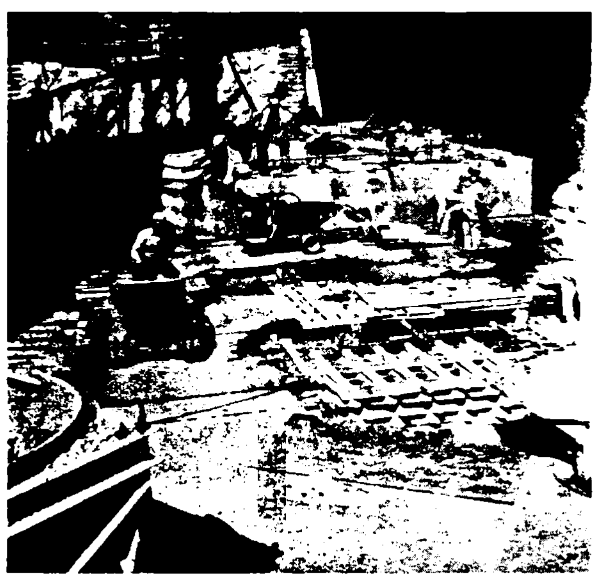


Fig. 57

Concrete Placement Showing Power Buggies,
Powerhouse, Site 1A

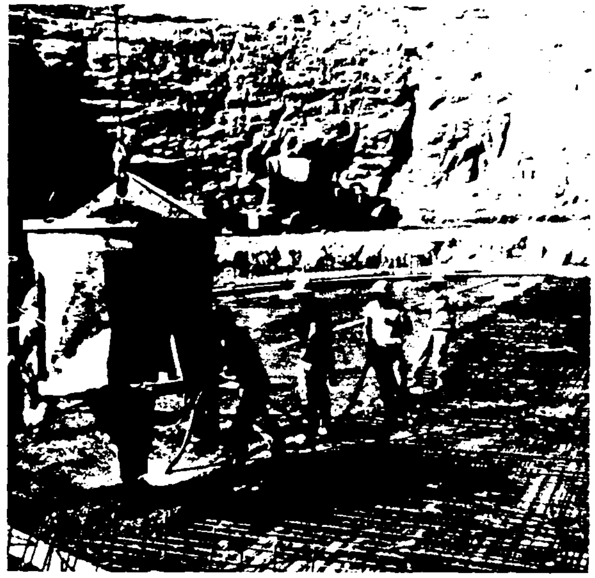


Fig. 58
Concrete Placement Showing Concrete Buckets, Site 1A
Control Center Foundation Slab

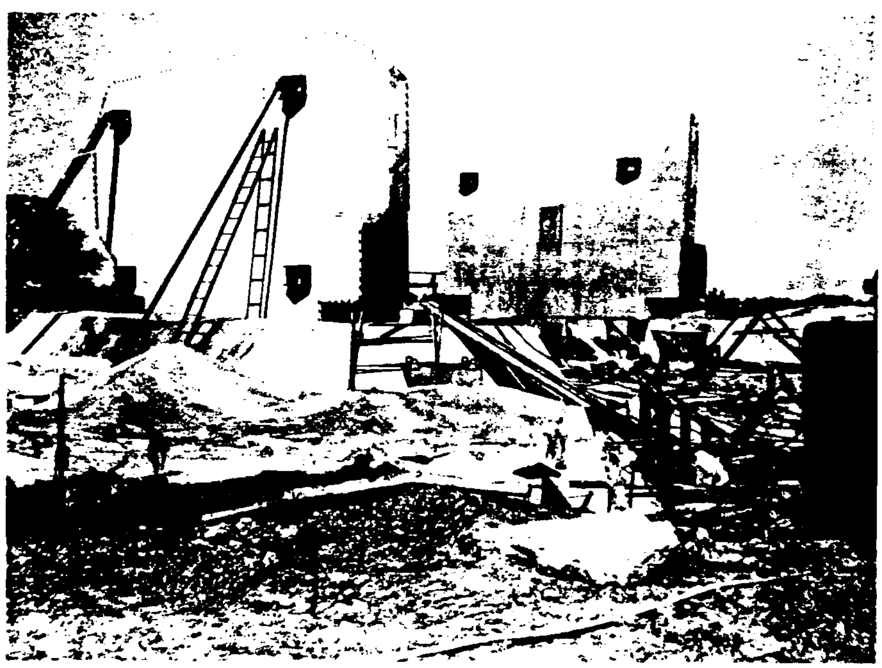


Fig. 59
Concrete Finish, Doors, Missile Silo #1, Site 1A

Curing was either water cure or with Edoco white pigmented curing compound. For those surfaces receiving waterproofing or dampproofing, the asphalt primer was used. (See Figure 60) Rainmakers or spray from perforated hose were utilized for water curing. Floor and foundation slab surfaces were flooded with water. Apparently the cure was effective as very little cracking of the concrete of any structure occurred.

DAMPPROOFING AND WATERPROOFING

Because of the seepage water conditions at Site 1A, all concrete structures were waterproofed. (See Figure 61) At Sites 1B and 1C the structures were dampproofed. The waterproofing and dampproofing operations proceeded exceptionally well and only minor problems were encountered. An asphalt primer was applied for both the dampproofing and the waterproofing. Two coats of hot asphalt were applied for the dampproofing. (See Figure 62) For waterproofing, five ply of thermoplastic bitumen treated fibrous glass membrane was applied with hot asphalt and protected on outside surfaces by fiber board. Inside foundation surfaces were protected by grout. Rock bolts were waterproofed with sealant.(See Figure 63)

MISCELLANEOUS

Ground Water

At Site 1A some trouble was experienced from the effects of seepage water during the placing of concrete and during the installation of some tunnels. The most serious trouble occurring during tunnel installation was that during the setting of Utility Tunnel #2, hydrostatic pressure raised the middle portion of the

tunnel approximately 4 inches. No corrective action was taken and tunnel was left in this position. During the installation of the Antenna Terminal the seepage water had to be collected in a temporary sump and pumped out before terminal could be set. In the Missile Silos water from tunnel drains, and that leaking through concrete walls, seriously hampered progress of welders working on the structural and pipe work. A modification was issued to contractor to repair water leaks where necessary throughout structures. Repair work consisted either of sealing leaks with epoxy grout or by channeling the water to the nearest sump.

At Sites 1B and 1C no ground water problems were encountered.

Tanks

At each site three Liquid Oxygen Storage tanks were installed. These tanks were 56'6" in overall outer shell length, 11'6" in outside diameter and weighed 125,000 pounds empty. Each tank, for shock mounting, was suspended by hangers from a structural frame. This structural frame was supported from the foundation slab by steel columns. (See Figure 64) The tanks were protected by a rolled steel channel shell. (See Figure 65) Two 30 ton cranes were used in setting tanks. (See Figure 66) The tanks were shipped by railroad to nearest siding and then transported by truck to the sites. (See Figure 67) Tunnel excavation and installation were underway during this period which limited space available for truck and cranes.

One RP-1 fuel storage tank was installed at each site. These tanks were 43'0" in overall length, 11' 6 3/4" in outside

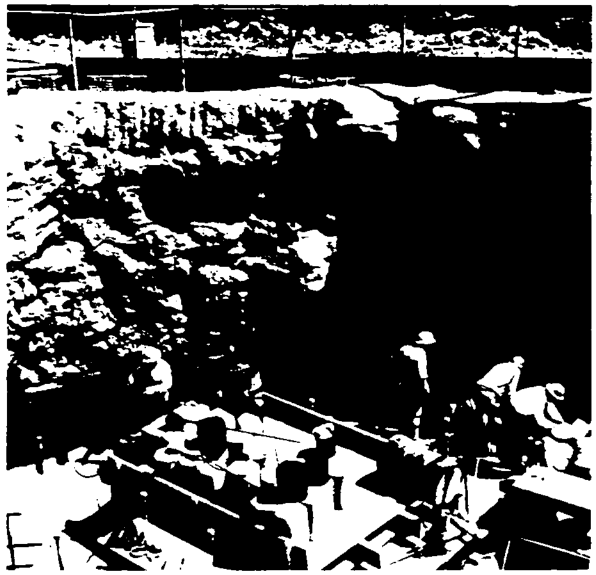


Fig. 61
Waterproofing, Site 1A, Propellant Terminal Footing

Fig. 62
Waterproofing, Site 1A

Fig. 63
Waterproofing, Rock Bolts, Site 1A

Fig. 64
Structural Frame, Liquid Oxygen Tank, Launcher #2, Site 1A

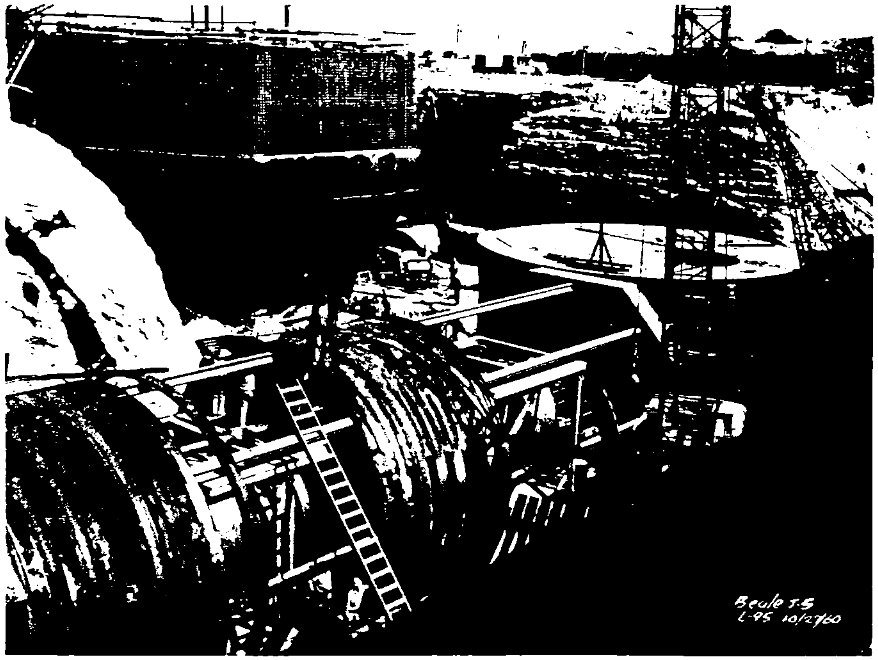


Fig. 65

Shell For Liquid Oxygen Tank, Launcher #1, Site 1A

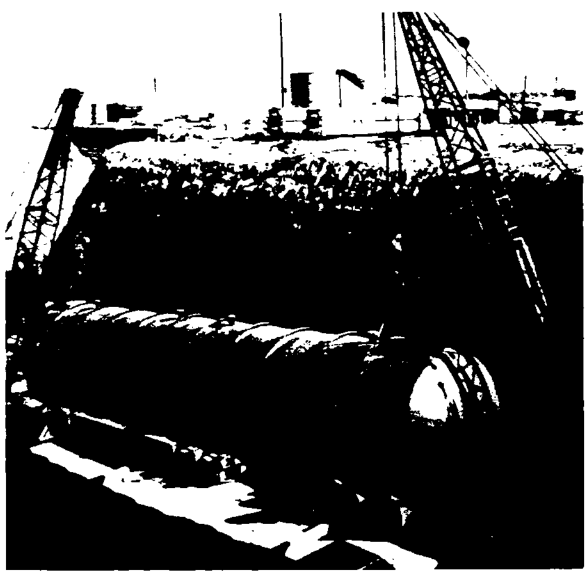


Fig. 66

Unloading Liquid Oxygen Tank, Site 1A

Fig. 67
Transporting Liquid Oxygen Tank, Site 1A

Fig. 68
Diesel Fuel Storage Tanks, Site 1B

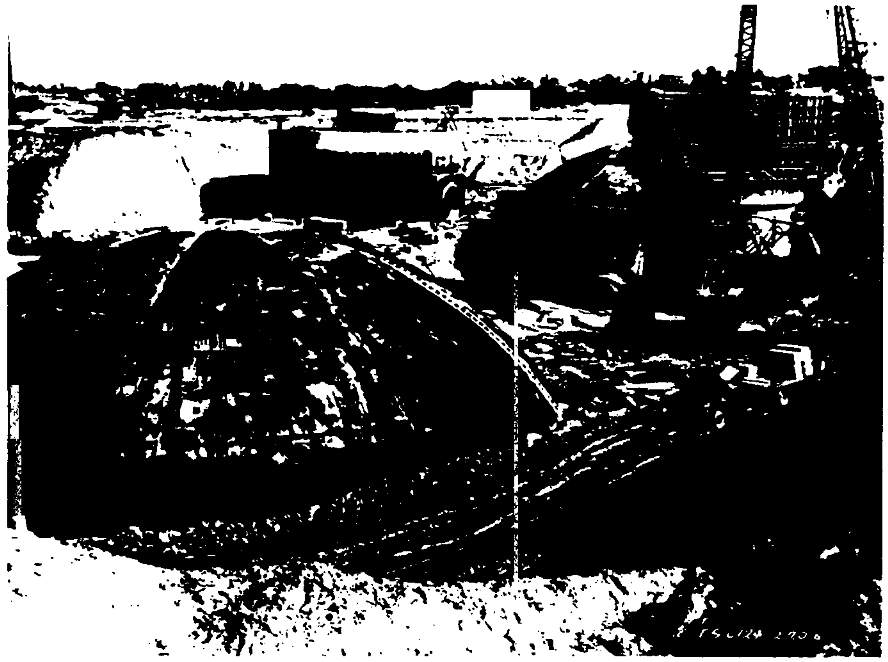


Fig. 60
Control Center, Powerhouse, Air Intake, Entry Portal Showing Use of Asphalt Primer for Cure

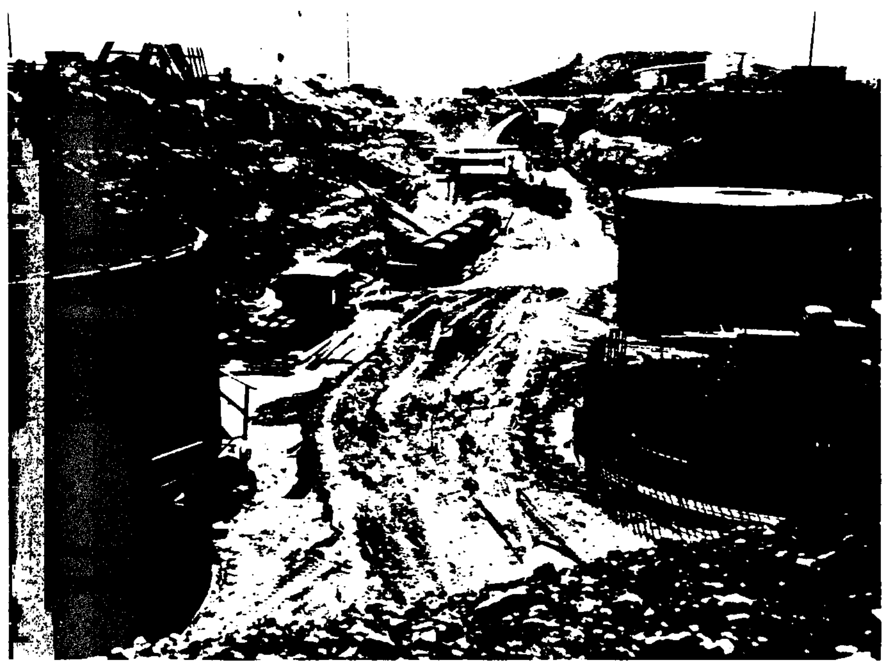


Fig. 69

Personnel Tunnel, Site 1C

diameter and weighed 34,728 pounds empty. Before the setting of these tanks it was discovered that the angle ring at front end of tank was misfabricated and would not clear tunnel junction bulkhead. The bulkhead openings were reworked to allow clearance for tank. No other problems were encountered.

Only minor problems were encountered in the setting of the two water storage tanks at each site. The overall length of the tanks at Site A was 61' 0" and outside diameter 12' 0". The overall length of the tanks at Sites 1B and 1C was 38' 0" and the outside diameter 12' 0".

Three diesel fuel storage tanks were installed at each site. (See Figure 68) Two of the tanks were 80' 0" in overall length and 12' 0" in outside diameter. The third tank was 24' 0" in overall length and 6' 0" in outside diameter. No unusual problems were encountered during installation.

7. STEEL TUNNELS

The Armco Drainage and Metal Products Company installed the steel tunnels and tunnel junctions. The tunnel system consisted of personnel tunnels (See Figure 69), utility tunnels, PLS interconnecting tunnels, ventilation tunnels (See Figure 70), tunnel junctions (See Figure 71) and Antenna Terminal. Two reinforced concrete blast locks, not part of Armco's work, provided blast protection from each launcher. (See Figure 72) In the ventilating tunnel system an air filtration structure provided for the air supply. (See Figure 73)

Armco established two fabrication yards, one at the Lincoln Airport to supply Site 1A and the other yard at Chico Airport to supply Sites 1B and 1C. At these yards the tunnel sections were assembled. Herrick Iron Works of Hayward, California fabricated the tunnel junctions at their Hayward, California plant. Tunnel sections were transported to the sites by truck. Tunnel junctions were shipped by railroad to nearest rail siding and then by truck to site.

The tunnel sections installed for the tunnel between Tunnel Junction 10 (Power House - Control Center) and the Antenna Terminal were preformed in the shop to a 3 percent larger vertical diameter. The tunnel section for remaining tunnels, with exception of the ventilating tunnel, were fabricated with ring beams, spaced 14 feet. (See Figures 74 and 75)

At Site 1A the installation of the steel tunnels started on 9 August 1960, at Site 1B on 15 September 1960 and at Site 1C on

6 September 1960.

At Site 1A difficulty was experienced in connecting the tunnels to the tunnel junctions. At this site a 2 1/2" round neoprene gasket was specified between connection of tunnel and inside rolled channel at opening of tunnel junction. The neoprene gasket was finally discarded and in lieu a steel ring was welded from end of channel to tunnel. At sites 1B and 1C, the ring neoprene gasket was not specified, and connections were made without difficulty.

After backfilling, some settlement occurred. At Site 1A the Antenna Terminal, the Air Exhaust Tunnel Junctions and the Air Intake Tunnel settled approximately 5 inches. In addition, the Air Exhaust Tunnel Junction into the Power House and the Air Intake Tunnel at both ends flattened about 7 inches at top. The only corrective work was done in the Air Intake Tunnel. Additional supports and neoprene waterstops were added. At Site 1B the Antenna Terminal settled approximately 4 inches. Grout was flowed under this structure to stabilize settlement. At Site 1C, the Air Intake Tunnel settled approximately 5 inches. However, the flattening effect at top was not as severe as at Site 1A. Additional supports were installed. No repair of the neoprene seal was required.

Construction control records indicated that compaction requirement had been met under all structures that settled.

Fig. 70

Ventilation Tunnel, Site 1A

Fig. 71

Tunnel Junction #10, Site 1A

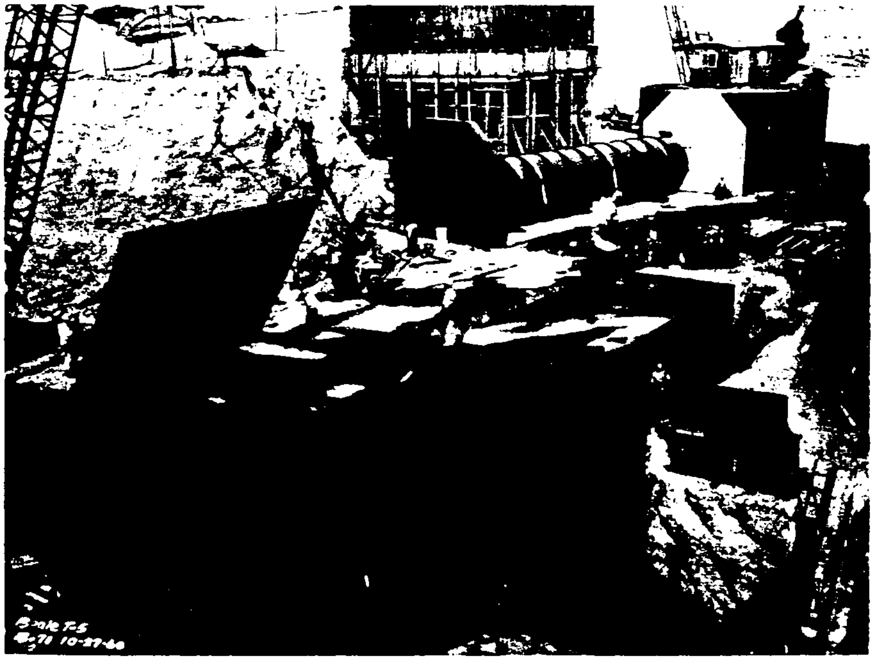


Fig. 72

Blast Lock #1, Site 1B

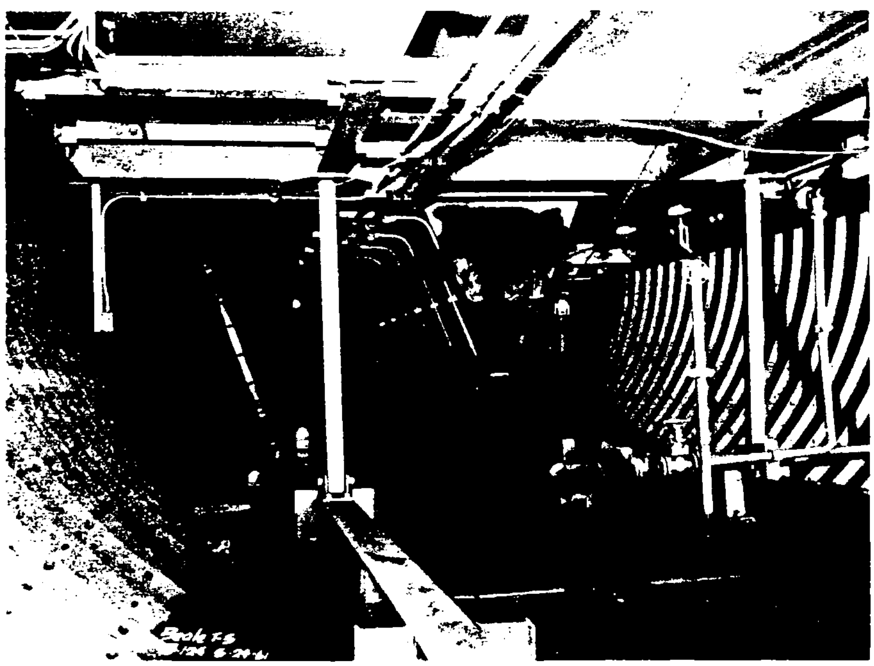


Fig. 73

Air Filtration Structure, Site 1B

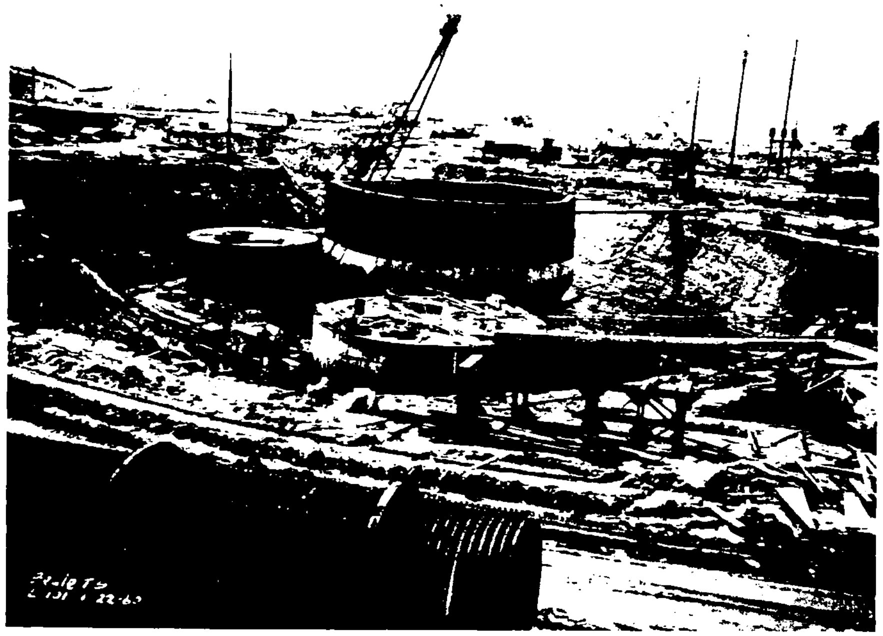


Fig. 74
Steel Tunnel Section Showing Ring Beams, Site 1A

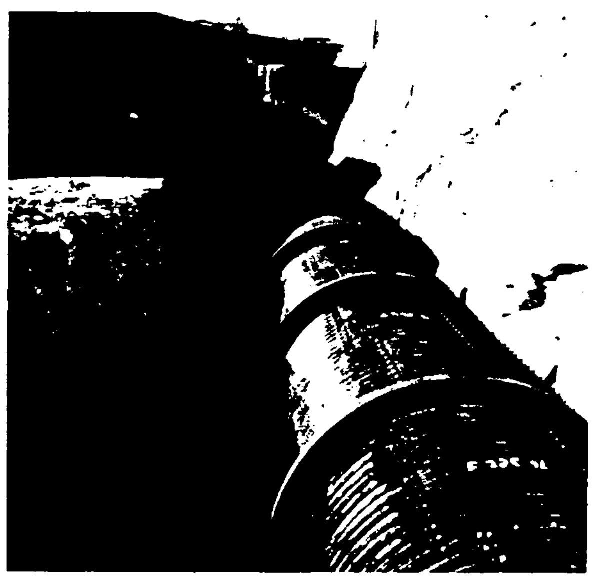


Fig. 75
Steel Tunnels Showing Rings, Site 1A
Blast Lock #2 to Tunnel Junction #2

8. STRUCTURAL STEEL

The structural steel was installed by the Keystone Fabricating Company of Compton, California.

In the Missile Silos all structural steel to elevation five feet was installed in the first sequence. This consisted of the pump platform and floor framing members. From this elevation and using the floor framing members as supports, a temporary working platform was erected. The inner columns of the working platform were constructed of six inch pipe and these were connected directly on the floor framing members. The outer portion of the working platform was attached to the wall unistrut around each level of the working platform. These levels of the platform were at twenty four foot intervals. The Lox and Fuel Cribs were installed in sections concurrently with the working platform. The tolerances of the crib-sections were 1/8 inch for outside dimensions and 1/4 inch for vertical alignment. (See Figure 76) 84 guide rail brackets for each Missile Silo were then installed on wall plates and these were set to a tolerance of 1/4 inch for elevation. (See Figure 76)

In the Power House a reinforced concrete main floor was supported from the pipe chase slab by reinforced concrete columns. The pipe chase slab was supported from the foundation slab by structural shock beams, designated as shock units "B". (See Figure 77) A reinforced concrete generator foundation slab was supported from the foundation slab by structural shock beams designated as shock units "A". (See Figure 78) The mezzanine

floor consisted of checkered plate fastened to light and wide flanged beams. These beams were supported from the main floor by 8" I.D. standard pipe columns. An Austin Western Hydraulic crane was utilized in erecting the structural steel for the mezzanine floor.

The reinforced concrete floor of the first level of the Control Center was supported from the foundation slab by structural shock beams. (See Figure 79) The upper level floor was supported by wide flanged steel beams which were supported from the main floor by 10" I.D. pipe columns, extra strong. The outer portion of the upper floor was cantilevered. The Austin Western Hydraulic crane was used from the lower floor in erecting the structural steel.

The lower floor of the Propellant Terminal was supported from the foundation slab by 114 coil springs. (See Figure 80) The structural framing for the upper floor was supported from the lower floor by square and WF columns. Horizontal spring units were installed. These units were connected from the structural framing to wall plates embedded in the reinforced concrete wall.

The floor of Level I of the Equipment Terminal was supported from the foundation slab by structural spring beams. The structural framing for floors of the other three levels was suspended from structural spring beam cross members. The spring beams were welded to wall plates. The columns were connected to hangers by a pinned connection and the hangers to the underside of the spring

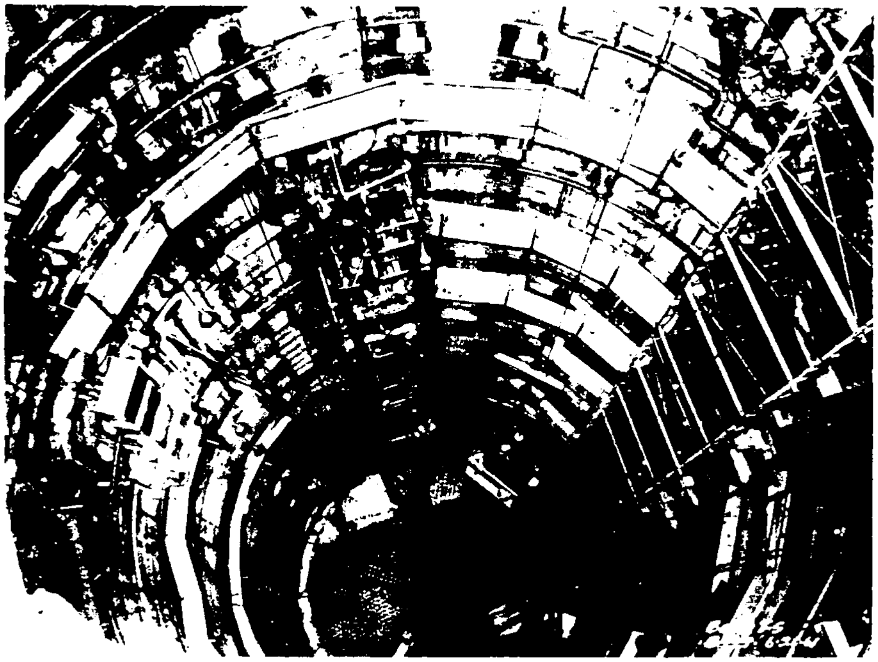


Fig. 76
Liquid Oxygen Fuel Crib, Missile Silo #1, Site 1B

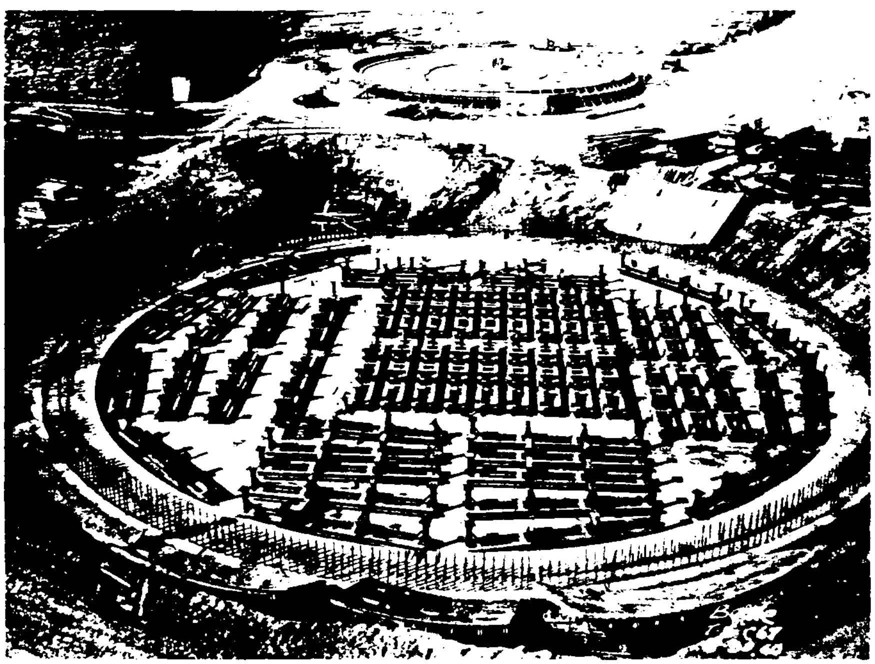


Fig. 77
Spring Beams, Powerhouse, Site 1C

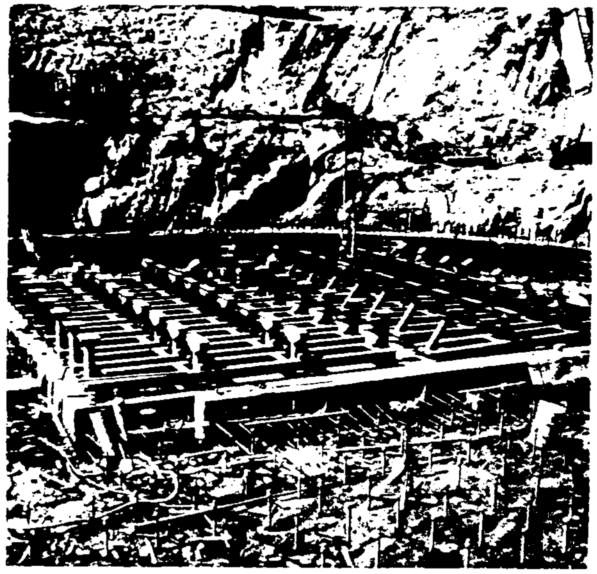


Fig. 78

Spring Beams, Powerhouse Generator Slab, Powerhouse, Site 1A

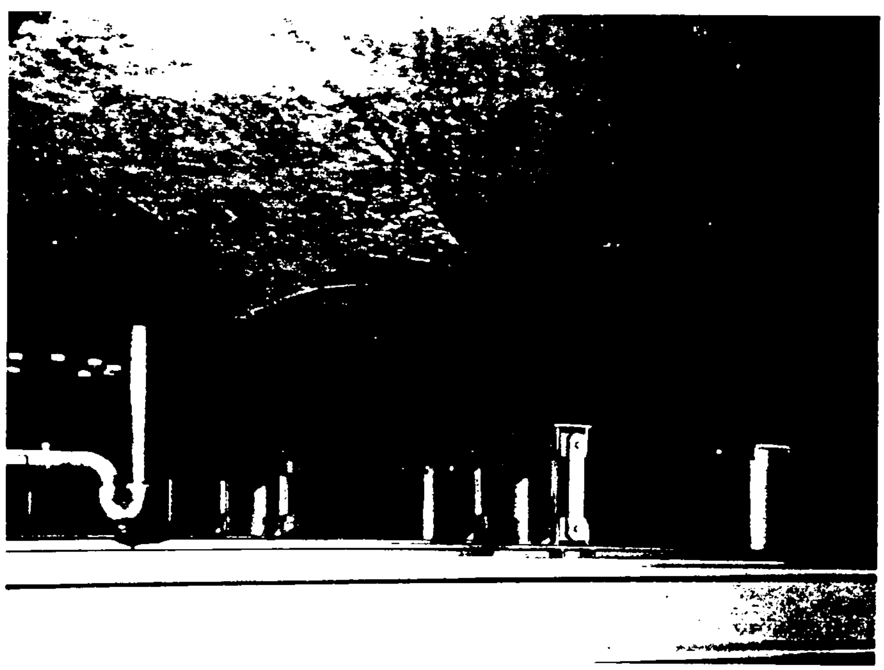


Fig. 79

Spring Beams, Control Center, Site 1C

Fig. 80

Coil Spring Mounts, Propellant Terminal, Site 1A

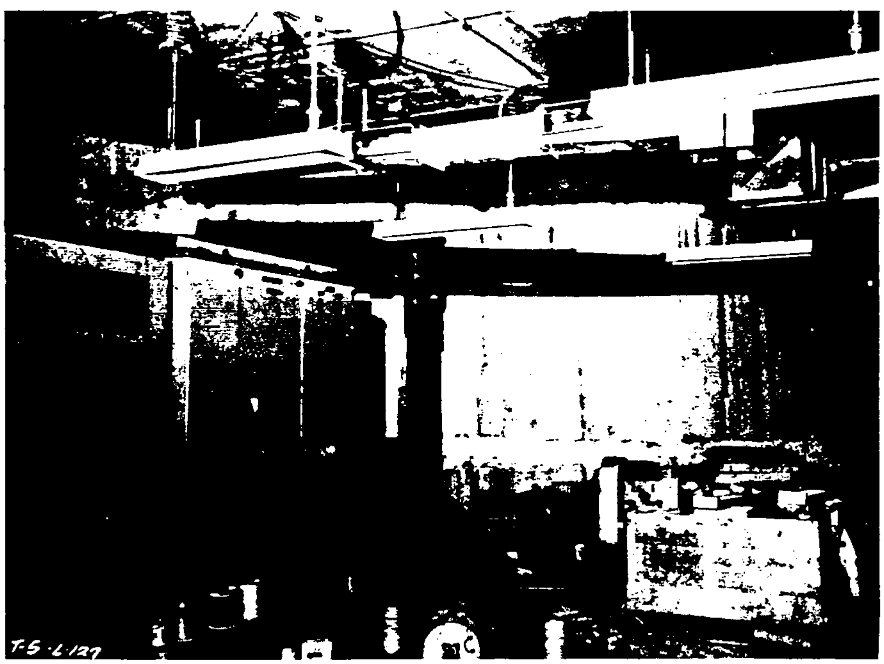


Fig. 81

Spring Beam, Equipment Terminal #1, Site 1A

beam by a pinned connection. (See Figure 81) The structural steel was erected prior to constructing the reinforced concrete roof.

The greatest difficulties encountered during the structural steel erection were setting the lox and fuel cribs in the Missile Silos to required tolerances and in reworking the structural shock beams in the Control Center. All cribs were reworked extensively before the tolerances were met. The pin connections of the shock mounts were found to be binding, requiring reaming of the pin holes to allow freedom of movement.

9. PROPELLANT LOADING SYSTEM

GENERAL

The purpose of the PLS was to store the missile propellants and auxiliary fluids and to transfer these fluids from the storage vessels to the missile. The system started at grade level with the storage vessel fill lines and terminated at the interface connections located in the missile silo. The propellants handled were liquid oxygen (-297°) and RP-1 fuel (high boiling point, aliphatic hydro-carbon). The auxiliary fluids were liquid nitrogen (-320°F), gaseous nitrogen and gaseous helium. A filtered compressed air supply was required for the actuation of the system's automatic control valves.

It was extremely important to keep this system clean at all times. The cleanliness requirements were far beyond those usually associated with the normal field construction requirements. The contamination limits were not to exceed the following:

1. Liquid oxygen, liquid nitrogen, gaseous nitrogen and gaseous helium systems:

   a. Total Hydrocarbons - 75 PPM(by weight as carbon)

   b. Acetylene - 1.0 PPM Illosvay method

   c. Total Solid Particles - 25 PPM(by weight)

   d. Particle Distribution - Maximum dimension in any one of three planes - 150 microns

2. RP-1 Fuel System

a. Total Solid Particles - 25 PPM(by weight)

b. Particle Distribution - Maximum dimension in any one of three planes-150 microns

To assure that the piping and components met the stringent cleanliness requirements imposed upon the system, inspection techniques other than normal construction inspection were utilized. The following inspection methods were employed:

1. Visual - examination of all equipment for evidence of corrosion products, foreign matter and physical mechanical defects that constituted a reactive or functional hazard to the system. Optical devices such as angle mirrors, white light, lucite rods for directing light in a curved beam and boroscopes were used to examine normally inaccessible areas.

2. Black Lite - visual examination with the aid of an ultra-violet light source. Light source was a long wave (3660 angstrom units) utilizing a spot bulb to concentrate the light source upon the inspected area. This inspection was used to detect hydrocarbons, as most common hydrocarbons fluoresce under black light radiation.

3. Wipe Test - The area under examination was wiped, using a medium pressure, with a hard-surfaced, clean, filter paper. The paper was then examined under an optical comparator to determine particle size.

4. Millipore Method - During cleaning, a sample of the effluent of the cleaning media was passed through a millipore

filter pad. This pad was a specially constructed cellulosic porous membrane containing millions of capillary pores. The pad, after the media had been filtered through, was examined under an optical comparator to determine particle size of the contamination caught on the filter. This method of examination was used throughout and was particularly important on equipment that had inaccessible internal surfaces which could not be examined using visual and wipe test methods.

SYSTEM STORAGE VESSELS

The cryogenic and high pressure vessels and system sub-coolers were Government furnished equipment, supplied to the contractor for installation. The vessels were located in an underground area designated as the Propellant Terminal. They were filled or charged through lines that had their fill connections at grade level. All fluids prior to entry into the vessels were passed through a 40 micron filter located in the fill lines.

The storage vessels and sub-coolers were completely installed before the PLS piping was connected to them. Correct location of these units was therefore essential. The placement and locating of this equipment were accomplished without any extreme difficulties.

A problem arose in the contractor's acceptance of the Government furnished vessels. The construction contractor was reluctant to connect his clean PLS piping to the vessels without making a cleanliness examination of the vessels. Therefore, although accepted at the factory as meeting the standards for cleanliness, the contractor employed an independent laboratory to

inspect the vessels. The blind flanges on the vessel connections were removed and the accessible areas given a visual, wipe and black lite inspection. Any contamination encountered was removed by cleaning the localized contaminated area with a suitable solvent, vacuuming, and/or brushing with a stainless steel or nylon brush.

After the areas were found acceptable, a blow down was made of the vessels. The vessels were charged with clean, dry, filtered GN_2 and a pad taken at the vessel's discharge connection. The GN_2 was blown to atmosphere through the blow down pad. When the analysis of the pad showed no particles over 150 microns and no hydrocarbons evidenced by black lite, the vessels were considered acceptable for connecting the PLS piping.

PLS PIPING

All piping was prefabricated and cleaned at a location centralized to the construction sites. The piping was fabricated into spool sections that could be easily joined by welding or bolt up in the field. After fabrication, the spool pieces were cleaned and then transported to the sites.

Due to the cryogenic temperatures, high pressures and shock loading requirements the liquid oxygen, nitrogen and gaseous oxygen, nitrogen, helium piping was fabricated from ASTM A-312, Type 304 stainless steel. The RP-1 pipe was fabricated from ASTM A-53 seamless carbon steel pipe. All shop and field welding was accomplished using a tungsten-inert-gas shielded arc welding process. To eliminate the use of backup rings, the pipe was purged with an inert gas during the welding operation. Argon was

used as the inert gas.

The major problem encountered at the fabrication shop was carbide precipitation of the stainless steel pipe in the welded area. Although this condition did not adversely affect the physical strength at the weld area, it was difficult to clean the precipitated areas of the pipe. Exposure to the acid pickling solution attacked the precipitated area and produced a granular or sugared surface. Upon taking a wipe test of this area, it was impossible to find the filter paper free of particulate contamination. The condition of sugared welds was resolved by controlling the welding operations so the dwell time that the weld zone was subjected to the sensitizing temperature which produced the precipitation was kept at a minimum. Air cooling and water application between each weld pass were used as methods to control the time in the critical temperatures. Immersion time in the acid pickling agent was also controlled to keep exposure in the acid at the minimum time necessary to provide cleaning action. This reduced the corrosive attack upon the precipitated areas and did not leave the sand or sugared appearance in the weld areas.

The prefabricated spools were cleaned and sealed prior to shipment to the sites. Cleaning was accomplished by the following procedure:

1. Stainless Steel Pipe

   a. Mechanical descaling

   b. Degreasing (Vapor degreasing with Trichlorethylene)

   c. Acid Pickling (Solution of HNO_3 and HF)

   d. Demineralized Water Flush

   e. Drying (Hot, clean, filtered Air)

   f. Inspection

2. Carbon Steel Pipe

   a. Caustic Bath

   b. Mechanical Descaling

   c. Acid Pickling (Solution of HCL and inhibitor)

   d. Neutralizer

   e. Rust Inhibitor Coating(Phosphate salt Solution)

   f. Dry (Hot clean filtered air)

   g. Inspection

After acceptance the open ends of the spools were sealed with a blind polyethylene gasket, taped, blind flanged and covered with a polyethylene bag. The spools were then transported to the construction sites by truck.

The problems encountered at the cleaning facility primarily dealt with quality control. The final inspection area had to be kept clean and free of fallout from the incoming air supply. No cleaning was to be performed in the final inspection area. A constant check of the acid strength, temperature and contamination level was made. Hourly determinations of specific gravity and

temperature, and a daily titration analysis were used to determine when the acid tank should be drained and refilled. These precautions were an absolute requirement and it was only through the concentrated efforts of all concerned that this was achieved.

At the sites the spools were stored in the following manner to protect them from damage and contamination:

1. Polyethylene sheets were placed on the ground.

2. Wooden stringers of sufficient depth to prevent flanges of stainless steel pipe from touching the ground were placed on top of the polyethylene sheets.

3. The pipe was placed on the stringers. Several layers of pipe were placed one on top of the other, taking care to prevent damage to plain ends and sealed flanges.

4. The pipe was then completely covered with canvas tarpaulins.

The spools were bolted or welded together in their actual underground field location in the launcher area. Prior to the start of work, the work area was cleaned and a protective polyethylene tent placed over the work area. When the sealed ends c the spools were opened and inspected, a flow of clean, dry, filtered nitrogen gas was maintained within the pipe. The pipe sp was given a visual, black-lite, and wipe test examination prior field welding or bolt-up. If there was evidence of minor contan nation, limited field cleaning was performed. No major pipe recleaning was accomplished in the field. Pipe spools requir extensive recleaning were sent back to the cleaning plant for

reprocessing.

When installation of a pipe spool was made to that portion of the system already installed, argon gas was used as the purge media. After completion of the joint make-up and during stand-by, the system was maintained with a positive pressure of argon gas to prevent contamination from being introduced into the system. The unconnected ends were kept sealed until the next section was ready for installation.

After the start of field installation, in an attempt to reduce installation costs, nitrogen gas was approved for use as the welding backup gas and system blanket media. The cost of the argon gas was approximately ten times the price of the nitrogen gas.

This use of nitrogen gas presented field problems not associated with the use of argon gas. The nitrogen gas, not being a chemically inert gas, caused the formation of nitrides during the welding operations. As the nitrides created a hazardous condition in the presence of liquid oxygen, they were not acceptable. Also the techniques using nitrogen gas as a backup during welding are more critical than with argon. With nitrogen, the gas inclosure surrounding the weld zone could not be maintained completely void of oxygen. Therefore, there was a development of undesirable oxides during the welding operation. After discovery that there was oxide and nitride contamination due to the nitrogen gas welding, the approval to use nitrogen gas was revoked. Those welds installed using nitrogen as a backup gas were removed from the system and replaced with argon backed welds.

Problems of mis-fabrication and interferences in the field necessitated the refabrication of many pipe spools. As alignment was a critical requirement, to prevent forcing of pipe into place during installation, pipe was field reworked or returned to the shop for refabrication to correct mis-alignment. Design interference and interferences created by layout drawings not complying with the contract plans also necessitated the rework and/or complete refabrication of pipe spools. Spools reworked in the field were routed to the cleaning facility for cleaning prior to installation in the system.

The contractor fabricated some pipe spools to connect to Government furnished equipment for which he was supplied the manufacturer's drawings prior to actual receipt of the equipment. The equipment received did not always conform to the manufacturers' drawings and necessitated some refabrication of pipe spools. As the Government furnished the system vessels, the cost for this refabrication was done at the expense of the Government.

Because of the expansion and contraction of the cryogenic lines and shock loading requirements of the complete PLS, extensive use was made of expansion joints and flexible metal hose in the piping system. As the design movements of the joints and hose were based on predetermined installed dimensions, the proper installation was critical. The joints and hoses were not used to make up construction misalignment or any deficiencies in the prefabricated pipe spools.

A problem was encountered in the cleanliness acceptance of

the hoses and joints at the construction sites. Although the units were cleaned at the point of manufacture, and sealed, upon inspection at the sites the units were found to be contaminated. Recleaning of some of the expansion joints and all the flex hoses was accomplished. The convolution type construction of both the flex hoses and expansion joints made the cleaning and inspection extremely difficult. Cleaning was accomplished by blowing hot, clean, dry, filtered nitrogen gas through the units while simultaneously rapping or vibrating the item. Inspection was performed by flushing isopropyl alcohol through the hose and taking a millipore extraction of the effluent of the flushing media. If the millipore filter was found acceptable, the item was dried, sealed and delivered to the sites for installation.

PLS SYSTEM COMPONENTS

All the valves, filters, pumps and associated PLS equipment were furnished by the Government to the construction contractor for installation. All the equipment was received from a common supplier who acted as a broker to handle all the varied items to be supplied. All the items were certified at the point of manufacture as being clean, and arrived at Beale sealed in accordance with the specifications.

Upon receipt at the construction site, the contractor refused to install the items without first performing his own inspection to assure that they met the required standards of cleanliness. A facility was set up to handle and process the items for inspection and any necessary recleaning. Visual, wipe, black lite and

millipore examinations were made on each item.

All the items required a flushing with isopropyl alcohol as they did not pass the initial millipore examination. Numerous fibrous particles in excess of 150 microns were evidenced during the millipore extraction. After a thorough investigation of the flushing facility and the procedures used, it was determined that the fibrous contamination was introduced by the alcohol. The fibrous particles were an inherent characteristic of the alcohol. The use of other flushing reagents was researched but the advantages of the alcohol outweighed the problem with the fibrous contamination. Two millipore filters in series were installed in the alcohol system. With a constant recirculation and frequent changing of the alcohol, it was possible to obtain a clean media for the inspection and cleaning procedures.

Additional time and effort was expended in removal of fluorescent stains that were present in the PLS valves. The alcohol would not remove this hydrocarbon contamination. Trial attempts were made with other cleaning agents such as trichloroethylene acetone, hydrochloric acid and caustic solutions without success. The installation of an ultrasonic cleaner, utilizing chlorothane as the wetting agent, successfully removed the fluorescent contamination.

A field installation problem was encountered with the socket weld control valves manufactured by Powell Company. Excessive heat concentration in the seat area, during the field welding of the PLS piping into the socket weld body, caused distortion of the

seating surface. This resulted in an excessive leakage past the seat. Shop welding, with controlled heat conditions, of a nipple pipe spool into the valve body prior to field installation eliminated the field distortion problem. Those valves installed without the nipple piece that had distorted seats were lapped in place to provide the proper seating surface necessary to prevent excessive leakage.

The Kieley-Mueller, Inc. automatic control valves failed at the valve seat and plug. This failure occurred after all the valves had been field installed. The material of the seat and plugs of the furnished valves were not of the stellite-surfaced material required by the specifications. During valve operation, the pressure on the control diaphragm closing the valve exerted a force that caused the "soft" plug and seats to scour and break on contacting each other. All the valves were disassembled and inspected in their installed position for damage. Damaged seats and plugs were replaced in approximately 25% of the furnished valves.

Considerable difficulty was encountered with the components that were connected to the piping with threaded joints. (Such as Pressure Regulating Valves, Control Valves and Check Valves) Design criteria specified that no lubricants or sealants were to be used on threaded joints. During acceptance testing, the dry joints presented a serious leakage problem. As these units were not provided with break outs for easy removal, endeavors were made to seal the leaks in the installed position. An attempt to

back-solder or braze the joints proved unsuccessful. The excessive heat build-up during the brazing operation caused distortion to the body and/or internal parts. The system was then cut and the components removed. When they were reinstalled, teflon ribbon was used as a thread sealant. Extreme care was used during the application of the ribbon to assure that no particles would propagate into the system. The ribbon provided an adequate installation to prevent leakage at the threaded joints.

The laborious task and expensive cost of removing those components that were threaded to the PLS piping resulted in the decision to install break-out connections for certain components. As the PLS installation was complete, only items that required removal for the correction of deficiencies or where it was determined that future maintenance functions would necessitate removal, were removed and provided with break-out flanges. This clearly indicates the requirement at any future installation for the use of break-out connections on components that are welded or threaded to connecting system piping.

Strainers in the high pressure gaseous helium subsystem presented a serious leakage problem. The specified teflon gasket between the strainer body and element would not provide the necessary seal to prevent leakage at the 3000 to 6000 psi pressure ranges. The installation of a stainless steel backup ring was used in an attempt to resolve the leakage problem. This did not stop the leakage and a material substitution was made for the teflon gasket material. A viton gasket with the stainless steel

backup ring prevented leakage under the high pressure condition. Neoprene was not used as a gasket material as it was difficult to obtain the neoprene free of undesirable hydrocarbons.

FILTERED COMPRESSED AIR SUPPLY

The copper tubing used for the PLS instrument control air was installed at the sites using an accepted method for field soldering. The use of the flux left an undesirable contamination in the tubing. It became necessary to remove that tubing which had been installed. The tubing was recleaned and installed using a fluxless soldering method. This technique, used with a nitrogen gas backup purge in the pipe during the soldering operation, produced a clean interior surface at the soldered joint. This method of joining the tubing was used for subsequent installations.

The contractor was also required to refabricate some of the tubing because of a misfabrication. The contractor used a constant diameter tube in connecting the automatic control valves to the supply header. Generally, this diameter was of insufficient size to assure the proper volume of air to provide the critically timed valve actuation. Therefore he was required to refabricate the tubing to get the proper cross-sectional area to assure sufficient air supply to the valves.

GUIDES AND ANCHORS

The location of the guides and anchors for PLS pipe presented more difficulties than is normally encountered in construction. Because of the critical alignment requirements, it was important not to deviate from designed location and configuration

of the necessary pipe supports and guides. As a design stress analysis of the PLS was not complete at the time of installation, makeshift pipe supports were used during the initial pipe installation. The after-the-fact determination of the location and type of supports instigated numerous field modifications to the final prescribed supports and guides.

To expedite installation the Government and Architect-Engineer provided a field team to resolve field problems. Solutions to interferences and additions required for adequate support and guide of the piping were determined at the sites. The exacting location and outline requirements of the supports resulted in some elevation changes to PLS piping already installed. This necessitated the removal, refabrication and reinstallation of some spool pieces to make the final installed elevations meet those specified by the contract plans.

PLS TESTING

Final acceptance testing of the PLS was performed upon the completed installations to insure that they would hold a proof pressure, that they did not leak at working pressure, and that they were clean. All associated equipment used for testing was cleaned to the same standards of cleanliness as the system prior to making any connection to the PLS. All test gauges were calibrated within the acceptance standards of the industry. All system filter elements were removed and the safety valve connections capped prior to testing.

Prior to pressure testing and cleanliness checks of the

system, all the system gauges, pressure controllers, liquid sensors and automatic control valves were verified that they were still within the calibration requirements of the specifications in their installed positions. Electrical continuity checks were made to assure that all the electrical equipment functioned properly.

The proof pressure was a pressure specified for each subsystem and was normally 1¼ times the working pressure. If the subsystem held a proof pressure for five minutes, the pressure was reduced to working pressure. At working pressure the entire subsystem was checked for deformation due to proof pressure testing. Leak checks of all connections at working pressure were then performed. In checking for leaks, a tape was placed encircling the complete flanged joint. A pinhole was punched in the tape and leak-tek applied over the hole. A formation of bubbles would indicate that nitrogen gas was escaping at the joint. If a joint indicated any leakage, the pressure was bled from the system, the leak repaired and a re-leak check performed.

A blow horn was installed, usually at the interface in each complete line of each subsystem to check the cleanliness of the lines. The blow horn was designed to hold a multi-layer gauze pad upon which the contamination could be trapped. The line was blown with nitrogen gas that passed through the blow horn for a certain amount of time or through a certain pressure drop at the pressure source. The pad was removed for a laboratory analysis of the contamination present. If no particle larger than 150

microns and no hydrocarbon were detected, the pad was accepted. The dew point of the gas remaining in the lines was then determined and a gas sample extracted. The gas sample was analyzed with an infrared spectrometer for evidence of hydrocarbon and acetylene. If the particle size, hydrocarbon, acetylene and dew point met the requirements of the specifications the line was accepted.

Upon acceptance of the individual lines, the subsystem was placed in stand-by condition. All system safety valves and strainer elements were installed and a revalidation leak check made of the broken connections. Revalidation checks were made at pressures just below the safety valve set pressures. The system was then maintained with a positive pressure blanket of clean, dry, filtered nitrogen gas.

A cold test was conducted on the liquid oxygen and liquid nitrogen subsystems. These tests were performed to validate the operational function of these subsystems when subjected to cryogenic temperatures as well as the air cleanliness. Particular attention was made to conditions of the expansion joints, pipe supports and guides during and after the cryogenic liquid flow through the system. Liquid samples were taken of the liquid nitrogen test media at the missile silo inter-face of the piping. It was analyzed for contamination and if the sample met the requirements for system cleanliness the subsystem was accepted. The subsystem safety valves and strainers were installed and the subsystem validated and placed in stand-by.

The liquid nitrogen for the cold tests and conversion to gas for the proof, leak and blow down tests was supplied by the Air Force. Liquid nitrogen was used in lieu of liquid oxygen because of the obvious safety hazards connected with the handling of LOX. The liquid nitrogen was produced at the Nimbus, California facility of the Air Force and delivered by truck to the construction contractor at the sites.

As the procurement specifications for the liquid nitrogen were not as rigid as the PLS cleanliness specifications, the liquid required filtration prior to being introduced into any subsystem. Difficulty was encountered in filtering the liquid to meet the necessary standards for cleanliness. All filters installed between the tankers and subsystems were Government furnished. This was originally intended to meet the Government's obligation to supply the construction contractor with clean media by providing adequate filtration at the site.

A pot type, 40 micron absolute filter, with a stainless steel dutch weave type element was placed between the delivery tanker and the charge connection to the subsystem. A liquid sample taken downstream of this filter showed evidence of contamination in excess of the construction contract requirements. A millipore filter, especially designed for the filtration of micronic sized metallic and fibrous particles, was installed in series, downstream of the pot type filter. This filter consisted of a dual pre-filter and millipore filter pad element (4 micron diameter pores) approximately 8 inches in diameter. With close

surveillance made of the sampling techniques and laboratory analyses, liquid samples taken downstream of the millipore filter were found acceptable.

In testing the RP-1 fuel loading system, the cleanliness was determined after the system had been circulated with RP-1 for a period of two hours through at least one system filter. At the end of this period an examination was made of the system filter element and also a liquid sample taken at the effluent of the system. Although clean liquid samples were obtained from the system, the millipore extraction of the filter elements contained particles in excess of 150 microns. This required the system to be recirculated. After repeated and prolonged periods of flushing, the millipore examination of the filter elements showed no decrease in the particle contamination. To expedite the progress of the testing program and in accordance with operational requirements a visual inspection of the element in lieu of the millipore examination was instituted.

The visual inspection of the filter element and clean liquid sample were acceptable methods upon which the cleanliness requirements of the using agency could be determined. Their criteria were not as strict as the construction specifications.

As with the liquid nitrogen, the RP-1 was delivered by the Government to the construction contractor at the sites. The RP-1 was circulated at the site to obtain a test media that met the cleanliness requirements imposed by the construction specifications. The difference between the Air Force procurement speci-

fications and the construction specifications caused considerable delay to the testing schedule while efforts were made to clean the fuel. Clean fuel samples were obtained only after four to eight hours of circulation through an Air Force filtering and dewatering unit.

Evaporation loss tests were performed on the liquid oxygen storage tanks. This was a seventy two hour recording of the evaporation loss or boil-off of the liquid contained within the tank. The tank was filled to capacity with liquid nitrogen. Upon stabilization of the liquid temperature, the readings for the seventy two hour test were started. The data obtained during this test was converted to a percentage of boil-off of liquid oxygen under conditions of standard temperature and pressure. All the vessels checked were within the specified evaporation loss rate of 0.25% by weight per day of liquid oxygen.

The tests, as outlined above, and performed on the PLS were the following:

1. Control system testing

   a. Continuity checks and field verification of component calibration.

2. Gaseous nitrogen subsystem

   a. Pressure storage vessels

   b. Propellant transfer pressurization piping

3. Gaseous nitrogen subsystem

   a. Pressure storage vessels

   b. System blanket and purge piping

4. Liquid oxygen subsystem

   a. Liquid storage vessels

   b. Transfer piping

5. Liquid nitrogen subsystem

   a. Liquid subcoolers

   b. Fill piping

6. Helium subsystem

   a. Pressure storage vessels

   b. Transfer piping

7. Fuel loading subsystem

   a. Gaseous nitrogen for fuel system blanket and purge.

   b. Circulation of fuel system with RP-1

8. Cold test of liquid nitrogen subsystem

9. Cold flow test of liquid oxygen subsystem

10. Revalidations

11. System standby configuration

12. Evaporation loss

The final acceptance testing at each site was conducted from a central control location. From this test control center, testing was directed in all three launcher areas simultaneously. A closed circuit telephone system tied the individual launcher stations to the test conductor at the test control center. This enabled the test conductor to coordinate activities without undue time loss. In conjunction with the test control center, a laboratory trailer was located at each site to perform the analysis of

the blow down pads and other required analyses under carefully controlled environmental conditions and procedures.

A total of 52 blow down sequences were required at each launcher area. An average of six blow downs were made during each sequence before an acceptable pad was obtained. No extreme difficulties were encountered in meeting the specified standards for cleanliness. Problems were encountered with the non-performance of components which are detailed in the section entitled "System Components".

During testing, the using agency questioned the cleanliness of the liquid oxygen storage tanks. Although the vessels were cleaned at the point of manufacture and had been previously inspected at the sites by the contractor, the using agency prevailed and the tanks were entered for inspection. Six tanks at two sites were physically entered. A black-lite, visual, and wipe examination was made of the interior surfaces, interior piping connections and the pressurization header. Only one vessel showed evidence of contamination. A cup-full of sand was found in the tank sump. This was leftover from the sand blasting used as a cleaning method for a few of the first tanks fabricated. The sand was easily removed by vacuuming and wiping the area with trichloroethylene and a blow down of the discharge nozzle for final acceptance.

The Government furnished to the contractor the following equipment for use during PLS testing: Tube Bank Trailers (13); Nitrogen Rechargers (6); Helium Compressors (3); Liquid Nitrogen

Trailers (7); RP-1 Trailers (4); Liquid Nitrogen Filters (9); Gaseous Filters (7). The contractor operated and maintained the equipment. Down time for maintenance of the equipment was within the acceptable time for the operation of construction equipment and did not delay the testing schedule.

The equipment furnished provided the necessary quantities required for the testing program. All equipment performed satisfactorily except for the liquid filters. The problems encountered with the filters were discussed previously in connection with the Government furnished liquids.

Representative photographs of the Propellant Loading System follow.

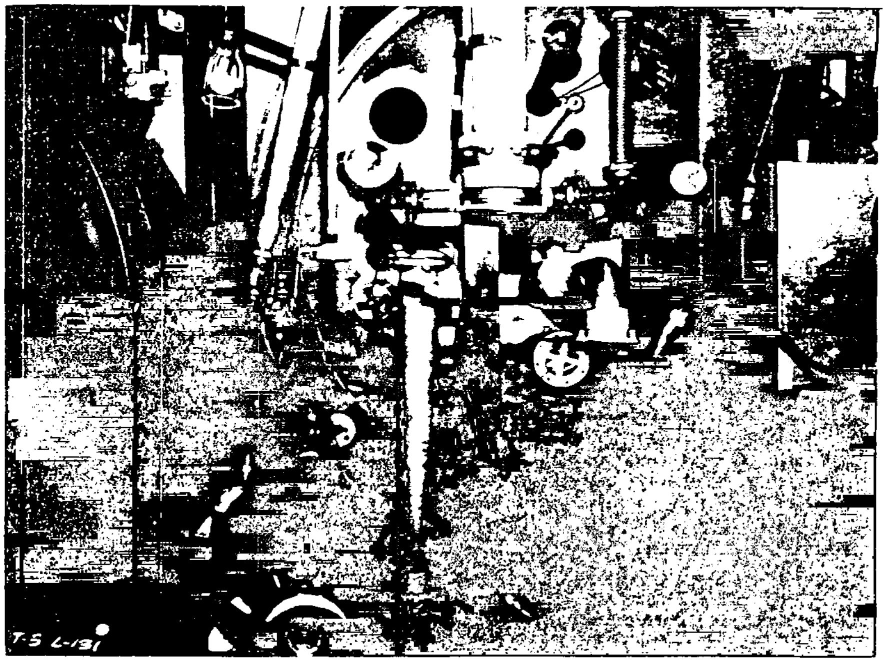


Fig. 82
Propellant Terminal Looking into Interconnecting Tunnel
(Sealed pipe ends and purge set-up)

Fig. 83
LOX Crib, Missile Silo, Interconnecting Tunnel Level
(Interim piping installation)

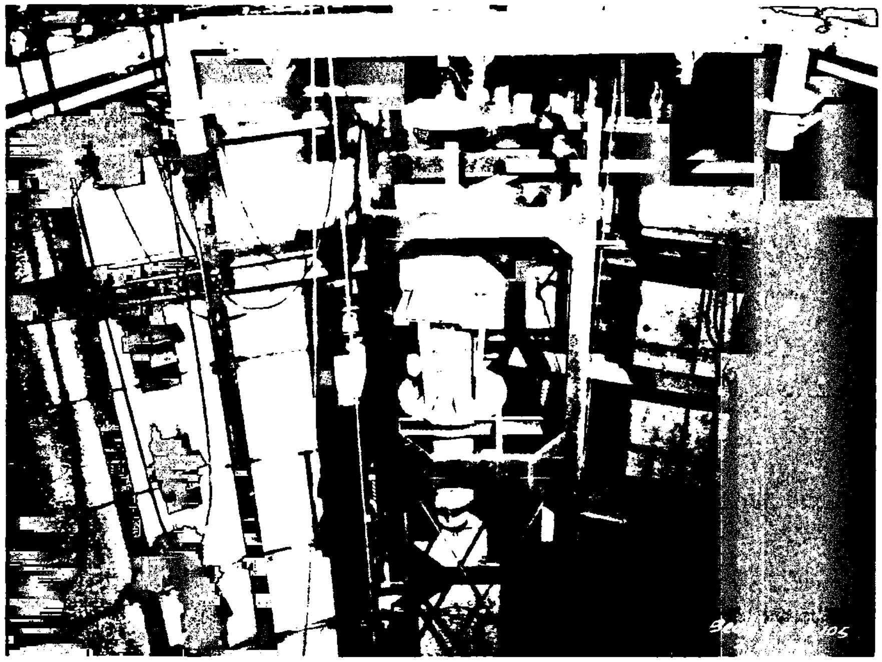


Fig. 84

Lox Crib, Missile Silo (Catch Pot Installation)

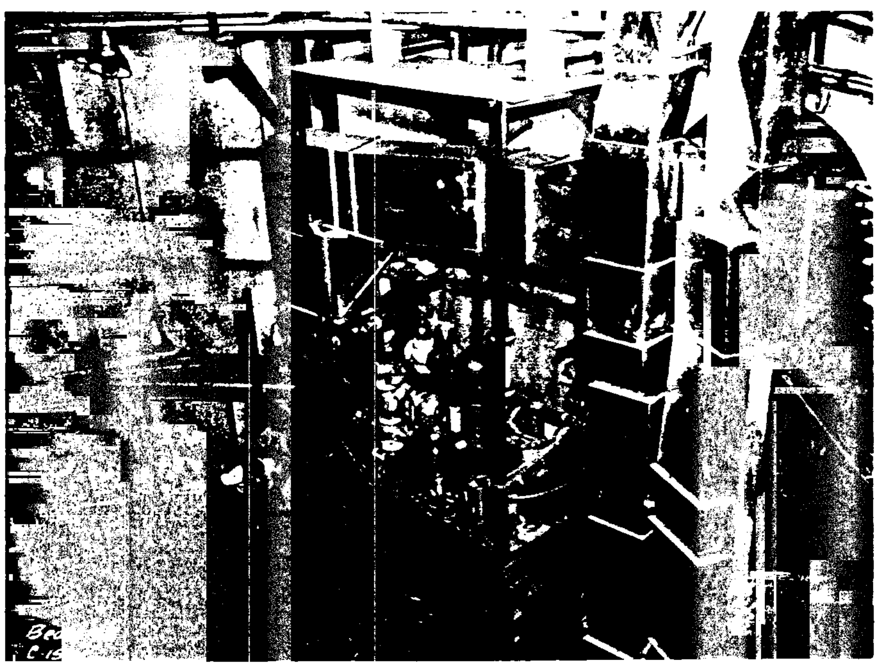


Fig. 85

Fuel Crib, Missile Silo (RP-1 flow controller and air release tank installation)

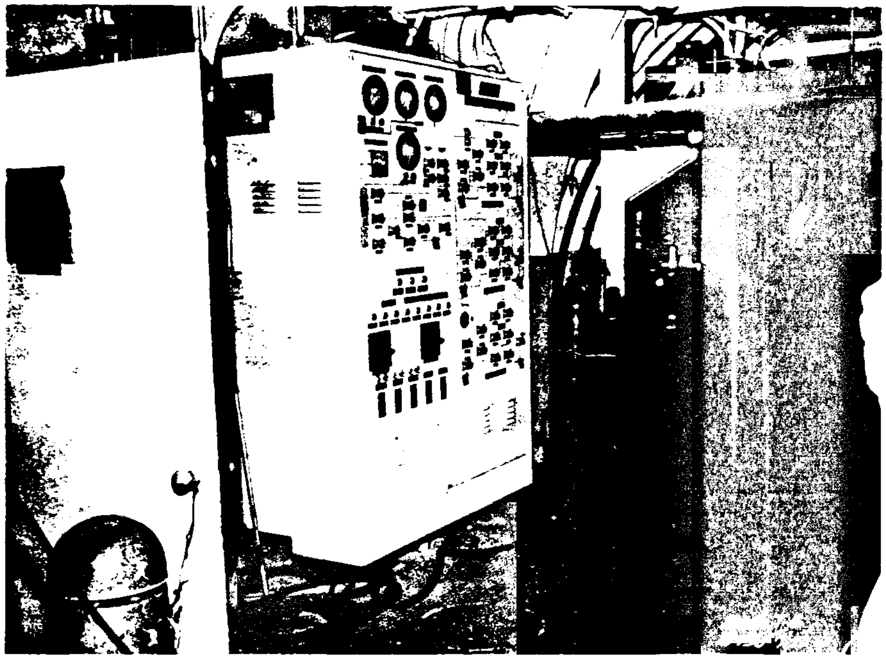


Fig. 86

Tunnel Junction 12, Fuel Transfer Panel

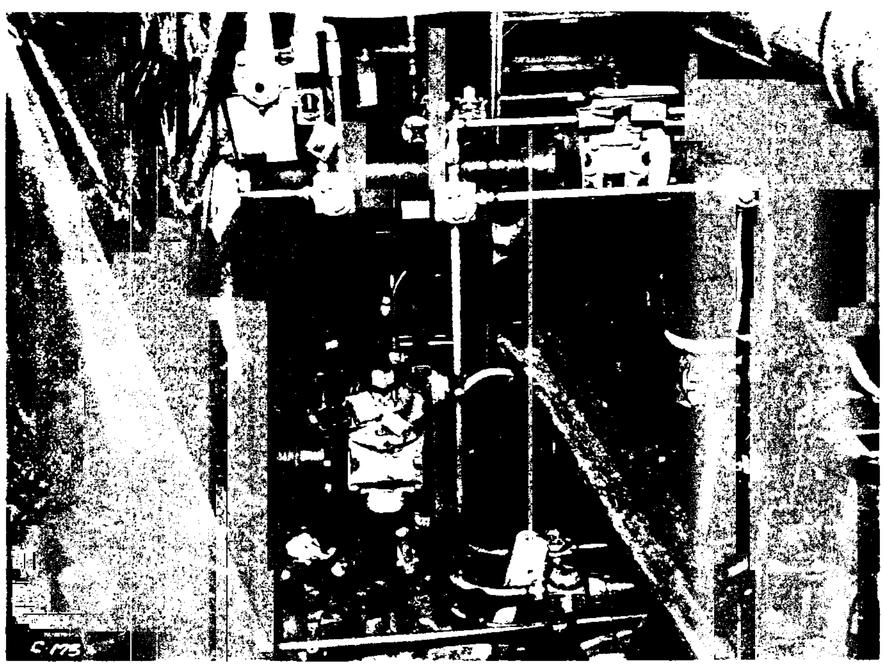


Fig. 87

Tunnel Junction 12, Fuel Control Valves and Piping Installation

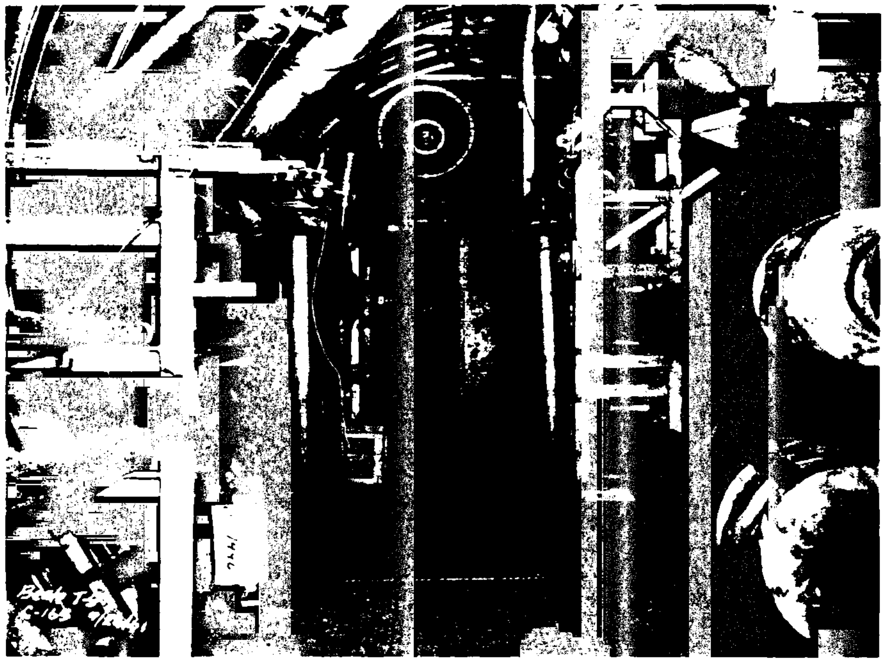


Fig. 88

Interconnecting Tunnel (Field installation set-up)

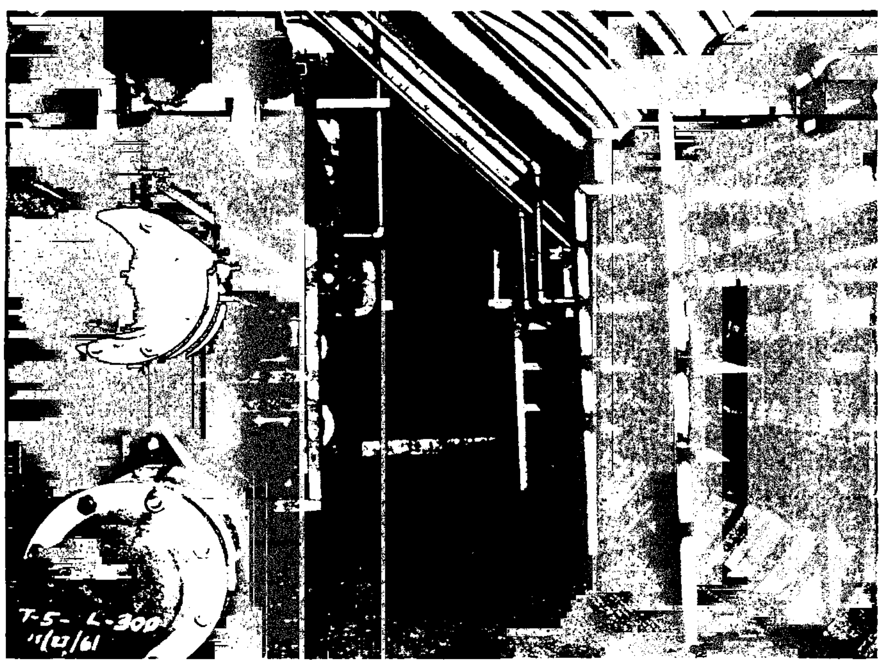


Fig. 89

Interconnecting Tunnel (Completed installation)

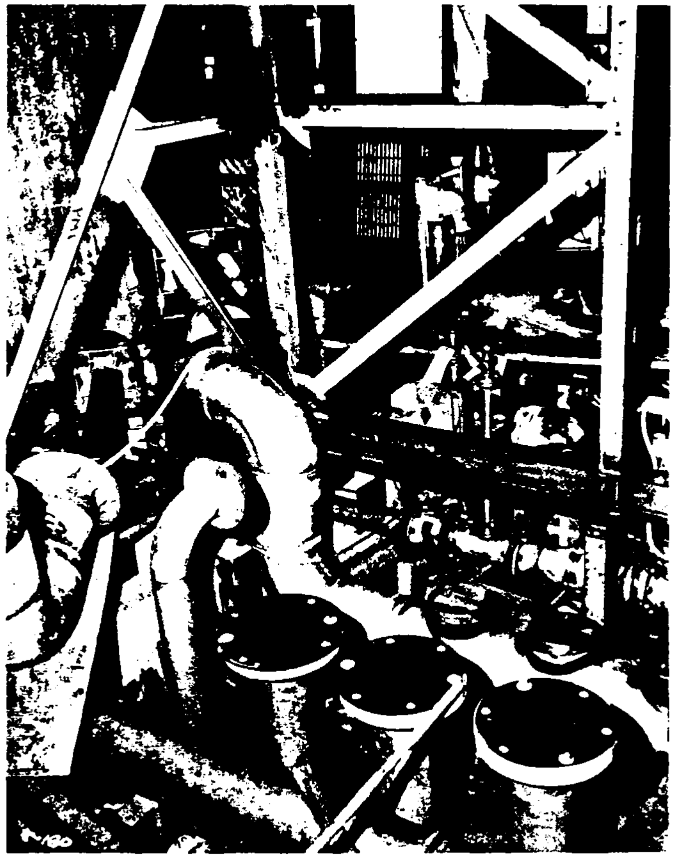


Fig. 90
Propellant Terminal,Main Deck-(Piping installation for LOX tank safety valve manifold)

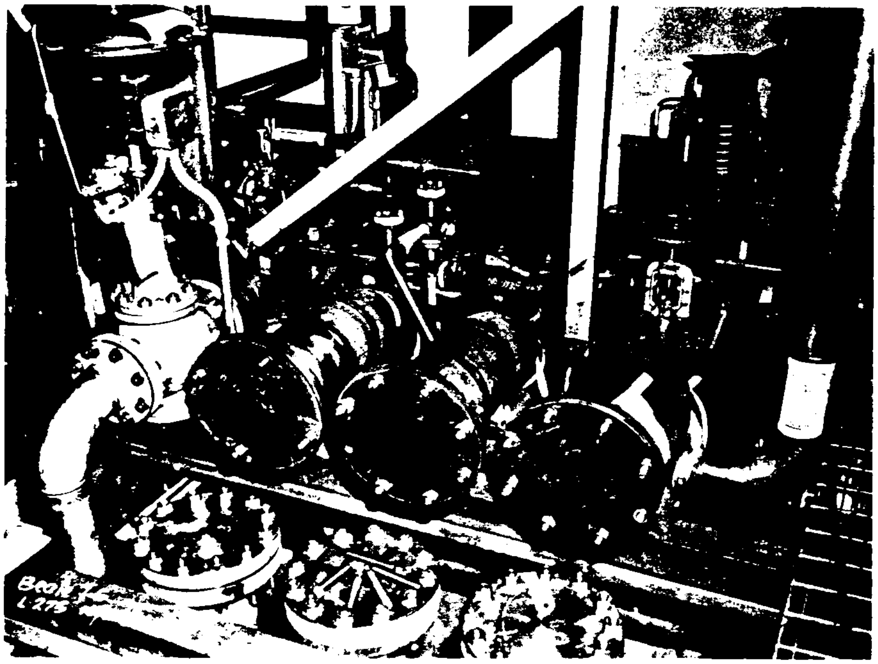


Fig. 91
Propellant Terminal, Main Deck (Valves and connections taped for leak check during testing)

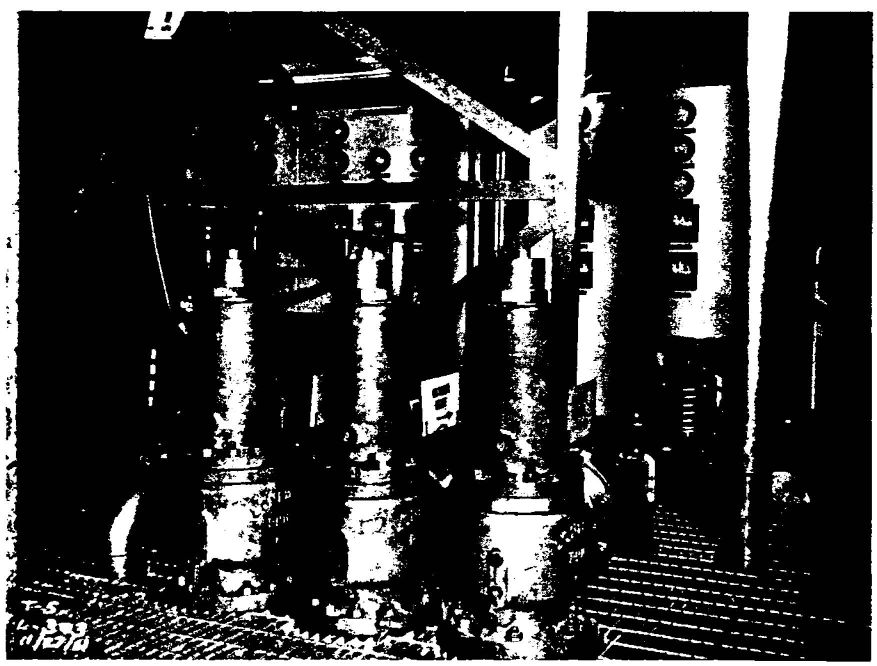


Fig. 92
Propellant Terminal,Main Deck (Completed installation of LOX tank safety valve manifold)(Transfer panels in background)

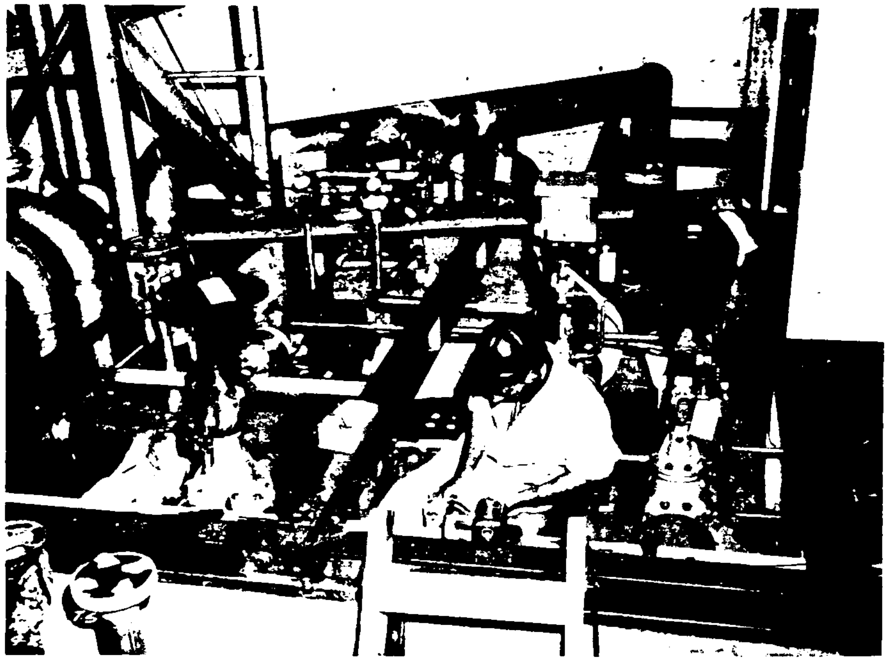


Fig. 93

Propellant Terminal, Main Deck (Interim LOX control valve installation

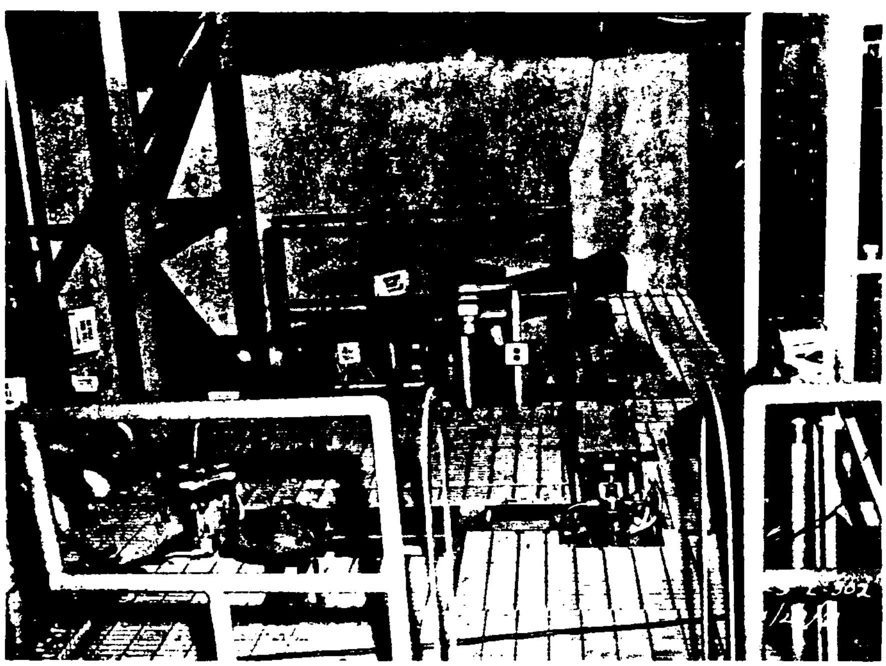


Fig. 94

Propellant Terminal, Main Deck(Completed valve installation and transfer panels)

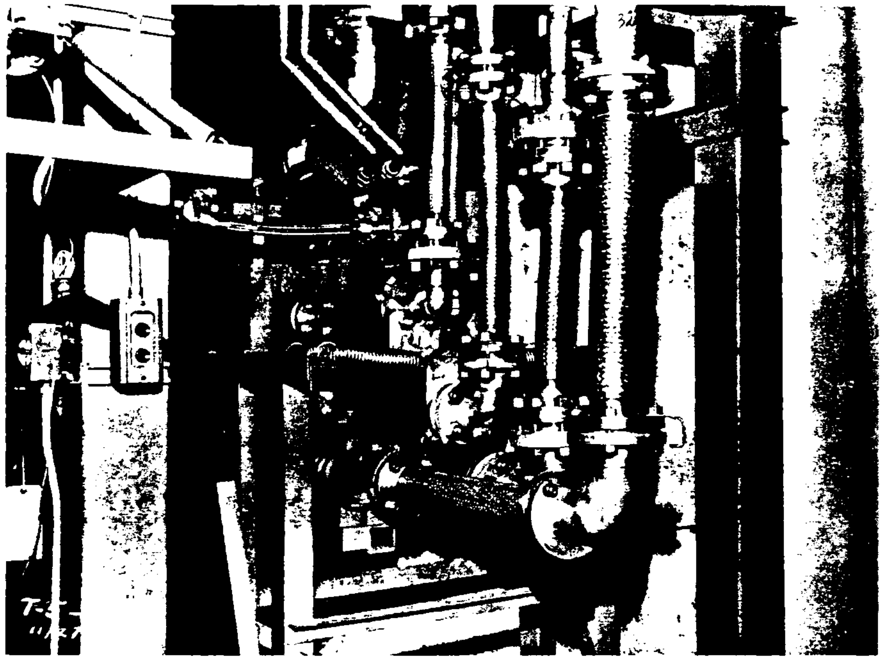


Fig. 95
Propellant Terminal, Lower Level (Flex hose and pipe support installation)

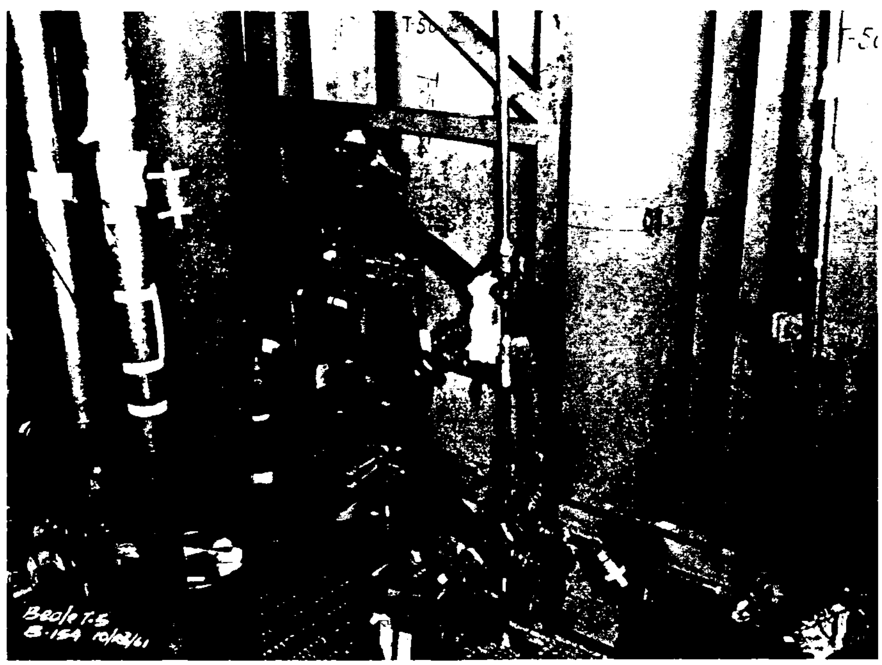


Fig. 96
Propellant Terminal, High Pressure Gaseous Bottle Cluster and Control Manifold

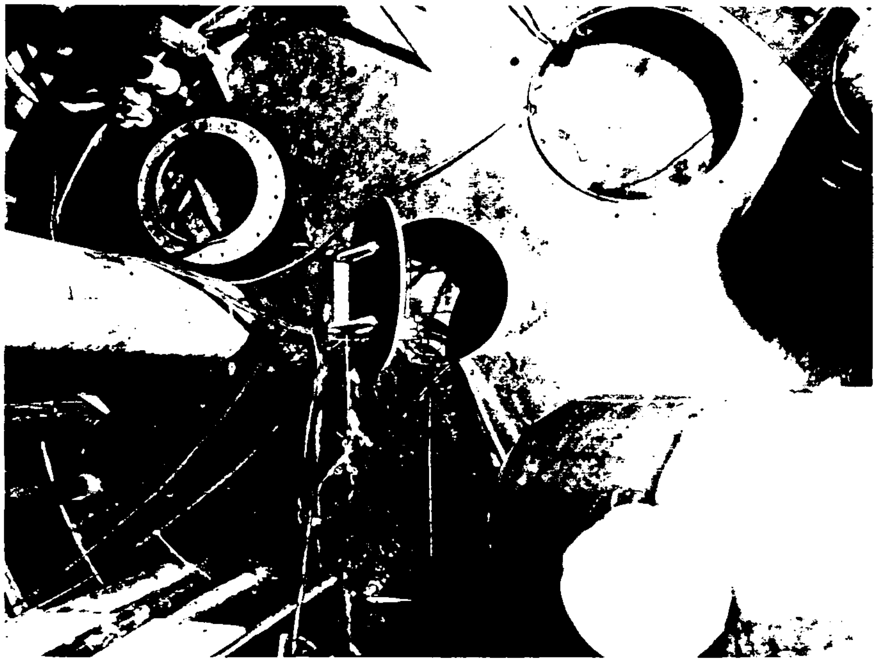


Fig. 97

Radiation Shield between Vent Shaft and Interconnecting Tunnel

Fig. 98

PLS Testing Equipment (High Pressure Recharger and Liquid Nitrogen Storage Tank)

10. MECHANICAL FACILITIES

GENERAL

The mechanical work for each complex consisted of the installation of various systems as listed below. The Propellant Loading System is described elsewhere in this report. The mechanical systems were:

1. Plumbing
2. RP-1 Fuel
3. Ventilating
4. Air Conditioning and Evaporative Cooling
5. Heating System: Forced-hot-water, Glycol, and Steam Converter and Boiler
6. Filming Amine
7. Water
    a. Domestic
    b. Fire
    c. Hot water supply and return
    d. Chilled water supply and return
    e. Deep well pumps
    f. Water storage underground
8. Diesel lube oil, supply and return
9. Diesel exhaust
10. Signal and Alarm
11. Compressed air
12. Blast closure
13. Sanitary sewer

Some of the piping was prefabricated at Beale Air Force Base and then shipped to each of the three sites; other piping was fabricated at the work site. The coordination of the work by Kiemech, Inc., the mechanical subcontractor, was an important part of the work.

PROBLEM AREAS

Pipe Supports

In many cases pipe supports were either not detailed or not located on the contract drawings. In some cases the supports that were detailed were considered inadequate from the shock viewpoint. The Architect Engineer, in preparing the contract drawings, should have either shown the location of all supports, or none. If the location was not shown on the contract plans, it could have been taken care of by tables and other descriptions in the specifications. The resolving of pipe support problems became a major duty of one structural engineer and one mechanical engineer who, as a team, were assigned to the various sites on a full time basis from April 1961 until December 1961.

Flexible Hoses

The location of certain flexible hoses was shown on the contract drawings but the location of many others was omitted. The Architect Engineer took the position that those hoses not shown were still required by the contract specifications. This was considered a weak argument and it was necessary to issue a modification in order to obtain these hoses.

Shock Testing

Due to the complex and different nature of this project, many items were required to pass shock testing prior to installation. Although many switches, solenoid valves and meters were available on the open market, they either did not have the capability of functioning under shock or it was not known by the manufacturer whether their product could operate under these conditions. As a result, valuable time was lost in having items shock tested, and sometimes having to re-test a product when the first test failed. The Architect Engineer provided valuable assistance in providing the names of approved manufacturers of some of the products that the contractor was unable to obtain.

Validation Testing

Validation testing was performed with representatives of the mechanical subcontractor, The Martin Company, Corps of Engineers, USAF-SATAF, and sometimes the manufacturer's representative. Generally speaking the validation testing, although time consuming, ran rather smoothly and as could be expected, certain adjustments and repairs were required as the tests proceeded.

11. ELECTRICAL FACILITIES

GENERAL

The electrical work for each complex consisted of the installation of a 2400 V power plant, including switchgear and a distribution system, lighting systems both emergency and normal, motor control centers, grounding systems, alarm, control and surveillance systems.

PROBLEM AREAS

Some of the more frequent problems involved interference of electrical items with those of other crafts, and the incompatability of Government furnished equipment with contractor furnished items. Another major problem arose with the installation of cable tray shock mounts. The shock mounts which were installed were different than those which had been originally designed for the contract.

The numerous changes and modifications also caused some delay and added to the number of problems. A difficulty which was never overcome was that the contractor frequently installed conduit and equipment without benefit of approved layout drawings. The electrical layout drawings were submitted to the Area office for approval and then directly back to the contractor. Many times the work would be accomplished before the approved layout drawings were returned to the job site. There were many other problems, too numerous to mention here, which normally occur on any project.

SHOCK TESTING

The electrical switch gear was manufactured and shock tested by Westinghouse Electric Corporation. The Architect Engineer

would not approve the Westinghouse procedure as originally written, due to the fact that their system would show when a switch would open and close, but it would not record the interval of time. Several months elapsed between the Architect Engineer's disapproval and the revision of the procedure which provided a method of measuring the interval of time that the breakers were open.

VALIDATION TESTING

Validation testing of all electrical systems was to be performed upon completion of each system. However, some systems were tested concurrently, due to the dependence of one on the other. Validation testing was one of the most troublesome items accomplished during the project and accounted for a large expenditure of time. Many times the system would not operate as designed, which necessitated adjustments or repairs before the test could proceed.. Adjustments or repairs could take hours or days. Another source of delay in testing was due to the fact that a system was not always ready for testing when scheduled.

12. PHOTOGRAPHIC COVERAGE

Photographs of the three sites were taken on a monthly basis and as needed for special requirements. The photographs presented detail and general views of work and events of major significance in engineering and construction fields. The photographer relied upon the judgment of the Resident Engineer in selecting the items of work to be photographed. Views were taken of building tradesmen and laborers actually performing specified or unusual functions within their field; clarifying the position of various components to the whole, sequence of operations and delay factors, as well as indicating overall progress.

Construction photographs depicted the following major features: size and depth of major structures, interior views of structures showing installed equipment, unusual as well as common (sanitary, mechanical and electrical), flexible mountings (spring shock mounts, suspended floors, expansion joints, etc.), interior views of personnel tunnels, above ground shots after backfilling was completed and any other shots which would aid in presenting the construction story to technical persons as well as the general public.

The photographs were used for briefing and claim purposes, to inform technical organizations and higher authority of unusual problems and various phases of the program and to provide a history of the work.

13. SUPPORT FACILITIES

CONTRACT NO. 2174 - RE-ENTRY VEHICLE FACILITY

Addition of one cubicle on existing Multi-Cubicle Storage Building, addition to existing Surveillance and Inspection Building and appurtenant paving and utilities. Cubicle building had reinforced concrete walls with precast lightweight roof panels. The addition to S & I Building included concrete block wall, lightweight steel joist roof, wood frame and gypsum board interior partitions, bridge crane, air conditioning, ventilating, heating and plumbing. There were no unusual construction features. Although some difficulty was encountered in obtaining satisfactory workmanship and timely completion, the facility was completed well ahead of the Using Agency's required occupancy date.

CONTRACT NO. 2175 - RE-ENTRY VEHICLE FACILITY

Consisted of storage building with structural steel frame and sheet metal siding with a small office area. Mechanical and electrical features were very simple.

CONTRACT NO. 2176 - HELIUM UNLOADING FACILITY

Included construction of small parking area and driveway adjacent to existing railroad siding, overhead lighting on existing power poles and provision of transformer and power outlet for operation of Government transfer pump. No unusual construction features were involved.

CONTRACT NO. 2177 - GUIDED MISSILE ASSEMBLY, TECHNICAL SUPPLY FACILITIES AND EDISON STREET EXTENSION

The Guided Missile Assembly included the following features:

1. Structural steel framework with precast, tilt-up concrete walls.

2. Steel roof deck.

3. Wood frame and gypsum board interior partitions.

4. Extensive electrical and mechanical facilities, including specialty piping for test purposes, heating, air conditioning and ventilation systems.

5. Appurtenant outside utilities and paving.

Considering the number of crafts involved, complexity of the work and the extremely short construction period, the contractor did an outstanding job of supervision and coordination. Even though there were several changes, the contractor finished the work on time. He was given a citation for outstanding performance for both timely completion and excellent quality of workmanship.

Administration of the contract was somewhat unwieldly, due to indirect communications with the Architect Engineer in resolution of design problems encountered.

CONTRACT NO. 2230 - ALARM SYSTEM FOR RE-ENTRY VEHICLE FACILITY

This work was done under a classified contract for installation of an intrusion alarm system for the facilities constructed under Contract No. DA-04-167-eng-2174.

14. LABOR

The Prime Contractor attempted to hold down overtime by working on a shift basis; however, some subcontractors were forced into overtime because their activity was the pacing factor in overall job progress. Labor outlay to completion of project is as follows:

Regular Time		Overtime	
Hours	Cost	Hours	Cost
3,160,000	$14,300,000	498,000	$4,130,000

(See Figure 99 for detailed breakdown.)

AVAILABILITY

With two exceptions the labor supply was adequate. There were of course some delays in manning at the start of various phases of work such as structural steel work. However, the labor business agents did catch up with job needs within a few days. In order to do this it was often necessary that the Union agents go outside their local area to recruit adequate forces. The two exceptions where the labor supply presented a major problem were:

1. Plumbers and Pipefitters

There was a shortage of qualified specialists, mainly welders, which delayed build-up of a full crew at the start of work. The Aerojet General Corp. was in competition with the contractor in securing this type of labor. In order to improve the supply the contractor contributed to a training program sponsored by the Union. During the later stages of construction there was a noticeable movement to other Missile Sites and A.E.C.

2. Electricians

In the latter part of 1961 the demand for electricians for associate contractor activities caused considerable job hopping in pursuit of overtime pay. Throughout the job, personnel turnover was quite high.

RELATIONSHIP BETWEEN CONTRACTOR AND LABOR

This relationship was very good. To a large extent this was due to the Prime Contractor's labor policy and the activities of their labor relations representative. The Prime Contractor operated on the principle that he and his subcontractors should make every effort to abide by union management agreements and, just as important, insist that labor make the same effort. On the whole the unions did cooperate. There were some disagreements and some "walkoffs" and the contractor appealed to the international representative in some instances. (See Figure 100, Work Stoppages) It is believed that the Prime Contractor's reputation and his contacts with the National Union representatives were very beneficial in holding labor problems to a minimum. There were no special agreements providing more liberal benefits or wage rates than those defined in the existing union management contracts. However, there were two separate agreements as follows:

1. An Agreement was drawn up by the electrical subcontractor and Local 340 of the IBEW establishing the exact limits of "High Time" of "Hazard Time" areas. This agreement did not materially change the pay for such work from that provided by the NECA agreement with Local 340.

BEALE AREA OFFICE
CONTRACTOR'S PAYROLL DISTRIBUTION
Contract No. DA-04-167-ENG-2140

MONTH	REGULAR TIME		OVERTIME	
1960	Hours	Cost	Hours	Cost
Apr	55,552	240,060	6,580	35,023
May	58,506	222,916	6,834	40,898
Jun	80,696	297,242	11,386	56,221
Jul	101,810	383,014	12,854	65,852
Aug	120,332	416,424	18,898	119,122
Sep	115,447	446,312	16,444	100,762
Oct	200,185	762,738	37,955	241,718
Nov	178,157	765,118	36,611	253,551
Dec	205,963	855,367	24,734	169,304
1961				
Jan	180,732	823,740	12,442	88,773
Feb	216,913	966,934	15,047	113,882
Mar	251,826	1,132,795	8,761	82,986
Apr	155,829	727,200	10,942	96,916
May	170,065	900,238	20,801	197,705
Jun	161,659	846,950	31,873	301,738
Jul	167,097	775,137	29,019	290,695
Aug	147,282	728,966	25,083	241,114
Sep	134,593	635,764	22,198	215,074
Oct	120,934	603,574	26,559	263,450
Nov	162,563	821,137	61,088	596,414
Dec	87,418	494,329	36,119	291,111

Fig. 99

MONTH 1962	REGULAR TIME Hours	Cost	OVERTIME Hours	Cost
Jan	$ 48,287	$ 255,599	$ 20,041	$ 193,677
Feb	21,825	107,005	4,734	45,062
Mar	13,517	61,480	249	1,942
Total to Date	3,157,188	14,270,039	497,252	4,102,990
Estimated Final	3,160,000	$14,300,000	498,000	$4,130,000

Fig. 99

WORK STOPPAGES
BEALE AREA OFFICE

Following is a tabulation of data pertinent to work stoppages on Contract No. DA-04-167-eng-2140:

1. Date: 18 August 1960
   Site: 1-B
   Craft: Electricians
   Number Men: 6
   Man Days Lost: 9
   Reason: Lack of ventilation and method of egress during shafting operations
   Impact: No appreciable affect

2. Date: 3 October 1960
   Site: 1-A and Beale Fabrication Yard
   Craft: Plumbers and Fitters
   Number Men: 24
   Man Days Lost: 89
   Reason: Argument regarding use of laborers to handle pipe in cleaning plant. Sacramento local pulled out at Beale and later at Site 1-A. Marysville and Chico local people at Beale continued working. Sacramento local directed by International to return to work
   Impact: No delay to overall project

3. Date: 16 January 1961
   Site: 1-A
   Craft: Electricians
   Number Men: 22
   Man Days Lost: 24
   Reason: Electricians walked off in protest of other crafts setting generators in violation of previous agreement established by contractor and crafts involved,ie:Operating Engineers, Millwrights and Electricians. Apparently Electrician Steward was not aware of agreement.
   Impact: Completion not appreciably affected

Fig.100

4. Date: 27 January 1961
Site: 1-B
Craft: Electricians (72)
Plumbers (150)
Ironworkers (40)
Number Men: 262
Man Days Lost: 95
Reason: Electricians walked off at noon on a Friday in protest of bad air in working areas. Plumbers and Ironworkers walked off at 2:30 P.M. All returned for work on Monday morning. Contractor installed additional ventilation fans.
Impact: Completion not appreciably affected

5. Date: 30 March 1961
Site: 1-A
Craft: Plumbers and Fitters
Number of Men: 180
Man Days Lost: 653
Reason: Walk off allegedly due to lag in paychecks after close of pay period and also time required for final pay for voluntary separations. Contractor's position was that payments were not delayed. As a result International withdrew all Beale Titan Sites from Sacramento local jurisdiction.
Impact: Site 1-A delayed approximately one week

6. Date: 3 April 1961
Site: Beale Air Force Base-Fabrication Yard
Craft: Plumbers and Fitters
Number Men: 17 (total crew 22)
Man Days Lost: 27
Reason: Exact reason unknown. There was opposition to reduction to 8 hour day. However, only Sacramento local men walked off probably in sympathy with walk out at Lincoln. As a result this area transferred from Sacramento to Marysville Local.
Impact: Negligible. Fabrication ahead of field installation

Fig.100

2. Pipe fabrications and cleanings for all three sites were performed at a central plant at Beale Air Force Base. The unions involved at each site requested that they have equal representation at the central plant. An agreement was drawn up to this effect.

PRODUCTIVITY

The contractor experienced considerable difficulty in obtaining adequate production from electrical workers. The subcontractors accused the union of slow-down tactics to obtain overtime concessions. The union counter-charged that the contractors' difficulty was due to poor management. There was considerable merit to the charges made by both parties; production was quite low, especially at Site 1B. This situation was improved to a big extent beginning the first of April 1961 when the contractor started a hire and fire program to weed out nonproductive workmen. This procedure was made possible through the efforts of the IBEW representative and the labor relations representative of the Prime Contractor.

To a lesser degree slow-down tactics were noticeable at Site 1A among plumbers and pipefitters. This trouble probably would have been greater had not the mechanical subcontractor been required to work considerable overtime to stay on schedule. Addition of more men was not possible due to limited working space. Therefore, more hours per man were required.

AVERAGE WAGE SCALE

The average wage scale at the beginning of the job, compiled from the Secretary of Labor reports for wage scales for the counties

in which the work was situated, reflected an overall average wage scale per hour of $3.75. It must be noted that this hourly wage scale was averaged from 35 classifications applicable to the work, but it does not include taxes and insurances and does not include foreman's wages for any of the classifications. A similar study was made of Secretary of Labor reports for the hourly wage scale for 30 classifications for the three counties in which the work was situated for the ending period for the job and this overall average was $4.17. Again it must be noted that this is the journeyman's rate only and does not include the foreman's rate or taxes or insurances as applicable. Therefore, in comparing the overall average for the beginning of the job of $3.75 an hour for journeyman, with the overall average rate for the ending of the job of $4.17 an hour for journeyman, showed an increase of 42¢ per hour or an increase of 10% for labor.

WORK STOPPAGES

There were six work stoppages during the course of the work. They were more of a wildcat or walk-off nature, rather than a strike. The only one which caused appreciable delay involved plumbers and fitters at Site 1A. The contractor appealed to the International for assistance in getting the men to return to work. Apparently the International felt that the local union action in this case had been wrong because Site 1A was transferred from the Sacramento Local to the Marysville Local. Details of each work stoppage are shown on Figure 100.

MISSILE SITE LABOR RELATIONS COMMITTEE

The local committee was organized by the SATAF representative, and the Commissioner of the Federal Mediation and Conciliation Service, who was the chairman. The committee consisted of five representatives each from Management and Labor. The Management Members represented the Air Force contractors, and Labor was represented by one man from each of the following:

Building Trades Council

Carpenters

Laborers

Operating Engineers

IBEW

Later a representative of the construction contractor was included in the group. The main features of the committee policy were:

1. Disputant parties would make every effort to resolve differences before referral to the committee.

2. All parties would comply with the ruling of the committee. Either party could appeal through proper channels but no stoppage would occur.

3. The committee would take action promptly on any matter referred to it and in no case later than 24 hours.

4. Any member representing a disputant would withdraw during the vote on the committee decision. Such a member would be temporarily replaced by an alternate from another company or union.

The Corps of Engineer's Area Engineer was designated as an observer with full liberty to submit suggestions or problems.

The committee undoubtedly can be credited with preventing labor disputes from developing into work stoppages. Although the committee made very few official decisions, its existence served as a deterrent to "wildcat" action. The Corps' contractor was never directly concerned. However, there were some trouble spots in associate contractor activities which could have spread to the Corps activity had not prompt action been taken.

15. RECOMMENDATIONS

RESIDENT OFFICE

The 10 foot by 50 foot office trailer did not provide adequate space. It is recommended that either an office building of 750 square feet minimum floor space, or two 10 foot by 50 foot trailers be provided.

RESIDENT OFFICE STAFF

It is recommended that:

1. The electrical inspection force should consist of one Electrical Engineer and one Electrical Inspector, with provisions for increasing this to two Electrical Inspectors when electrical installation work is in full progress.

2. The mechanical inspection force should consist of:

a. One Mechanical Engineer and two Mechanical Inspectors for all mechanical work excluding the Propellant Loading System and the RP-1 System.

b. One Mechanical Engineer and from one to twelve Mechanical Inspectors for the Propellant Loading System and RP-1 System work.

c. The Mechanical Inspectors to be Corps of Engineers personnel.

d. The Martin Company to be excluded from furnishing Inspectors to the Corps for the Propellant Loading System or RP-1 System work.

3. A Construction Management Engineer, Grade GS-11, be assigned as a full time Office Engineer, and that an Engineering

Aid, Grade GS-7, be assigned to assist the Office Engineer.

4. The Clerk-Typist grade be upgraded to GS-6. This is felt necessary in order to attract qualified people for field office duty.

PART III

CONTRACT ADMINISTRATION

Contract administration at the Area level compared in importance with construction in the number of people involved and magnitude of work accomplished. Contract administration was directly or indirectly involved in most of the numerous problems arising during the course of the project. To aid in the review of activities this summary was divided into the following topics:

1. A brief history of each construction contract.
2. Estimating and negotiation.
3. Reasons for increased costs.
4. List of principal subcontractors, scope of work, effectiveness of subcontractors' operations.
5. The race against time, showing construction period and statement of liquidated damages.
6. Standardized equipment contracts.
7. List of all contracts administered by CEBMCO, Beale Area.
8. List of all modifications for each contract.
9. Administrative problems.
10. Conclusions and recommendations.

16. HISTORY OF EACH CONSTRUCTION CONTRACT

Following is a brief history of each construction contract with original and final contract cost exclusive of unsettled claims, and the total number of modifications and claims exceeding $100,000, together with their description and comments concerning their settlement. The information provided concerning the modifications and claims is current as of 31 March 1962.

WS-107 A-2 TECHNICAL FACILITIES

COMPLEXES 1A, 1B and 1C, BASE T-5

BEALE AIR FORCE BASE

Contract Number:	DA-04-167-eng-2140
Date of Contract:	15 January 1960
Contractor:	Peter Kiewit Sons' Co. 345 Kieways Avenue Arcadia, California
Construction:	WS-107 A-2 Technical Facilities Complexes 1A, 1B and 1C, Base T-5 near Beale Air Force Base Marysville, California
Notice to Proceed:	20 January 1960
Original Contract Amount:	$30,157,150.50 for three sites

MODIFICATIONS

Of the 317 modifications, exclusive of claims, the following modifications resulted in increases of over $100,000:

Mod. No.	Description	Amount
72	Furnish L & M for GFP cleanliness inspection	$ 299,000
102	Design changes to PLS System	186,526
104	Modification to shock test equipment	195,436
109	Miscellaneous changes to certain drawings	793,847
122	Revised Propellant Loading System tunnel supports	211,292
127	Required revisions to fuel system and fire water supports in Missile Silo	110,742
135	Revised PLS Piping Supports in Missile Silo and P.T. Lox Cribbing	1,100,000
137	PLS Test Specification Changes	1,824,007
147	Segmentation of MCC and additional installation of package controls	131,453
151	Hardstands for Assoc. Contractor, revised grading and relocate portion of Security Fencing at Site 1B	175,000
161	Blowdown of C. F. Cryogenic Vessels and Tanks	198,976
166	Provide additional pipe supports for PLS piping in P.T. and inter-connecting tunnels, 3 Complexes (Flex. Hose)	194,662
262	Revise Pipe Supports T.J.12, RP-1 Fuel Systems	162,852
267	Provide for Contractor purchasing RPIE Spare Parts for Use during PLS Testing	101,387
286	Clean RP-1 Fuel by circulating thru Filters	128,869
	TOTAL	$ 5,814,049

Contract:	DA-04-167-eng-2140
Modification No. 72	84 No. 91
Date of Modification:	22 November 1960
Description of Work:	Furnish labor and materials to provide for additional cleanliness inspection of Government furnished property installed in the Propellant Loading System at Complexes 1A, 1B and 1C.
Amount of Modification:	$299,000.00

- -

Contract:	DA-04-167-eng-2140
Modification No. 102	84 No. 172
Date of Modification:	31 January 1961
Description of Work:	Revision to the PLS piping System
Amount of Modification:	$186,526.00

- -

84 No. 395 - Accelerate Completion of Electrical Work held in Abeyance due to Changes in Blast Valves.

This modification was initiated to accelerate the adjustment of the limit switches on the blast valves on premium rate. Proposed Amount $2,200.

84 No. 397 - Revise Blast Lock Covers of 36" Blast Valves

The 36" Blast valve shafts after previous modifications were found to be short; therefore this modification will correct the above deficiency. Proposed Amount $1,800.

TOTAL - - - - - - - - $809,000.

CLAIMS

As of 31 March 1962, 214 claims were submitted by the contractor and have been processed as follows:

Modifications over 100,000	5
Modifications under 100,000	25
Claims negotiated but not processed into Modifications	30
Claims withdrawn, cancelled or denied	123
Claims unsettled	31

An explanation of each of the above categories follows:

Modifications Derived from Claims over $100,000

Mod. No.	Claim No.	Amount
149	C-17	$210,253
209	C-2	246,087
264	C-45	264,904
313	C-87	435,000
319	C-7	195,000
	TOTAL	$1,351,244

Modifications Derived from Claims Under $100,000

Mod. No.	Claim No.	Amount
51	None Assigned	4,620
115	C-160	2,700
247	C-15	3,320
263	C-134	2,400
265	C-145	4,391
273	C-113	1,487
279	C-124	850
280	C- 49	2,757
282	C-138	4,921
287	C- 71	428
289	C- 83	12,788
290	C-152	635
293	C-153	404
294	C- 11	7,015
311	C-144	3,500
312	C-206	20,088
315	C-149	11,500
317	C-141	2,100
329	C- 84	1,406
326	C-117	3,000
321	C-200	35,000

Mod. No.	Claim No.	Amount
322	C-208	815
325	C-215	4,072
328	C-218	600
320	C-222	1,500
	TOTAL	$ 132,297

Modifications Derived from Claims

Claim No.	Mod. No.	Description	SETTLEMENT
None Assgnd.	51	Claim (Dampproofing E.T.)	4,620
C- 2	209	Changed Conditions at Site 1A	246,087
C- 7	319	Excessive Engineering Costs	195,000
C- 11	294	Size of Ice Banks	7,015
C- 15	247	Protective Coating T-110 Tanks	3,320
C- 17	149	Two Hole Straps	210,253
C- 45	264	Scope of Required Painting	264,904
C- 49	280	Accessories for Engine Instrument Board	2,757
C- 71	287	Safety Valves for GFE	428
C- 83	289	Shock Flexible Connections. E.T.	12,788
C- 84	329	Fire Water Valves in T.J. No. 10 & B.L.	1,406
C- 87	313	Delay GFE, Errors in Drwgs. Interference	435,000
C-113	273	Relocation of Door 11/13 Control Centers	1,487
C-117	326	PRV-562 Valve Failures	3,000
C-124	279	Interference-Drain Pipe and LOX Crib	850
C-134	263	Vermicalite Concrete in Tunnel Inverts	2,400

Claim No.	Mod. No.	Description	Settlement
C-138	282	Control for PHLC-5V	4,921
C-141	317	Support Flex Hose at Line 1-½" CF-1023	2,100
C-144	311	Color Coding for Pipe Line Identification	3,500
C-145	265	LOX and Fuel Crib Changes	4,391
C-149	315	Interference between CV-702 & Pipe 540-1	11,500
C-152	290	Support for 2" AA-703	635
C-153	293	Completion for Furnishing Recharger Oil	404
C-160	115	Electrical Hand Hole Receptacles	2,700
C-200	321	Misc. Changes to C-2 Compressors	35,000
C-206	312	Piping for SOV 565	20,088
C-208	322	C-1 Compressors	815
C-215	325	Insulate Cyclonic Separators	4,072
C-218	328	Additional Security Guards 1-B	600
C-222	320	Enclosures for Helium Compressors	1,500
		TOTAL	$ 1,483,541

Claims Negotiated

Claim No.	Description	Settlement
C- 12	LOX Bay Covers	23,007
C- 48	Bolting Down Low Voltage Switchgear	3,386
C- 76	Backup Gas for Installation of PLS Piping	55,994
C- 79	Unusable Neoprene Ring Gasket, 1A	58,328
C- 80	Galvanizing Ladders	18,800
C- 89	Asphalt Coating of LOX Structures, etc.	45,692

Claim No.	Description	Settlement
C- 97	Rework of LOX Supports - PT	7,514
C-100	Telephone Manhole Cable Racks	875
C-101	Cleanliness Inspection of GFE-Reinspection	161,803
C-115	Installation of Flexible Hoses	300,000
C-139	Duct Work in Interconnecting Tunnel	1,626
C-140	Reverse Valve Flow	20,000
C-148	Safety Valve Design Deficiencies	2,562
C-155	Mounting of C-1 Compressor	6,493
C-158	Bonding and Grounding of RP-1 Fuel Piping	45,000
C-173	Sheared Conduit at Entry Portal Surface Hatch	1,309
C-174	Misc. Addtional Work performed by Booth	9,856
C-175	Grounding of Cable Trays	5,833
C-191	Powerhouse Light Fixtures Relocation	600
C-193	Installation Breakout Flanges PRV's	20,531
C-194	Reverse Gimball Joints in CSO-320	3,000
C-197	Powers Misc. Extra Work	10,885
C-211	Supports, Anchors & Bolts for GFE	18,431
C-214	By-passes at PCV's and TCV's	20,000
C-220	Repair & Replace GFE	175
C-224	Slot for Support Steel MCC 9	2,139
C-228	Repair & Replace FCV	10,500
C-229	Repair & Replace CHV's	4,080
C-231	Repair FC-122 & 123	40,000
C-232	Kiemech Portion - Late Delivery GFE	111,000
	TOTAL	$ 1,009,469

Claims Unsettled

As of 31 March 1962, 31 claims remained to be settled. A brief description, with the anticipated cost of each unsettled claim follows:

Claim No.	Description	Cont. Prop.	Gov. Est.
3	Delays, Government Furnished Equipment	$555,297	$ 500,000
36	Neoprene Water Stops	351,011	200,000
93	Refabrication of PLS Spools	582,983	300,000
109	Powerhouse Pipe Supports	120,189	10,000
112	Tunnel Subsidence	627,127	400,000
129	Additional Cost for Procurement of Sump Pumps	30,815	20,000
150	Vibration Isolators Supports	3,453	2,000
151	Discrepancies in Nozzles,GF Vessels	143,002	120,000
154	Misalignment of Piping due to P.T. Design Deficiencies(Spring Mounts)	390,378	250,000
155	Mounting of C-1 Compressors	6,633	5,000
158	Bonding of RO-1 Fuel Piping	66,917	75,000
171	Additional Bolts MS Light Fixtures	65,739	10,000
176	Remove and Replace Blowdown-Powell CV	136,000	100,000
182	6" Firewater Line Interference with Assoc. Ductwork	45,836	40,000
184	Overall Time Claim	-	2,550,000
190	Superior's Cost Factors for Mods.	500,000	50,000
192	Additional PLS Pipe Supports	91,263	80,000
196	RP-1 Punch List Items	55,599	40,000
198	PLS Changes by Area Engineer Letter	32,537	15,000

Claim Nos.	Description		Cont. Prop.	Gov. Est.
199	Repair of Sump Pumps-	Part Denial	$ 11,673	$ 5,000
209	GFE Water Chillers		15,985	10,000
211	Supports, Anchors and Bolts GFE		52,621	20,000
220	Repair and Replace GFE		472	400
234	Delay to Validation Testing Due to Damage by Assoc. Contractors		17,726	15,000
236	Electric Revisions due to 2140-212		105,679	60,000
241	Boltdown of GF Federal Pacific Switchgear - KV 2.4		8,808	4,000
69	Validation Testing		-	500,000
247	Cable Tray Shock Mounts		-	-
	Clarification of Conflicts			300,000
	Superior Acceleration		-	1,000,000
	Armco Acceleration			500,000
		TOTAL		$7,181,400

CONTRACT 2140 - TOTAL ANTICIPATED COST

ORIGINAL CONTRACT AMOUNT FOR 3 SITES			$30,157,150
OVERRUNS - UNDERRUNS			161,383
MODIFICATIONS EXCLUDING MODS. DERIVED FROM CLAIMS			
	Over $100,000	$ 5,814,049	
	Under $100,000	2,284,633	
		TOTAL	8,098,682
MODIFICATIONS OPEN (POSSIBLE SETTLEMENT)			809,000
MODIFICATIONS DERIVED FROM CLAIMS			
	Over $100,000	$ 1,351,244	
	Under $100,000	$ 132,297	
		TOTAL	1,483,541
CLAIMS NEGOTIATED			1,009,469
UNSETTLED CLAIMS			7,181,400
CONTRACT 2140 - TOTAL ANTICIPATED COST			$48,900,625

SUPPORT FACILITY FOR
WS-107 A-2 BASE T-5
BEALE AIR FORCE BASE

Contract Number:	DA-04-167-eng-2174
Date of Contract:	26 September 1960
Contractor:	Fullerton Constr. Co. & Samuel N. Zarpas Inc. 2583 Valley Road Sacramento, California
Construction:	Re-Entry Vehicle Facilities at Beale Air Force Base
Notice to Proceed:	28 September 1960
Original Contract Amount:	$146,000.00
Modifications:	A total of five Modifications was proposed:
	1. $ 279.67
	2. 7,366.00
	3. 920.45
	4. - 475.00
	5. N.C.
Net Overrun on Unit Bid Items:	$1,699.20
Claims:	None
Final Contract Amount:	$155,790.32

SUPPORT FACILITIES

Title	Contr.No.	Orig. Amt.	Start	Comp.	Contractor
Re-Entry Vehicle Facilities at Beale Air Force Base	Eng-2174	$146,000.	3 Oct.60	None	Fullerton Constr. Co.

Mod.No.	Date	84 No.	Description	Amount of Change
1	6 Jan. 61	2	Arch Culvert in lieu of Circular Culvert	$ 279.67
2	9 Jan. 61	1	Evaporative Cooling of Room 100	7,366.00
3	6 Feb. 61	4	Per Letter dated 19 Dec. '60. Extend Time by 2 Calendar Days	920.45
4	12 Apr. 61	5	Eliminate Duct Work in Room No. 100	475.00
5	14 Aug. 61	-	Extend Time to 15 July 1961	N.C.

CONTRACT NO. DA-04-167-eng-2174

UNIT BID ITEMS

Item 3	PCC Pavement	- 5 C.Y.@$35.00	-$	175.00
Item 8	Roadway Excavation	+514 C.Y.@$ 2.40	+	1,233.60
Item 9	Borrow	+ 70 C.Y.@$ 1.00	+	70.00
Item 11	Select Material S.B.	+ 18 C.Y.@$ 8.00	+	144.00
Item 12	Stab. Aggregate Base	+ 7 Tons@$ 5.00	+	35.00
Item 13	Base for P.C.C.	- 2 C.Y.@$ 8.00	-	16.00
Item 14	Liquid Asp. MC-1 Prime	-0.113Ton@100.00	-	11.30
Item 15	Paving Asphalt 85-100 Penn.	-0.184Ton@$50.00	-	9.20
Item 16	Bituminous Surfacing	+6.85 Ton@$10.00	+	68.50
Item 18	Seeding	+0.899 AC@400.00	+	359.60
			+	$1,699.20

SUPPORT FACILITY FOR
WS-107 A-2 BASE T-5
BEALE AIR FORCE BASE

Contract Number:	DA-04-167-eng-2175
Date of Contract:	26 September 1960
Contractor:	Harbison & Mahoney 220 Sandburg Drive Sacramento 19, California
Construction:	Re-Entry Vehicle Facility at Beale Air Force Base
Notice to Proceed:	29 September 1960
Original Contract Amount:	$20,650.00
Modifications:	None
Claims:	None
Final Contract Amount:	$20,650.00

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SUPPORT FACILITIES

Title	Contr.No.	Orig.Amt.	Start	Complete	Contractor
Re-Entry Vehicle Facilities at Beale Air Force Base	Eng-2175	$ 20,650.	11 Oct.60	16 Feb. 61	Harbison & Mahoney (Partnership)

SUPPORT FACILITY FOR
WS-107 A-2 BASE T-5
BEALE AIR FORCE BASE

Contract Number:	DA-04-167-eng-2176
Date of Contract:	3 October 1960
Contractor:	Baldwin Construction Co.Inc. Marysville, California
Construction:	Helium Unloading Facility Beale Air Force Base
Notice to Proceed:	6 October 1960
Original Contract Amount:	$13,500.00
Modifications:	One only modification was proposed: 1. $367.00
Claims:	None
Final Contract Amount:	$13,867.00

SUPPORT FACILITIES

Title	Contr. No.	Orig. Amt.	Start	Comp.	Contractor
Construction of Helium Unloading Facility, Beale Air Force Base, California	Eng. 2176	$ 13,500.	24 Oct.60	5 Dec. 60	Baldwin Contr. Co. Inc.

122

Mod. No.	Date	84 No.	Description	Amount of Change
1	2 Dec. 60	1	Additional Guying Facilities, Electrical Distribution System	$ 367.00

SUPPORT FACILITY FOR
WS-107 A-2 BASE T-5
BEALE AIR FORCE BASE

Contract Number:	DA-04-167-eng-2177
Date of Contract:	10 October 1960
Contractor:	Fruin-Colnon Contracting Co. Burlingame, California
Construction:	Guided Missile Assembly, Technical Supply Facilities and Edison St. Extension, Beale Air Force Base
Notice to Proceed:	14 October 1960
Original Amount of Contract:	$694,000.00
Modifications:	A total of 14 modifications was proposed:

1.	$ 669.10	6.	$ 202.47	11.	$ 118.00
2.	170.16	7.	1,205.86	12.	11,634.75
3.	16,220.00	8.	1,185.63	13.	717.91
4.	6,709.00	9.	- 723.79	14.	31,235.00
5.	246.48	10.	3,584.00		

Claims:	The Contractor submitted two claims, which were settled and paid for by Modifications 13 and 14.
Final Amount of Contract:	$ 767,174.57

SUPPORT FACILITIES

TITLE: Guided Missile Assembly, Technical Supply Facilities & Edison Street Extension at Beale Air Force Base

Contr.No.	Orig.Amt.	Start	Comp.	Contractor
Eng-2177	$ 694,000.	19 Oct.60	14 June 61	Fruin-Colnon

Mod.	Date	84 No.	Description	Amount of Change
1	27 Jan. 61	3	Rev. Const. Foundation Footings & Pipe Trench	$ 669.10
2	13 Jan. 61	5 & 60	Clarify Press. of N_2 Tank & Larger Conduits	170.16
3	13 Jan. 61	4	Rev. Piping & Fittings in N_2 System	16,220.00
4	20 Feb. 61	1	Imported Select Fill Under Buildings	6,709.00
5	24 Mar. 61	9	Raise Ceiling; Add and Relocate Lights	246.48
6	27 Mar. 61	7	Rev. Const. of Side Walk Facilities	202.47
7	27 Mar. 61	8	Relocation of Hot Water Heater	1,205.86
8	6 May 61	11	Paint Exp. Int. Steel. Omit Painting	1,185.63
9	20 May 61	10	Delete Hydrostatic Testing of N_2 System	723.79
10	26 May 61	15	Steel Flanged Fittings in Lieu of Cast Iron	3,584.00
11	13 July 61	12 & 13	Delete Valves in H_2O System, etc.	118.00
12	30 Aug.61 30 Aug.61 30 Aug.61	14 16 17	Accoustical Tile Ceilings Rooms 204, 221, 222; Floor Tile Ladders; Fence & Walk Remove Dry Pack & Re-Seal	11,634.75
13	8 Oct.61	18	Claim C-2 Paint Weld Burns	717.91
14	27 Nov.61	19	Claim C-3 Water System Demineralize	31,235.00

WATER-WELLS

Location	Contractor	Start. Date	Contract No.	Compl.Date	Depth	Contract Amt.
Buttes #1	Weeks Drlg. & Pump Co. Sebastopol, Calif.	17 Aug. 59	2097	17 Sept. 59	535 ft. 250 g.p.m.	$ 40,005.
Buttes #2	Precision Drilling Co. Santa Rosa, Calif.	19 Nov. 59	2109	14 Dec. 59	401 ft. 250 g.p.m.	20,751.
Chico #1	Weeks Drilling & Pump Co. Sebastopol, Calif.	12 Sept.59	2102	29 Sept.59	530 ft. 300 g.p.m.	41,725.
Chico #2	Precision Drilling Co. Santa Rosa, Calif.	20 Dec. 59	2141	10 Jan. 60	400 ft. 250 g.p.m.	21,858.

17. ESTIMATING & NEGOTIATIONS

COST ESTIMATES

In general, cost estimates for Contract 2140 and other contracts in the Titan I Program were prepared in accordance with applicable instructions contained in the following publications:

1. CEBMCO Manual - ENGMA-1180-2, dated 6 October 1961, entitled "Corps of Engineers Ballistic Missile Construction Office, Standing Operating Procedures for Modifications and Claims under CEBMCO Contracts".

2. Contract Modification Construction Manual issued by the U. S. Army Engineer District, Sacramento, California, dated June 1961.

3. Preparation of Cost Estimates, Military Construction, EM 1110-345-730 dated 2 March 1959.

4. Engineering Manual, Part CXlll, Chapter II, dated March 1949, Cost Estimate of Fair and Reasonable Cost to the Contractor.

5. Instructions for Preparation of Cost Estimates for Military Work issued by the U. S. Army Engineer District, Sacramento, California.

6. Pertinent Notes Issued by CEBMCO Titan I entitled "Data for Computing Cost of Modifications, Acceleration, Impact, Effect and Markup".

Other pertinent data used in the preparation of cost estimates for this job are current material, labor and pricing manuals, some of which are listed herewith:

1. National Construction Estimator.

2. National Electrical Contractor's Association Manual.

3. The Market Report giving a current pricing of all types of materials.

4. Armco Materials and Data Book.

5. Sweets Catalog.

6. Electrical Trade Book edited by Biddles that gives prices for all electrical materials and some services.

7. MacMasters Catalog that prices and describes all sorts of fasteners, screws, bolts, nuts, boxes, and many other items.

8. Grinnell Catalog that has to do with piping, valves and fittings.

9. Crane Catalog that has to do with piping, valves and fittings giving methods of installation and pricing of materials.

10. Walworth Catalog that prices many items.

11. Thompson Diggs Company Catalog that prices materials of many items, and describes methods and practices for installation.

12. The Coast Equipment Company Catalog that describes all sorts of Construction Equipment.

13. The Caterpillar Handbook that prices all of Caterpillar equipment, giving specifications, methods for estimating, and capacities and specifications for this equipment.

14. Labor Agreements for Northern and Central California issued by the Associated General Contractor's of America.

15. Current Labor Agreements issued by the Department of Labor.

16. Ryerson Catalog listing prices of steel, and methods.

17. The Jorgenson Steel Company Catalog listing prices of steel.

18. Cla-Val Company Catalog that describes and prices different valves pertaining to control valves.

19. The Ladish Company Catalog that describes and prices stainless and carbon steel welding fittings.

20. Dresser Coupling Catalog that describes and prices dresser couplings.

21. Power's Regulator and Pneumatic Valves Catalog describes and prices pneumatic control systems.

22. Minneapolis Honeywell Catalog that describes and prices electric and pneumatic control systems.

23. Parker Tube Fittings that describes and prices special tubing connections.

24. Unistrut Catalog that describes and prices unistruts and supports of all kinds.

25. Carey Insulation Catalog that describes and prices all types of insulation.

26. C. M. Bailey Catalog that describes and prices Bailey Valves.

27. Current price book that describes and prices mechanical items of all types and services.

SUPPORT FACILITY FOR
WS-107 A-2 BASE T-5
BEALE AIR FORCE BASE

Contract Number:	DA-04-167-eng-2230
Date of Contract:	Classified
Contractor:	Slater Electric Company Folsom, California
Construction:	Classified
Notice to Proceed:	24 April 1961
Original Contract Amount:	$3,980.00
Modifications:	One only modification was proposed:
	1. $710.75
Claims:	None
Final Contract Amount:	$4,690.75

28. Associated piping and Engineering that describes and prices special welding assemblies.

29. Carrier Air Conditioning Catalog that describes and prices air conditioning equipment, ducts, etc. of all types.

30. The Burk Company Catalog that describes and prices concrete construction specialties.

31. Pameco Metals and Supplies Catalog that describes and prices non-ferrous metals of all types.

The following publications are used as pertinent:

1. The Military Engineer Magazine.
2. The Engineering News Record Magazine.
3. The Constructor's Guide.
4. Southwest Builder and Contractor.
5. Handbook of Engineering Materials.
6. Civil Engineering Handbook by Urqhart.
7. The Machinery Handbook.
8. The Asphalt Handbook.
9. Handbook of California Standard Specifications.
10. The Steel Construction Handbook issued by AISC.
11. The Electrical Construction Cost Manual by Ralph E. Johnson.
12. Aviation Week and Space Technology Magazine.
13. Estimating General Construction Cost by Dallavia.
14. Construction Estimates and Cost by Pulver.
15. Estimating Construction Cost by Peurifoy.

16. The Labor Handbook by the Electrical Estimator's Association of Los Angeles, California.

This office was extremely fortunate regarding estimators. Most of the estimators in the Beale Area Office came to this job from the Sacramento District, Corps of Engineers, with a good background in estimating. The average number of years of experience for each estimator was approximately ten years. However, the sections pertaining to electrical and mechanical were particularly strong, in that these estimators had approximately a fifteen year background in mechanical and electrical estimating.

Due to the nature of this job it was realized that new factors not heretofore experienced had to be introduced into the preparation of estimates as applicable to this particular job. Therefore, the above data and experience was supplemented by current on-the-job studies of all phases of the work with respect to the preparation of estimates, and within a very short time after the job began, these factors were introduced into the estimates when a good representative study could be obtained.

Field studies were made for comparison with Government estimates of the most complex change orders and these comparisons have reflected that Government estimates have been adequate, well prepared, fair and equitable.

It is pertinent to note that at the start of the job a meeting was held with representatives of the contractor and a mutual schedule was worked out whereby estimates, proposals, and the negotiations of modifications could be expeditiously scheduled

and completed. On the more complex estimates and change orders a scope of work meeting was usually held and the general scope agreed to and a general format decided on. Coincident with the request for a proposal from the contractor, the Government started preparing the Government estimate. The Government estimate was scheduled to be completed before the suspense date for the Contractor's proposal and therefore was completed prior to the receipt of the contractor's proposal, thus meeting the established requirements and reflecting an unbiased estimate.

The services of Estimators Limited, a commercial firm specializing in estimating service, was utilized during the peak work load. Three estimators were used for eight months, two for four months and one for three months.

TIME EXTENSIONS

During the period when the Area Office was under the Sacramento District, February 1960 to November 1960, it was the Government's understanding that no time extensions would be granted; justified time in a few instances was paid for in modifications. After take-over by CEBMCO in November 1960, to approximately April 1961, operating procedures were not clearly established. Therefore, time extensions were not included with the settlement and were of necessity deferred to a later date.

In July 1961 a modification was written extending the completion dates of the various structures and in effect bring the justified time extensions accumulated by the various modifications to date. The contractor did not agree with the amount of time

provided by this modification and declared it an unilateral action.

Subsequent to that time, the Government attempted to negotiate time for each modification with the contractor. In most instances the contractor failed to agree and took exception to the time granted in the modification. He stated that he would prepare an overall time study for which he would file a claim. The claim had not been presented at the time of this writing.

NEGOTIATIONS

At the beginning of the job, January 1960, negotiations were fairly simple for the civil type work, such as excavation, backfill and concrete operations. As the job progressed and the changes began to involve the more complex mechanical and electrical work, the negotiations became more difficult. Changes compounded on changes and removal of completed work added to the complexity. The very nature of the work involved new procedures such as purging of pipes, cleanliness requirements and welding of stainless steel pipe. An idea of the magnitude of the job, using rounded figures, may be gained by comparing the original contract amount of thirty million dollars with the addition of approximately 400 changes with a dollar value of approximately ten million.

Negotiations in the majority of cases, although sometimes lengthy and time consuming, were satisfactory. Some of the problems of negotiation and reaching an equitable adjustment were: effect of change on original work and delays to original work, joint occupancy to a minor degree, labor congestion, inefficiency, shift differential, material handling, loss of productivity,

supervision and engineering, overhead and profit. Equitable adjustment of time was a constant problem and will not be resolved until the contractor submits his overall time study. The Government adjusted for time during the course of the job but the contractor took exception to those adjustments in most instances. Very little difficulty was experienced in negotiation for overtime or the cost of materials. The negotiations were conducted on an individual modification basis with no overall fixed factors being applied. The Government was prepared to negotiate as soon as the contractor submitted his proposal for the work. Multiple part change orders were issued so as to provide prompt payment for completed work.

Impact and effect were difficult to evaluate but were considered with each modification. The contractor generally took exception to the amount allowed. In those instances where agreement could not be reached on certain modifications, rather than defer settlement, a unilateral modification was issued. The above actions kept the number of outstanding modifications to a satisfactory minimum throughout the life of the job and precluded a large number of modifications to be settled at the end of the job.

18. LIST OF PRINCIPAL SUBCONTRACTORS, SCOPE OF WORK COST AND EFFECTIVENESS OF SUBCONTRACTORS' OPERATIONS

SUBCONTRACTORS

The principal contractor had approximately 10 first and second tier subcontractors. See Figure 101 for their names and the portion of the work performed by each. In addition to the subcontractors listed, there were numerous third and fourth tier subcontractors that performed specialty work and supplied materials and equipment.

The subcontractors performed approximately 80% of the total contract work.

CONTRACTOR-SUBCONTRACTOR WORKING RELATIONSHIP

Sub-contracts were awarded by Peter Kiewit Sons' Co. on the basis of competetive proposals offered upon invitation by the Prime Contractor. Management and supervision of the sub-contract work was a responsibility of the Prime Contractor. The sub-contract work was scheduled by the individual subcontractors, subject to approval by the Prime Contractor, based on overall job schedules as determined by the Prime Contractor.

Number of shifts, number of men and overtime requirements were generally the determination of the individual subcontractor. However, at times the Prime Contractor directed certain subcontractors to work additional personnel and overtime hours to pace certain critical phases of the job. During the earlier phases of the job, the Prime Contractor paid the premium portion of this directed overtime work. This payment of premium time was especially true with regard to the reinforcing steel subcontractor. In as much as the

mechanical subcontractor was a subsidiary of the Prime Contractor, the management policies of this subcontractor were essentially the same as those of the Prime Contractor, and the number of men, hours of overtime and number of shifts were more closely controlled by the Prime Contractor. This close control of the mechanical work was especially true during the final phases of the work.

The close relationship between the Prime and mechanical subcontractor made possible a somewhat closer coordination of work by second tier mechanical subcontractors than might otherwise have occurred. Problem areas in subcontractor work developed as follows: structural steel work, when the subcontractor went into receivership, requiring the Prime Contractor to assume managerial responsibility; tunnels and tunnel junctions, when management and supervision problems of the subcontractor caused lack of progress and impeded overall job progress; electrical work, when progress was impeded by labor and labor supervision problems of the subcontractor, causing delays in job completion; and mechanical work, due to management and organizational problems of a newly formed subsidiary.

EFFECTIVENESS OF SUBCONTRACTORS' OPERATIONS

The extent of work accomplished by subcontractors was consistent with normal practices of most general contractors. With the exceptions noted above, the effect of sub-contracting was dependent upon the efficiency of the individual subcontractors. The bankruptcy of the structural steel installation subcontractor caused additional expense to the Prime Contractor in assuming management responsibility and also labor costs; however, job operation and

FIRST AND SECOND TIER SUB-CONTRACTORS

	Name and Address	Extent & Character of Work	Approx.% of Work
1.	Sacramento Roofing & Insulation Co., Inc. P. O. Box 2253 Sacramento 10, Calif.	Waterproofing, Dampproofing and Rock Bolt Sealant - Complexes 1A, 1B and 1C	0.2
2.	Otis Elevator Company 1 Beach Street San Francisco 11, Calif.	Elevators Complexes 1A, 1B and 1C	1.5
3.	The Justice Company 1260 59th Street Oakland 8, Calif.	Erosion Control Seeding Complexes 1A, 1B and 1C	0.1
4.	John B. Duff 920 N. Miller Street Santa Maria, Calif.	Surveying Complexes 1A, 1B and 1C	0.5
5.	Armco Drainage & Metal Products	Tunnels	5.
6.	Parrish Bros. & Murphy Bros.	Excavation	20.
7.	A.M.Van Valkenburg & Co. P. O. Box 1192 Sacramento, Calif.	Portion of Water Line Complex 1A only	0.1
8.	Superior Electric Const. Co., Inc. 346 Brunswick Avenue Trenton, New Jersey	Electrical Work - Complexes 1A, 1B and 1C	6.
9.	Kiemech, Inc. 126 South First Ave. Arcadia, Calif.	Mechanical Work - Complexes 1A, 1B and 1C	19.
10.	Yuba Erectors Marysville, Calif.	Structural Steel and Misc. Iron	24.
11.	Frank M. Booth Marysville, Calif.	Ductwork on Installation of Air Conditioning	3.6

The above subcontract work amounted to approximately 80% of the total contract.

Fig.101

efficiency were not effected. The management and supervision problems of the subcontractor supplying and installing the tunnels and tunnel junctions caused temporary loss of job efficiency and considerable additional cost to the subcontractor. Costs to the Prime Contractor were incidental to delays to backfill and subsequent concrete operations, and were relatively minor in nature.

The labor, supervision and management problems of the electrical subcontractor caused considerable loss of efficiency and additional cost, and in some cases resulted in delay of final completion of individual structures. This particularly effected efficiency and caused considerable expense to the subcontractor and incidental losses to other subcontractors and the Prime Contractor. The relatively unusual occurrence of a major subcontractor being closely affiliated with the Prime Contractor did cause operational difficulties during the earlier phases of the mechanical work. These operational difficulties resulted from the responsible party for the subcontractor operation also being the administrative supervisor of the job site personnel. This situation caused job site personnel considerable difficulty in obtaining desired progress in the mechanical work. Final completion of some structures was delayed due to lack of efficiency by the mechanical subcontractor and resulted in added costs to the subcontractor and to the Prime Contractor. In summary, during the early phases of the job, approximately the first half, sub-contracting beneficially effected operation, efficiency and cost of the work. However, the operation, efficiency and cost of the latter half of the work was adversely effected by certain

subcontractors, due to their accomplishing a major portion of the work.

19.- THE RACE AGAINST TIME- SHOWING CONSTRUCTION PERIOD AND STATEMENT ON LIQUIDATED DAMAGES

CONTRACT NO. DA-04-167-eng-2140

Site	Item		AF Directed Completion Dates		Contract Completion Dates		Beneficial Occupancy Dates	
			ORIGINAL	REVISED	ORIGINAL	REVISED	SCHEDULED	ACTUAL
1A	M.S.	No.1	2/1/62	10/1/61	2/1/62	12/1/61	5/22/61	5/23/61
1A	M.S.	No.2	2/1/62	10/1/61	2/1/62	12/1/61	5/22/61	6/3/61
1A	M.S.	No.3	2/1/62	10/1/61	2/1/62	12/1/61	5/22/61	5/31/61
1A	E.T.	No.1	7/1/61	6/1/61	7/1/61	6/1/61	6/1/61	5/24/61
1A	E.T.	No.2	7/1/61	6/1/61	7/1/61	6/1/61	6/1/61	5/31/61
1A	E.T.	No.3	7/1/61	6/1/61	7/1/61	6/6/61	6/1/61	6/6/61
1A	P.T.	No.1	2/1/62	10/1/61	2/1/62	12/1/61	10/1/61	11/9/61
1A	P.T.	No.2	2/1/62	10/1/61	2/1/62	12/1/61	10/1/61	11/21/61
1A	P.T.	No.3	2/1/62	10/1/61	2/1/62	12/1/61	10/1/61	12/1/61
1A	P.H.	No.1	9/15/61	7/1/61	9/15/61	7/18/61	7/1/61	8/17/61
1A	L.C.C.	No.1	10/15/61	4/22/61	10/15/61	4/19/61	4/22/61	4/27/61
1A	E.P.S.	No.1	9/15/61	7/25/61	9/15/61	7/18/61	7/25/61	7/17/61
1A	A.S.	No.1	7/1/61	5/20/61	7/1/61	5/20/61	5/20/61	5/22/61
1A	A.S.	No.2	7/1/61	6/6/61	7/1/61	6/6/61	6/6/61	6/5/61
1A	A.T.	No.1	7/1/61	5/20/61	7/1/61	5/1/61	5/20/61	6/6/61
1A	B.L.&Tunnels	-	6/1/61	5/1/61	8/15/61	5/15/61	5/1/61	6/15/61

$50.00 Liquidated damages assessed for Late Completion of access road.

THE RACE AGAINST TIME–
SHOWING CONSTRUCTION PERIOD AND STATEMENT ON LIQUIDATED DAMAGES

CONTRACT NO. DA-04-167-eng-2140

Site	Item		AF Directed Completion Dates ORIGINAL	AF Directed Completion Dates REVISED	Contract Completion Dates ORIGINAL	Contract Completion Dates REVISED	Beneficial Occupancy Dates SCHEDULED	Beneficial Occupancy Dates ACTUAL
1B	M.S.	No.1	12/1/61	11/1/61	12/1/61	1/1/62	6/22/61	6/19/61
1B	M.S.	No.2	12/1/61	11/1/61	12/1/61	1/1/62	6/22/61	6/22/61
1B	M.S.	No.3	12/1/61	11/1/61	12/1/61	1/1/62	6/22/61	6/27/61
1B	E.T.	No.1	5/1/61	7/1/61	5/1/61	6/26/61	7/1/61	6/16/61
1B	E.T.	No.2	5/1/61	7/1/61	5/1/61	6/26/61	7/1/61	6/21/61
1B	E.T.	No.3	5/1/61	7/1/61	5/1/61	6/26/61	7/1/61	6/26/61
1B	P.T.	No.1	12/1/61	11/1/61	12/1/61	1/1/62	11/1/61	12/15/61
1B	P.T.	No.2	12/1/61	11/1/61	12/1/61	1/1/62	11/1/61	12/22/61
1B	P.T.	No.3	12/1/61	11/1/61	12/1/61	1/1/62	11/1/61	12/27/61
1B	P.H.	No.1	7/15/61	8/1/61	7/15/61	8/15/61	8/1/61	9/11/61
1B	L.C.C.	No.1	8/15/61	5/22/61	8/15/61	5/10/61	5/22/61	5/9/61
1B	E.P.S.	No.1	7/15/61	8/25/61	7/15/61	8/17/61	8/25/61	8/16/61
1B	A.S.	No.1	5/1/61	6/20/61	5/1/61	6/1/61	6/20/61	6/12/61
1B	A.S.	No.2	5/1/61	6/20/61	5/1/61	6/19/61	6/20/61	6/19/61
1B	A.T.	No.1	5/1/61	6/20/61	5/1/61	6/19/61	6/20/61	6/19/61
1B	B.L.& Tunnels	–	4/1/61	6/1/61	6/15/61	6/7/61	6/1/61	6/17/61

$200.00 liquidated damages assessed for late completion of access road.

THE RACE AGAINST TIME-
SHOWING CONSTRUCTION PERIOD AND STATEMENT ON LIQUIDATED DAMAGES
CONTRACT NO. DA-04-167-eng-2140

Site	Item		AF Directed Completion Dates		Contract Completion Dates		Beneficial Occupancy Dates	
			ORIGINAL	REVISED	ORIGINAL	REVISED	SCHEDULED	ACTUAL
1C	M.S.	No.1	1/1/62	12/1/61	1/1/62	2/1/62	7/22/61	7/15/61
1C	M.S.	No.2	1/1/62	12/1/61	1/1/62	2/1/62	7/22/61	7/25/61
1C	M.S.	No.3	1/1/62	12/1/61	1/1/62	2/1/62	7/22/61	7/24/61
1C	E.T.	No.1	6/1/61	8/1/61	6/1/61	7/21/61	8/1/61	7/18/61
1C	E.T.	No.2	6/1/61	8/1/61	6/1/61	7/21/61	8/1/61	7/21/61
1C	E.T.	No.3	6/1/61	8/1/61	6/1/61	7/21/61	8/1/61	7/25/61
1C	P.T.	No.1	1/1/62	12/1/61	1/1/62	2/1/62	12/1/61	1/3/62
1C	P.T.	No.2	1/1/62	12/1/61	1/1/62	2/1/62	12/1/61	1/22/62
1C	P.T.	No.3	1/1/62	12/1/61	1/1/62	2/1/62	12/1/61	1/22/62
1C	P.H.	No.1	8/15/61	9/1/61	8/15/61	8/31/61	9/1/61	10/9/61
1C	L.C.C.	No.1	9/15/61	6/22/61	9/15/61	6/1/61	6/22/61	6/9/61
1C	E.P.S.	No.1	8/15/61	9/25/61	8/15/61	9/19/61	9/25/61	9/18/61
1C	A.S.	No.1	6/1/61	7/20/61	6/1/61	7/1/61	7/20/61	7/17/61
1C	A.S.	No.2	6/1/61	7/20/61	6/1/61	7/1/61	7/20/61	7/10/61
1C	A.T.	No.1	6/1/61	7/20/61	6/1/61	6/1/61	7/20/61	7/14/61
1C	B.L.& Tunnels	-	5/1/61	7/1/61	7/15/61	7/8/61	7/1/61	8/4/61

20. STANDARDIZED EQUIPMENT

In the interest of securing the same kind of equipment for all of the Titan I missile projects throughout the nation, nine separate schedules of items were established for central procurement. These schedules were advertised and bids on them were obtained by Omaha District. When supply contracts were awarded, the nine schedules were divided into fourths making a total of thirty six supply contracts. The thirty six supply contracts were then divided among three districts for four projects as follows:

1. Omaha District received nine contracts for items for the Ellsworth project.
2. Walla Walla District received nine contracts for the Larson project items.
3. Sacramento District received nine contracts for the Beale project items.
4. Walla Walla District received an additional nine contracts for the Mt. Home project.

All districts with the exception of Sacramento then proceeded to assign their contracts to their respective prime construction contractors. Sacramento District elected to handle their contracts following procedures normally used for government furnished supply contracts; consequently the district had to deal with the eight suppliers for the nine schedules of items to be used on the Beale project. This proved to be a wise course of action because, as the projects developed throughout the nation, changes in connec-

tion with the supply contracts in all districts were forthcoming. In order to negotiate these changes other districts, because they had assigned their supply contracts,would have been forced to deal with supply contractors through prime construction contractors. To alleviate this situation, Sacramento District accomplished negotiations, except for delivery schedules, with the supply contractors for the other districts.

It was necessary for all of the missile projects concerned to insure that equipment arrived at the various sites at the appropriate time; therefore, frequent meetings of supply personnel were held centrally to properly determine which projects were to receive certain supply items. These meetings were termed "Management Group Operations".

The Beale Area executed checks for damage at point of delivery on those items for use in the Beale project. If there was no damage to the item concerned, it was accepted by Area personnel and immediately transferred to the prime construction contractor at point of delivery.

The Sacramento District Engineer was the Contracting Officer for the following contracts:

Contract Number		Basic Amount
5927	Cryogenic Vessels	$ 794,529.
5933	Air Conditioning & Refrigeration	147,516.
5939	Air Compressors	93,120.
5945	Alarm System Damage Control and Annunciator	88,170.
5951	Contaminated Waste, Booster & Fire Water Pumps	87,700.
5961	2.4 K V Switchgear	277,965.
5967	Electric Generating Equipment	1,098,726.
5977	PLS Pressure Vessels	992,838.
5984	PLS Valves & Related Equipment	679,397.
	Total - - - - - - -	$ 4,259,961

The Government procurement of standardized equipment by the Omaha District was proposed with the threefold purpose of: (a) accelerating delivery of certain long lead-time items, (b) effecting monetary savings through volume purchase, and (c) by standardizing types and makes of material procured in the interest of simplifying future care and maintenance.

In practice, the theoretical advantages of Government procurement were offset by some distinct disadvantages: (a) A different architect-engineer wrote the specification for the standardized equipment purchase than wrote the specification for the Beale T-5 site construction. As a result, there were numerous discrepancies that resulted in costly changes to the Beale construction contract to resolve the differences. (b) The increased cost of Government administration and inspection of the standardized equipment

contracts probably offset any saving in the initial procurement cost. This applied particularly to items requiring cleanliness inspection where there was divided responsibility between the Government and construction contractor in the inspection and handling from vendors' factories to completed site installation.

(c) Late delivery of some standardized equipment resulted in the construction contractor making claim for compensation in time and money because of the Government's failure to meet promised schedules.

An overall appraisal of the results obtained with Government furnished standardized equipment for the T-5 construction contract would indicate that the disadvantages outweigh the advantages. It is believed that the interests of the Government would have been better served by having the construction contractor furnish all equipment required for T-5 site construction.

A summary of the total cost of standardized equipment for the Beale Project follows:

TOTAL COST: STANDARDIZED EQUIPMENT CONTRACTS

Basic contract amount	$ 4,259,961
Modifications over $100,000	260,858
Modifications under $100,000	651,835
Pending claims	188,986
Total anticipated cost	$ 5,361,640

A breakdown of modifications and claims follows:

Modifications over $100,000

Contract Number	Mod. No.	Description	Amount
5984	11	Bench Tests of Safety Relief Valves	$138,308
5984	13	Manufacturer's Representative Services	122,550
		TOTAL	$260,858

Modifications under $100,000

Contract Number	Total Mods.		Amount
5927	20		$ 98,235
5933	9		30,461
5939	5		4,853
5945	6		36,524
5951	8		39,007
5961	7		24,361
5967	7		53,070
5977	5		3,330
5984	14		361,994
		TOTAL	$651,835

Pending Claims

Contract Number	Description of Claim		Amount of Claim
5927	S. S. Vessel Cleaning		$ 53,539
5927	Third Facility		29,261
5927	X-Ray		2,746
5927	Overtime - 3 Shifts		97,650
5927	Equipment List		690
		TOTAL	$ 183,886
5984	None		2,100
5984	None		2,500
5984	None		500
		TOTAL	$ 5,100

21. LIST OF CONTRACTS ADMINISTERED BY CEBMCO, BEALE AREA

CONSTRUCTION CONTRACTS

Contract Number	Description	Basic Amount
Active Contracts		
2140	WS-107 A-2 Technical Facilities	$ 30,157,150

See Section 20 for list of Standardized Equipment contracts.

Contract Number	Description	Basic Amount
Completed Construction Contracts		
2230	Protective Alarm Systems, Re-Entry Vehicle Facility	4,691
2097	Water Wells	37,535
2102	Water Wells	37,460
2109	Water Wells	19,772
2110	Area Office	25,550
2141	Water Wells	20,803
2174	Re-Entry Vehicle Facility	155,790
2175	Re-Entry Vehicle Facility	20,650
2176	Helium Unloading Facility	13,867
2177	GMAB and Tech Supply	767,175

PROCUREMENT

7378	Columbia-Geneva	48,263
7379	Cosmodyne	36,252
4520		17,624
6623		12,415
Contracts Misc.		20,010
7609	Cleaning & Testing Rechargers	24,112

Contract Number	Description	Basic Amount
Procurement (Continued)		
7738	ADSCO	1,200
7747	Accessory Product - Filter	4,000
7644	Air Products Co. (Overhaul & Recharge)	30,000
7677	Rehabilitate Helium Compressor	3,560
7383	Western Filter Company	2,870
P.O. 19-56358	General Air Equipment	3,633
P.O. 19-56065	General Air Equipment	1,109
P.O. 19-55992	CompuDyne	492
5886	Blast Detection	34,852

SURVEY CONTRACTS

2143		30,909
2144		73,730
2217		34,975
2218		82,710

ARCHITECT ENGINEER CONTRACTS

12	TEMCO	128,974
13	DMJM	684
16	Estimators Ltd	87,703
2148	Earl & Wright Inc.	550
2153	DMJM	119,000

Contract Number	Description	Basic Amount
Architect Engineer Contracts (Continued)		
5886	Ralph Parsons	509
7660	National Engineering	2,975
3598	Zep Aero	231,421
58	United Testing Laboratory	36,831

The above Construction Contracts were administered by the Beale Area Office with the exception of the water well contracts which were administered by the Sacramento District. The Procurement Contracts were administered by CEBMCO, Los Angeles. The Survey Contracts were administered by the Sacramento District. The Architect Engineer contracts were administered by CEBMCO, Los Angeles with the exception of 2148 with Earl & Wright Inc. and 2153 with DMJM&A which were administered by the Sacramento District.

22. LIST OF MODIFICATION NUMBERS FOR EACH CONSTRUCTION CONTRACT

CONTRACT NO. DA-04-167-eng-2140

MOD. NO.	DESCRIPTION
1	Revised Revision Blocks
2	Reschedule of Completion Dates
3	Relocate & Enlarge Laboratory
4	Revised Contr. Operational Area
5	Revised Installation of Rock
6	Delete Segregated Magazine & Access
7	Miscellaneous Modifications
8	Liner Plates
9	Dimensional Errors on Drawings
10	Delete Interior Paint in Tank
11	Install Additional Unistruts
12	Conduit, Panel to Air Dryer
13	Pipe Sleeves thru Fire Wall
14	Seal Coat Certain Floors
15	Remove Unstable Material
16	Revise LOX Tank, Substitution of Rock Bolts and Modify MG Circuit Breaker
17	Changes re - Blast Valves
18	Delete Swage Nitro-Couplings
19	Electrical Changes
20	Modify Water Control Valves and Correct Dimensions
21	Relocate Targets
22	Correct Conflict Filter Box

MOD. NO.	DESCRIPTION
23	Correct Water Distribution Main
24	Fabricate 36WF 260 Yoke and Modify Anchor Bolts & Air Cutouts
25	Changes External Process Connections
26	Install Swivel Lift Plates
27	Clarify & Correct Drawings
28	Large Weld Caps & Enlarge Tubes
29	Revise Deep Well Submersible Pumps
30	Revise Latch & Support Blocks
31	Revise Construction of Launcher #2, 1A
32	Revise Latch on Blast Doors
33	Revise Air Filters in Control Center
34	Revise Blast Door Opening Dimensions
35	Different Type Transformers in Sub-Station
36	Additional Support-Cable Hanger Antenna Silos
37	Revise Electrical Circuit Air Compressor Piping, Revise Instrument Air Compressor Piping, Modify Contaminated Waste Line
38	Contractor-Furnished Anchor Bolts
39	Enlarge Size Telephone Cabinets
40	Revise Blast Lock Doors & Frames
41	Add Swing Check Valves
42	Miscellaneous Mechanical & Electrical Changes
43	Revise Installation-Anchor Bolts
44	Reroute Conduit in Missile Silos
45	Revise Clovis Mounts

MOD. No.	DESCRIPTION
46	Ground Well Complex 1
47	Revise Wiring and Revise Location of Lights and Temporary Opening
48	Delete Anchor Bolts, Missile Silo
49	Relocate Control, Anchor LOX Tanks and Relocate Pressure Devices
50	Government Inspection Facility at Beale
51	Claim (Dampproofing Equipment Terminals)
52	Larger Size Hydraulic Pipe
53	Contractor Installed Pillow Blocks, etc.
54	Revise Walls Room 402 Equipment Terminals
55	Delete Heat Tubes in Antenna Silo
56	Modification to Flex Hose
57	Water Stops for C.C. & P.H. Domes at 1A
58	Furnish Standard Hex Nuts & Washers
59	Furnish & Install Flexible Conduit Ells, Equip.Terminals
60	Revise Shutoff Facility in Personnel Tunnels, P.T.
61	Changes in Elevation in Specifications
62	Labor and Material to Install 3 Vessels
63	Revise Cooling Tower Elevation
64	Install 1" Conduit Telephone Box to Tray and Waterproof Rolled Channel Junctions
65	Revised Flanges for Process Piping
66	Additional Benchmarks in Missile Silos
67	Asphalt Tile & Rubber Hose and Revise Limit Switch Mounting Plates,Equipment Terminal

MOD. NO.	DESCRIPTION
68	Delete Certain Valves and Relocate Boosters
69	Relocate LOX Tank in Propellant Terminals
70	Increase Size of Sleeves
71	Change Blast Locks & Air Intake Filtration
72	Furnish Labor and Material for Government Furnished Property Cleanliness Inspection
73	Revise Powerhouse Construction for Diesel Foundations
74	Miscellaneous Electrical Changes & Tunnels Drawings
75	LOX and Fuel Crib Changes
76	Change Dimensions Blast Locks
77	Install Color Coded Cable for Instrumentation in PLS
78	Delete Hardened Silo Antenna
79	Rehandling Ice Banks & Revise Beams in Equipment Terminal
80	Alternate Method Floor Panels
81	Assemble Contaminated Waste Pumps
82	Extend 1-2/o Soft Drawn Grounding Cable
83	Facility for Trailers-Power,Sanitary Water for 10 People
84	Dampproof Top-Sides of Blast Locks No.s1&2, 1B & 1C
85	Delete Item No. 114 contained in Mod. No. 47 for Temporary Openings
86	Revise Bellows Joints, PLS System
87	Delete Gate House All Sites
88	Revise Chilled and Chilled Return Line in Equipment Terminal and Delete Gimball Joints and Install Insert Spools
89	Change Size Curb Closure Angle in Powerhouses

MOD. NO.	DESCRIPTION
90	Delete Spring Support & Shock Isolator and Revise Pump Support for Deep Well Pumps
91	Revise Wiring in Control Center & Launchers
92	Delete Sht. 486c in its Entirety
93	Change Type Lighting Fixture in Equipment Terminals
94	Change Yokes from Semi-Steel to Steel on Control Valves
95	Revise Location of Tank T-401
96	Provide Painted Wainscot on Panels and Revise Drain Line to Tank T-204
97	Calk Channel Joints at LOX Tank and Air Filtration structures of 1A
98	Revise Permanent Type Air Filters, Utilize Excavated Rock Material and Delete Drain from Junction Boxes on Missile Silos
99	Revise Location of Anchor Bolts in Antenna Silos
100	Provide Framed Opening in Firewall of Utility Tunnels - All Sites
101	Pave Inverts of Fuel Tunnels
102	Design Changes to PLS System
103	Correct Terminal Strips to be used in Junction Boxes 1500, 1600, 1601, 1602
104	Modifications to Shock Test Equipment
105	Furnish and Install Exhaust Transition Pieces-Nordberg Generators - Powerhouses
106	Revised Piping-LOX Subcooler Tank T-401
107	Revise Connection of LOX Tunnels - Missile Silo
108	Recorder Controller-Powerhouse, Delete 3-2" Conduit Sleeves on Sheet 568 and Revise Dimension of Templates for Doors Missile Silo
109	Miscellaneous Change to Certain Drawings

MOD. NO.	DESCRIPTION
110	Extend 2-3" Conduits to Telephone Manhole
111	Revise Support of 12" Fire Water Lines
112	Provide Additional Resteel in Bottom Face of Missile Silo
113	Change Location and Size of Duct Cut-Outs in Antenna Terminal
114	Revise Installation of Lighting Fixtures in Communication Equipment Rooms
115	Contractor Request for Concrete Encasement of Yoke Beam in Tunnel Junctions
116	Revise P-10 Drains in Tunnel at 1A
117	Delete Reference on Contract Drawings
118	Fill Floor Block - Outs in Equipment Terminals with Mastic
119	Furnish and Install Different Type Gaskets in Certain Process Lines
120	Electrical Service to Test Control Station in Powerhouse
121	Structure Change to LOX Cribs
122	Revised Propellant Loading System Tunnel Supports
123	Relocate Horizontal Spring Mounts in Propellant Terminal
124	Cope Stairway Stringer - Propellant Terminal
125	Re-route lines in Propellant Terminal at 3 Complexes to clear wide flange Beam
126	Install 2 additional Conduit Sleeves through Control Center Domes
127	Required Revisions to Fuel Systems and Fire Water Supports in Missile Silo
128	Revise Installation of Tank T-510 to Tunnel Junction No. 12
129	Install Communications Conduit Sleeves through Walls of Blast Locks 1 and 2
130	Relocate Lighting Fixtures in Tunnel Section A, B and C, 3 complexes

MOD. NO.	DESCRIPTION
131	Install kits between water chillers and switchgear,3 Sites
132	Lower Fuel Line Piping in certain Blast Lock Structures, 3 complexes
133	Furnishing and Installing Vibration Isolators for Air Compressors #C-4
134	Revise Neoprene Water Stops - Tunnels
135	Revise PLS Piping Supports in Missile Silo and Propellant Terminal Lox Cribbing
136	Relocate Firewater Rollout in Personnel Tunnel
137	Revised Testing Procedure of Propellant Loading System, 3 Complexes
138	Cancelled
139	Revise Security Fencing Facilities 3 Complexes
140	Stop Procurement of TV Surveillance System
141	Revise Sealing of Sleeves, Utility Tunnels Drains Missile Silo Complex 1A
142	Revise Installation of Ball Joints on Water Line
143	Revise Installation of Drains in Top of Antenna Silos, Testing with Liquid Nitrogen in lieu of LOX and Revise Installation of Bench Marks in Missile Silo Walls
144	Relocate Orientation Target No. 2 at Complex 1B, Furnish Pressure Switches (FH-15), and Delete Installation on Felt Between Tank and Supports in Propellant Terminal
145	Revise Communication System - All Sites
146	Install Spools in PLS Piping in lieu of Contaminated Valves, Replace with clean Valves
147	Segmentation of MCC and Additional Installation of Package Controls
148	Revise Water Supply Facilities in Tunnel Sections and Revise Piping Configuration in Fuel Lines to Diesel Generator

MOD. NO.	DESCRIPTION
149	Installing Two Hole Strap Supports for Conduit and Tubing
150	Install Additional Pipe Supports for all Piping, 2" or Smaller in Tunnel
151	Hardstands for Associate Contractor, Revise grading and Relocate Portion of Security Fencing at 1B
152	Revise Antenna Silos Elevators - all Sites
153	Revise Construction of Holes to Vaults in Control Center
154	Delete Neoprene Cork Pads from between Piping & Supports
155	Connect 4"-CSO-326 Line to 8" CSO-326 Line in lieu of to 11" CSO-326 Line
156	Extend Completion Dates for Powerhouses Complex 1A by 30, 1B-20, 1C-10 days
157	Furnish and Install Pressure Control Stations in HW, HWR, CH AND CHR Lines, CC and Antennas
158	Extend Completion dates for Control Center Complex 1A-18 days and 1B by 9 days
159	Revised Cable Tray Layout in Second Floor of Control Centers
160	Revised Installation of 36" Diameter Blast Valves in Blast Locks
161	Blow-down of Government Furnished Cryogenic Vessels &Tanks
162	Delete Air Supply Duct in Antenna Terminal and add top grill and Provide One Coat Paint on Edges Accoustical Baffles in Control Center
163	Install Additional Supports under Free End of Grating Antenna Silos
164	Overhaul Required to Provide Advanced Space for Martin Warehouse, Site 1A
165	Correction of Design Deficiencies to Steel Ladders in Equipment Terminals
166	Provide additional Pipe Supports for PLS Piping in Propellant Terminal and Interconnecting Tunnels - 3 Complexes

MOD. NO.	DESCRIPTION
167	Revised Fabrication of Cable Trays in Control Centers and Lower Fuel Piping Sleeves through Firewall in Tunnel Junction 12, Sites 1A and 1C
168	Relocate Piping and Install Nitrogen Check Valve in Propellant Terminals
169	Notch and Reinforce 8" Channel Platform Support in LOX Bay
170	Time Extension
171	250 PSI Gate Valves in 3" Plant Air Line in Equipment Terminal in lieu of 125 PSI Valve
172	Not Issued
173	Not Issued
174	Revise Termination of 4" Firewater Ring Header in Missile Silos 3 Complexes and 6" Flanged Steel Firewater Lines to Pipe Specified Fire Hydrants in lieu of Cast Iron
175	16 Gauge Aluminum Ducts in Interconnecting Tunnels in lieu of Galvanized Ducts, 3 Complexes
176	Revise Installation of Anchor Bolts for Accumulator, Antenna Silos
177	Extension of Completion Dates for Tunnel Junction No. 10 (16 days at each Complex)
178	Revise Seal Bearing Plates on East Leaf of Antenna Silo Doors Complexes 1B & 1C and Delete Flexible Connection from Plumbing Vent Lines in Toilet Rooms, CC1A,1B,1C
179	Change Size of Door in Propellant Terminal leading to Personnel Tunnel from 7'0" to 6'6"
180	Install 2-4" Conduits through air Intake Structure to terminate 2' below Finish
181	Revise Specified and Add Additional Conduit Sleeves for Associate Contractor Cables
182	Correct Ground Water Leaks at Complex 1A
183	Revised Installation of CSN-572 Line, CSN-568 Line, OSH-613 Line and Valve SV-607 in Propellant Terminals

Contract:	DA-04-167-eng-2140
Modification No. 104	84 No. 50
Date of Modification:	10 March 1961
Description of Work:	Modification to shock test equipment. Furnishing equipment, labor and material required to shock test certain specified electrical and electronic equipment in Shock Zone C of all three complexes in accordance with revisions of the contract specifications. This is additional shock testing to that required by the contract.
Amount of Modification:	$195,436

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Contract:	DA-04-167-eng-2140
Modification No. 109	84 No. 115
Date of Modification:	22 December 1960
Description of Work	Design changes of Process Piping, Process-piping fuel system, Air Conditioning, Cooling System, Diesel Generating Plant and Compressed Air System in the Powerhouse, Control Center and Tunnels. COC Nos. 268,270,271 and 275.
Amount of Modifications:	$793,847.00 (5 pts)

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Contract:	DA-04-167-eng-2140
Modification No. 122	84 No. 196
Date of Modification:	13 June 1961
Description of Work:	Revision to Propellant Loading System Pipe Supports and Anchors in the Interconnecting Tunnels to Missile Silos at all three Complexes.
Amount of Modification:	$211,292.00 (2 pts)

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Contract:	DA-04-167-eng-2140
Modification No. 127	84 No. 211
Date of Modification:	4 August 1961
Description of Work:	Design changes to the Fuel System Fire Water Piping and Supports at all three Complexes.
Amount of Modification:	$ 110,742.00

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Contract:	DA-04-167-eng-2140
Modification No. 135	84 No. 212
Date of Modification:	28 July 1961
Description of Work:	Revision of Pipe Supports for PLS Piping Lox Cribs, Missile Silos and Propellant Terminals. Based on A. D. Little stress analysis.
Amount of Modification:	$ 1,100,000.00(3 pts unilateral)

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Contract:	DA-04-167-eng-2140
Modification No. 137	84 No. 94
Date of Modification:	3 April 1962
Description of Work:	Revised Test Procedure for PLS System.
Amount of Modification:	$1,824,007.00 (4 pts)

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Contract:	DA-04-167-eng-2140
Modification No. 147	84 No. 231
Date of Modification:	10 March 1961
Description of Work:	Segmentation and Re-assembly of Motor Control Sections and Advance Delivery Date.
Amount of Modification:	$ 131,453.00

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Contract:	DA-04-167-eng-2140
Modification No. 151	84 No. 233
Date of Modification:	4 May 1961
Description of Work:	Advance Completion Dates of Site Grading, Paving of Access Roads, Security Fencing and Construct Hard Stands at all three Sites.
Amount of Modification:	$ 175,000.00 (2 pts)

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Contract:	DA-04-167-eng-2140
Modification No. 161	84 No. 236
Date of Modification:	19 June 1961
Description of Work:	Additional Blow-downs required to clean Cryogenic Tanks and Pressure Vessels at all three Sites.
Amount of Modification:	$ 198,976.00 (3 pts)

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Contract:	DA-04-167-eng-2140
Modification No. 166	84 No. 250
Date of Modification:	18 July 1961
Description of Work:	Furnish additional Pipe Supports for PLS Piping at interconnecting Tunnels of the Propellant Terminal.
Amount of Modification:	$ 194,622.00 (3 pts)

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Contract:	DA-04-167-eng-2140
Modification No. 262	84 No. 323
Date of Modification:	19 January 1962
Description of Work:	Revisions to Pipe Supports and RP-1 Fuel System Tunnel Junction 12.
Amount of Modification:	$ 162,852.00 (2 pts)

Contract:	DA-04-167-eng-2140
Modification No. 267	84 No. 341
Date of Modification:	28 December 1961
Description of Work:	Procure and Store PLS Spare Parts
Amount of Modification:	$ 101,387.00

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Contract:	DA-04-167-eng-2140
Modification No. 286	84 No. 333
Date of Modification:	26 February 1962
Description of Work:	Re-circulate RP-1 fuel oil through filters above ground to insure cleanliness.
Amount of Modification:	$128,869.00

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Modifications Under $100,000. excluding those Modifications Derived from Claims

Mod. No.	Amount	Mod. No.	Amount
1	N/C	21	- 779
2	N/C	22	412
3	9,141	23	1,731
4	N/C	24	N/C
5	- 11,420	25	21,418
6	- 13,554	26	1,479
7	87,700	27	1,387
8	- 26,500	28	2,539
9	N/C	29	- 1,565
10	- 20	30	12,723
11	729	31	49,310
12	758	32	577
13	703	33	3,460
14	4,700	34	55
15	4,800	35	- 6,432
16	N/C	36	1,273
17	1,544	37	N/C
18	- 1,265	38	4,845
19	- 881	39	773
20	N/C	40	370
41	2,068	62	1,307
42	3,169	63	1,609
43	2,981	64	841

Mod. No.	Amount	Mod. No.	Amount
44	345	65	3,103
45	3,003	66	4,233
46	1,179	67	2,907
47	1,844	68	- 9,664
48	- 665	69	4,551
49	2,716	70	5,526
50	8,328	71	720
52	384	73	17,486
53	7,593	74	11,665
54	1,852	75	18,211
55	- 14,384	76	4,829
56	67,126	77	4,056
57	6,902	78	- 15,039
58	573	79	943
59	2,099	80	- 4,788
60	1,094	81	2,450
61	1,391	82	3,125
83	17,451	129	3,892
84	3,212	130	16,397
85	(- 1,844)	131	8,274
86	9,402	132	6,454
87	(- 92,571)	133	(- 4,737)
88	15,651	134	5,775
89	868	136	7,553
90	600	138	N/C

Mod. No.	Amount	Mod. No.	Amount
91	306	139	23,291
92	(- 1,043)	140	47,450
93	2,333	141	2,800
94	(- 341)	142	1,000
95	5,389	143	N/C
96	2,837	144	(- 639)
97	4,359	145	52,346
98	1,268	146	8,779
99	6,650	148	818
100	5,019	150	68,650
101	3,772	152	1,836
103	6,924	153	823
105	8,997	154	212
106	18,621	155	8,704
107	6,920	156	N/C
108	2,486	157	28,674
110	1,050	158	N/C
111	25,626	159	32,771
112	10,883	160	21,000
113	4,130	162	245
114	2,236	163	3,941
116	4,545	164	4,950
117	(- 660)	165	1,884
118	3,435	167	1,333
119	31,531	168	2,497

Mod. No.	Amount	Mod.No.	Amount
120	3,030	169	1,242
121	27,977	170	N/C
123	2,924	171	5,843
124	850	172	N/C
125	10,566	173	N/C
126	2,090	174	816
128	1,814	175	1,682
176	3,500	221	730
177	N/C	222	(- 300)
178	1,022	223	3,141
179	2,722	224	1,490
180	1,038	225	577
181	16,493	226	1,140
182	50,189	227	60,451
183	16,590	228	21,785
184	3,459	229	26,824
185	1,925	230	3,135
186	6,056	231	18,916
187	5,119	232	2,882
188	5,592	233	1,466
189	5,956	234	1,120
190	11,420	235	33,982
191	24,261	236	13,554
192	12,230	237	950
193	8,016	238	(- 4,236)

Mod. No.	Amount	Mod. No.	Amount
194	24,273	239	47,016
195	20,753	240	33,725
196	22,827	241	1,031
197	24,862	242	633
198	1,324	243	4,179
199	8,855	244	1,274
200	20,089	245	1,034
201	50,454	246	15,114
202	16,916	248	476
203	3,759	249	782
204	11,123	250	12,741
205	1,229	251	14,086
206	(- 1,818)	252	56,178
207	N/C	253	20,485
208	77,379	254	5,833
210	3,290	255	2,714
211	1,172	256	6,411
212	1,051	257	22,484
213	28,041	258	769
214	6,715	259	59,541
215	2,013	260	(- 350)
216	3,708	261	23,166
217	538	266	4,202
219	(- 652)	268	697
220	524	269	9,088

Mod.No.	Amount	Mod.No.	Amount
270	52,000	307	12,423
271	(- 62,865)	308	700
272	11,280	309	(- 2,500)
275	27,006	310	4,666
276	15,735	314	49,181
277	81,055	316	4,143
278	8,076	TOTAL	$ 2,284,633
281	9,130		
283	3,371		
288	2,868		
291	31,917		
292	12,785		
295	10,418		
296	1,330		
297	40,770		
298	3,498		
299	60,000		
300	8,461		
301	2,974		
302	4,141		
303	7,525		
304	4,892		
305	6,521		
306	4,674		

Five Remaining Open Modifications:

84 No. 276 - Validation Tests in Addition to Contract Requirements at Complex 1A

The Government feels that the original contract provided for validating of all systems for the launcher complexes and its components for the entire job. The Government subsequently revised, clarified and refined the validation test plan for the above by this modification. The contractor claims the Government revamped the testing over and above the original contract requirement and therefore disagreement exists. Proposed Amount $500,000.

84 No. 379 - Modification to Fire Water Systems, 3 Complexes

Design deficiencies required replacement of the fire water jockey pumps, conversion of fire water control valves and correction of electrical circuit systems. Therefore it was necessary to correct the above deficiencies. Proposed Amount $55,000.

84 No. 385 - Modifications to Fire Water Control Facilities, 3 Complexes and P 1, P 3 and P 5 Tests.

This modification includes the installation of piping and electrical controls in the Missile Silos to carry out the P-11 validation test which is designed to verify the function of the complete fire water protection system which replaces the P 1, P 3 and P 5 tests. Proposed Amount $250,000.

MOD. NO.	DESCRIPTION
184	Revised Slide Plate between Pipe Chase Slab and Generator Slab in Powerhouse
185	Revised Installation of Bench Marks Provided for Mods. Nos. 97 and 143 in Missile Silos Walls, 3 Complexes
186	Revise Water Ring Header "E" through LOX Crib Elevation: 66In Missile Silos
187	Re-route 2" JSN-511 Line to Clear 3" CSN-522 Line and Ring Header E Missile Silos
188	Re-locate AC Duct in Missile Silos to Clear Conduits
189	Revise LOX Level Instrumentation on LOX Storage Tank, PLS, 3 Complexes
190	Resolve Conflicts Between PLS Piping Structural and Support Members, 3 Complexes
191	Revise Installation of Cylinder Shock Mounts in the Antenna Silos, 3 Complexes
192	Reverse or Rebuild Doors to East Antenna Silo -Complex 1A
193	Miscellaneous Electrical Changes in Control Center and Powerhouse
194	Revised Installation of PLS Piping Supports and Braces in Tunnel Junction No. 12
195	Additional Supports in Air Intake Tunnel and Add Neoprene Seals 1A and 1C
196	Revise Installation of Air Conditioning Ducts in Antenna Silos, 3 Sites and Air Duct Support,Antenna Silos
197	Relocate Vertical Domestic Water, Waste and Vent Lines in Equipment Terminals
198	Install 1½ inch Check Valve and a 3 inch Gate Valve in RW Line in Powerhouse
199	Revise Meter for Fuel Oil Consumption of Diesel Generators in Powerhouse
200	Revised Installation of Supports for Fog Nozzles in Missile Silos
201	Remove, Clean and Reinstall Diesel Engine Lub Oil Piping

MOD. NO.	DESCRIPTION
202	Relocate Diesel Engine Crankcase Blowers
203	Revise Framing for PLS Piping Guide G-320-57 in Propellant Terminal - 3 Complexes
204	Clean at Job Site Installed Tank T-110
205	½" Checkered Splice Plate at Entrance to Entry Portal from Personnel Tunnel in Lieu 5/8" Plate,3 complexes
206	Delete Plugging of Access Hole to Equipment Terminal and Sand Backfill. Place Plug 30' from Opening
207	Extension of Time - Portion of Structure All Sites
208	Changes to Installed Facilities in Antenna Silos to Conform to Associate Contractor Equipment
209	Formerly Claim No. C-2-Reimbursement for Latent Conditions
210	Revise Pump Base Bed Plates in Powerhouse
211	Revise Location of J-Box for Weather Instrument Indicator-Control Centers and Revise Sub-Floor Ladders in Powerhouse Air Intake
212	Revise Cable Supports of F.P.E. Switchgear to Handle 2-3 Conductor Cables instead of 3 Conductors
213	Relocate Vertical Drain Lines at El 85 in Missile Silo and Relocate 6" Contaminated Waste and 4" Firing Seal Drain Lines in Missile Silo
214	Clean the Diesel Engine Lube Oil Supply and Return Line in Powerhouse
215	Filter Screens over Air Intake Filters for Diesel Generators in Powerhouse, 3 Complexes
216	Revise Supports for Lines to AC-1 and 2 A.T.; Revise Support 730-51 and Rack #3, Propellant Terminal
217	Revised Certain Floor Cutouts in Antenna Terminal
218	Validation Testing
219	Revise Fuel Transfer Pumps in Powerhouse
220	Add Anchor Bolts to Communication Covers

MOD. NO.	DESCRIPTION
221	Pull Additional Wires in Conduit for Fire Water Control in Missile Silos and Personnel Tunnel
222	Paint Checkered Floor Plate in Air Filtration Structures in Lieu of Galvanizing
223	Add Four Dowels to Each Portal Silo Door Clevis Plate
224	Increase Width of Partition at Elevator Gates in Antenna Silos
225	Relocate Fuel Sensor from Fuel Storage to Tunnel Junction #12
226	Miscellaneous Changes in Specified Structures Exclusive of Antenna Silo
227	Labor, Material and Equipment to Adjust Nordberg Generators and F.P. Switchgear
228	Resolve Minor PLS System Interferences - 3 Complexes
229	Revise Routing of 3/4" JSH-610 Line in the Propellant Terminals, 3 Complexes
230	Additional Relays for Waste Pumps and Revise Level Controller in M.S.
231	Add Sealer over Insulation in the LOX Tunnel and Stacks
232	Add Bracing to Platform for Accumulators in Entry Portal
233	Iron Guards Around Diesel Generator Concrete Pads, Powerhouse 1A
234	Install IR Detector-3 Sites
235	Radiologically Examine all Welds of the Entry Portal Hydraulic Piping Subject to 1000 psi or more
236	Add Drip Pan Above Switchgear in Powerhouse
237	Drill Holes in Powerhouse 1A for Bench Marks and Temperature Facilities
238	Above ground Radiation Detectors w/range 0-5000 in lieu of .01 to 10,000 roentgens

MOD. NO.	DESCRIPTION
239	Change Procurement and Delivery of Testing Media
240	Pickle All Fuel Oil Piping, 3 Complexes
241	Install Auxiliary Drain Pump Between Lines in B.L.#1B
242	Correction of Interference Encountered During Construction, All Sites
243	Revise PLS Guide G-326-54 at all 3 Complexes, P.Terminals
244	Change to Liquid Level Indicator Facilities in PLS Instrumentation
245	Radiologically Examine PLS Line Field Welds
246	Air Eliminator in Cooling Tower Pump Suction Line High Point in Powerhouse, 3 Sites
247	Protective Coating T-110 Tanks
248	Annunciator Alarm Panel Windows in Powerhouses-3 Complexes
249	Procure 27 Additional General Duty Fire Sensors - E.T.
250	Reinforce Neoprene Seal at the Fan Housing, Air Intake Structure
251	Revise LOX Tank Bay Pipe Support, 3 Complexes
252	Reimbursement to Contractor for notice to Suspend Work on Entry Portal Facilities and Revise Entry Portal Facilities to Forestall Dropping Door and to Insure Proper Door Operation
253	Additional Test Requirements for PLS(Fuel System) Low Pressure Nitrogen Blanket Piping
254	Revise Diagonal Bracing in LOX Crib in Missile Silos
255	Relocate Electrical·Facilities due to Interference with Pipe Supports in Missile Silo
256	Revise Explosion Defecting Blast Valves Circuits and Over-ride Interlock Panels
257	Relocations to Pipe, Conduit and other Facilities to Eliminate Conflicts

MOD. NO.	DESCRIPTION
258	Wheel on Security Fencing Sliding Gate All Sites
259	Add New Pipe Supports on PLS System Piping -3 Complexes
260	Delete Sandfill in Propellant Terminal Roof Access Shafts, All Sites
261	Revise Pipe Supports-PLS
262	Revise Pipe Supports, Tunnel Junction #12, Revise RP-1 Fuel Systems, 3 Complexes
263	Vermiculite Concrete Fill-Tunnel Invert at Connections to Structures, 3 Complexes
264	Additional Painting
265	LOX and Fuel Crib Field Changes
266	Field Changes to Eliminate Interference and Conflicts
267	Provide for Contractor Purchasing RPIE Spare Parts for Use During PLS Testing
268	Relocate Control Panel in Air Filtration Structure
269	Install Terminal Strips in Junction Boxes Nos. 1500, 1600, 1601, 1602, 3 Complexes
270	Revise Blast Valves, All Complexes
271	Government to Furnish all Diesel Oil for Tests and Initial Fill of Tanks
272	Revise Pipeline Color Coding in Propellant Terminal, All Sites
273	Relocate Doors 11/13 in Control Centers, 3 Sites
274	Flush RP-1 Fuel Systems; 3 Complexes on Weekends
275	Reclean Tanks T-201, Site 1B and 1C
276	Clean RP-1, T-110 Tank, Site 1A
277	Clean Instrument Air Lines in Propellant Terminal,All Sites

MOD. NO.	DESCRIPTION
278	Supports for Lines CF-1022 and CF-1023 at Personnel Entrances into Missile Silos, 3 Complexes
279	Interference of 3" Drain Pipe with LOX Crib in Missile Silos at 1A
280	Installation of Accessories for Engine Instrument Boards
281	Alterations to the C-2 Compressors, 3 Sites
282	Claim for Level Controllers for Pneumatic Valve LC-5V
283	Provide Required Drain Lines from Various Drip Pans in Powerhouse, 3 Complexes
284	Revised Authorization Provisions to Include Claims
285	Weld Neck Flanges in Lieu of Socket Flanges (C-6)
286	Accomplish Cleaning of RP-1 Fuel by Circulating thru Filters
287	Claim C-71 for Safety Valves for Government Furnished Fuel Oil Pumps P-15 and P-18
288	Delete Valve SOV-9 and Switch FLS-1 from C-2 Compressor 3 Sites
289	Claim C-83 for Additional Shock Flex Connections in Equipment Terminals
290	Claim C-152 for Support of 2-inch AA-703 in Propellant Terminals, 3 Complexes
291	Additional Revisions to Blast Valves at All Sites
292	Reposition Taper Holes in 48" Blast Valve Shaft,3 Sites
293	Claim C-153 for Furnishing Recharger Oil (Nitrogen Vaporizer Rechargers 7D3741 and 7D3744)
294	Claim C-11 for Extra Handling and Transportation charges for Increased Size Ice-Banks
295	Repair Damages to Utility Alarm and Control Systems Caused by Other

MOD. NO.	DESCRIPTION
296	Revise Connectors for Coaxial Cables Radiation Detection System, 3 Complexes
297	Rework Kieley-Mueller Valves, 3 Sites
298	Field Changes to Correct Deficiencies and Interferences at Complex 1B
299	Revise Size of Wire in Conduits at Grade, Relocate LS-206 in Missile Silo
300	Procure Fire Detectors - 3 Complexes
301	Replace Gland Nuts and Sleeves on FCV-603 and FCV-605 Valves
302	Field Changes to Eliminate Interferences and Conflicts at 3 Complexes
303	Reinstall G-F Fire Sensors in Missile Silos and TJ #12 and Install Guards, 3 Complexes
304	Revise Mounting of Instrument Tube Cap and Location of Radiation Detectors
305	Additional Hold-down Screws in Buchanan Terminal Block
306	Field Changes to Elim. Minor Interferences & Conflicts,3 Comp.
307	Control Sta. for Flow Cont.Valves FCV-806 & FCV 807 PTs,3 Comp.
308	Relocate Hydraulic Switch,Entry Portal Pers.Ent. at 1A & 1B
309	Delete Dismantling,Moving & Reerecting Bldg. No. T-345,
310	Field Changes to Elim.Minor Interferences & Conflicts,3 Comp.
311	Color Coding Pipe Lines, 3 Complexes
312	Revisions to Piping for SOV-565
313	Delay of Government-Furnished Equipment
314	Required "Fixes" to Place RP-1 Fuel Systems in Operable Condition and P-10 Tests at 1C
315	Rotate Valve CV-702 Located on Tank TK-401-Propel. Terminals
316	Elimination of Addit'l.Interferences,Conf.&Damage by Others
317	Support for Flex Hose, Line CF-1023; Relocate Support on Line CF-1022

CONTRACT NO. DA-C4-167-eng-2174

MOD. NO.	DESCRIPTION
1	Different Size Arch Pipe Culvert Under Access Road
2	Provide Evaporation Cooling in Room No. 100
3	Security Restriction Shutdown and Standby Time
4	Delete Ducts in Room No. 100 and Cover Opening in Wall
5	Extend Time to 15 July 1961

CONTRACT NO. DA-04-167-eng-2176

MOD. NO.	DESCRIPTION
1	Additional Guying Facilities,Electrical Distr. System

CONTRACT NO. DA-04-167-eng-2177

MOD. NO.	DESCRIPTION
1	Revised Construction of Footings and Foundations of Guided Missile Assembly Building
2	Revise Nitrogen Storage Vessel (N-3) Pressure Requirements and Provide Conduit Between Telephone Cabinets
3	Revise Stainless Steel Piping in Nitrogen System
4	Import Select Material for Fill Under Building in lieu of Material from Borrow
5	Raise Ceiling, Add Light, and Relocate 8 Lights and 1 Panel
6	Revised Construction of Sidewalk Facilities
7	Hot Water Heater in Demineralized Water System
8	Paint Exposed Structural Steel; Delete Painting of Electrical Conduit, Metallic Tubing, Ducts and Piping in Concealed Areas
9	Complete Systems Test of Nitrogen Piping in Lieu of Hydrostatic Test of Each Sec.
10	Furnish and Install 150# Cast Steel Flanges in Lieu of 125# Cast Iron in Industrial Waste
11	Delete Pressure Regulating Valve in Demineralized Water System and Raise Existing Post Indicator Valve on Existing Sprinkler Line approximately 24 Inches
12	Accoustic Tile on Ceilings and Walls Rooms No. 204, 221 and 222; Miscellaneous Additional Work to Comply with 851 SMS on Final Inspection and Chip out Dry-Pack from Construction Joints and Refill with Mastic and Caulking
13	Claim C-2 - Paint Weld Burns-Roof Decking
14	Water Systems,Guided Missile Assembly Bldg. Revise Cleaning of Nitrogen & Demineralized.

CONTRACT NO. DA-04-167-eng-2230

MOD. NO.	DESCRIPTION
1	Drill Holes, Add Anchors, Exterior Wiring, Extended Time

23. REASONS FOR INCREASED COSTS

The cost increase of the launcher Contract No. DA-04-167-eng-2140 with Peter Kiewit Sons' Co. was greater than that generally expected on a construction project of this size. The increased cost may be attributable to a large extent to the following:

1. Concurrency
2. Design Changes
3. Changed Conditions
4. Delay in getting cleaning plant into operation
5. Late Delivery of Government Furnished Equipment
6. Propellant Loading System Testing
7. Shock Mounting and Testing Equipment
8. Cleaning RP-1 Fuel
9. Joint Occupancy
10. Pipe Supports
11. Validation Tests

CONCURRENCY

The concept of concurrency was used in the development of the ICBM program. Simplified, this meant that some portions of the construction were being designed, developed and otherwise improved upon while the project was being built. This was one of the major factors that contributed to the cost growth. Due to the urgency of the program it was necessary to construct the project concurrently with development, manufacture and test of the missile itself. This resulted in the introduction of a great number of changes during construction, installation and checkout phases of the missile base, which resulted in numerous modifications to the contract. Also due to the urgency of the program

the plans and specifications were hastily prepared and incomplete, necessitating numerous clarifications which also contributed to additional modifications.

DESIGN CHANGES

During the advertising period, 27 November 1959 to 12 January 1960, there were three addenda issued. The first addendum issued included four new drawings for the Gatehouse and Vehicle Storage Building and eighty three revised drawings. This addendum also revised many pages and added new sections to the specifications. The added sections were:

Section 70 - Excavation, Filling and Backfilling Gate House and Vehicle Storage Building

Section 71 - Concrete - Gatehouse and Vehicle Storage Building

Section 72 - Prefabricated Steel Building, Gate House and Vehicle Storage Building

Section 73 - Carpentry, Gate House and Vehicle Storage Building

Section 74 - Gypsum - Wallboard (Dry Wall) Finish Gate House and Vehicle Storage Building

Section 75 - Glass and Glazing, Gate House and Vehicle Storage Building

Section 76 - Painting, Protective, on Metal, Gate House and Vehicle Storage Building

Section 77 - Painting, General, Gate House and Vehicle Storage Building

Section 78 - Builders' Hardware, Gate House and Vehicle Storage Building

Section 79 - Accessories, Toilet Metal, Gate House and Vehicle Storage Building

Section 80 - Plumbing, General Purpose, Gate House and Vehicle Storage Building

Section 81 - Heating and Ventilating, Gate House and Vehicle Storage Building

Section 82 - Electrical Work, Gate House and Vehicle Storage Building

The above sections and drawings for the Gate House were later deleted from the contract.

One other section was added by this revision, Section 103A, Double Bituminous Surface Treatment for Access Roads.

Addendum No. 2 revised Section 37, Cleaning, Propellant Loading Systems.

Addendum No. 3 revised a few specifications and made only two drawing revisions.

One of the first contractural changes revised seventy five drawings, added six new drawings and deleted two drawings from the contract; also revised several pages in the specifications.

The second contractural change, and one of the largest, revised 103 drawings, added six new drawings and deleted two drawings. This change included seven pages of revision to the specifications.

One of the first design changes was the revision of the

diesel engine block in the Power House. The standardized equipment which was government furnished, supplied Nordberg diesel engines and generators for power to the complexes. The contract drawings were based on the Worthington diesel engine and therefore the whole diesel foundation had to be redesigned to accomodate the Nordberg units. This resulted in the addition of four new sheets to the contract set and the revision of seven drawings. These structural changes caused a subsequent requirement for mechanical changes which were reflected in the Powerhouse piping and electrical drawings.

CHANGED CONDITIONS

Only one change order was issued by the Beale Area Office under Clause 4, "Changed Conditions".

This change provided equitable adjustment to the Contractor for additional costs incurred in excavation of certain areas at Site 1A.

Briefly summarized, the changed conditions were:

1. During excavation of launchers Nos. 2 and 3, rock was encountered that would not stand without support. The Government's exploration data, design and administrative actions subsequent to award of the contract justified a conclusion that the rock would stand without supports.

2. In the Powerhouse area, rock requiring blasting and increased difficulty in removal, was encountered at elevations markedly above the elevation at which rock could have been expected, based on the Government's explanation data supplied the

Contractor in the bidding documents.

These changed conditions increased the difficulty and additional cost to the Contractor by:

1. Increasing difficulty of excavation, and causing him to furnish and install additional steel rib supports, lagging and blocking throughout most of the silo shafts of launchers Nos. 2 and 3.

2. Excessive rock excavation requiring extensive drilling and blasting operation in the Powerhouse Area. The Powerhouse and Air Exhaust Structures were affected. Costly and time consuming loading and handling operations were required.

3. Payment of premium time operations required to get the work back on schedule after being delayed by 1 and 2 foregoing, the contractor having been advised by the Government representatives that additional construction time would not be allowed.

Cost increases associated with the foregoing are:

1. Government Estimate. A formal Government estimate was not prepared prior to or reflective of the final settlement. The price was negotiated by Sacramento District personnel on a detailed review and finding of the contractor's proposal as set forth in the Record of Determination and Findings. These findings were prepared by Sacramento District personnel pursuant to South Pacific Division 1st indorsement to CEBMCO basic letter of 21 January 1961.

2. The Contractor's original proposal dated 2 September 1960 in the amount of $211,248 was withdrawn and his final proposal in the amount of $296,392 was submitted 11 April 1961.

3. The final settlement was in the amount of $246,087.

DELAY IN GETTING CLEANING PLANT INTO OPERATION

The contractor had originally scheduled to get his central cleaning plant at Beale Air Force Base for cleaning PLS components into operation during the month of July 1960. The mechanical subcontractor experienced considerable difficulty in getting the plant into operation and after he did get started it wasn't until December that the rate of production was considered adequate to meet the job requirements. This materially increased the congestion and problem of coordination of subcontractors' work during installation within the structures. There was a fairly high rate of rejection for cleanliness at the job site due to improper handling and storage. This problem was minimized after proper field procedures were established.

LATE DELIVERY OF GOVERNMENT FURNISHED EQUIPMENT

The standardized equipment for the Beale Project, costing in excess of $5,000,000. was furnished to the contractor as Government Furnished Equipment. The shop drawings for this equipment were to be furnished to the contractor within 180 days after award of the contract. The Government was unable to meet this requirement in most instances, causing the contractor to be delayed in coordinating related work and placing orders for materials related to this equipment. The delivery of the equipment was also delayed. The principal items that were

received late were as follows:

PLS Vessels

Electrical Switchgear and Control Panels

PLS Valves

Pumps

In addition to the late delivery of the equipment, upon arrival, the PLS valves were found to be dirty, did not meet the cleanliness requirements, and had to be recleaned at the job site, causing additional delay.

The contractor's claim for the above delay was in excess of $2,250,000. The Government's position had not been determined when this was written.

PROPELLANT LOADING SYSTEM TESTING

Preliminary revisions modifying the contract specifications for final acceptance testing of the Propellant Loading system were transmitted to the Contractor 9 August 1960. In requesting a preliminary proposal from the Contractor, it was noted that the changes were of a preliminary nature, clarifying the contract, and that an increase in Contract cost was not anticipated. The Contractor replied 12 October 1960 that, in his opinion, the work exceeded his contractural obligations and submitted a preliminary proposal in the amount of $673,486. This was almost immediately withdrawn.

The Air Force on 16 December 1960 requested that negotiations be initiated modifying the Contract to include the revisions to the PLS acceptance testing. Detailed revisions to the PLS testing

specifications were furnished the contractor on 25 January 1961, followed by a Memorandum Directive dated 27 January 1961, directing that PLS testing be accomplished in accordance with the revised specifications. Included were provisions for a Gaseous Nitrogen Purge for the Propellant Loading System. This was expanded to include the RP-1 System. The contractor submitted a proposal 31 March 1961 in excess of Eight Million Dollars for the proposed changes.

Many changes in the revised specifications were made, the final revision being dated 7 September 1961. The revision having the greatest impact on the change was that affecting the date for completion of the PLS testing at the various sites. This reaffirmed those dates established under the original contract, namely 1 December 1960, 1 January 1961 and 1 February 1961 at Sites 1A, 1B and 1C respectively.

The contractor originally contemplated testing with one test crew, working forty hours per week. He proposed starting at Site 1A the last of May 1960 and finishing at 1C by the first of February 1961. Due to delays, testing did not get under way at Site 1A until the last week of August 1961. Later starting dates were made at Sites 1B and 1C. Completion of the testing was accomplished at each site within the specified completion dates. To do this, the contractor worked several test crews on a two shift operation, working sixty hours per week per shift.

Negotiations to arrive at a common understanding in the scope of work contemplated under the change, and to reach bilateral

agreement in price, started in the Beale Area Office in April 1961. Unable to reach agreement at this level, a negotiation was held 4 and 5 January 1961 in the office of the Contracting Officer in CEBMCO Headquarters, Los Angeles, California. A bi-lateral agreement was not reached, the contractor standing at $3,200,000. and the Government at something in excess of $1,426,000.

A final negotiation held in the Beale Area Office 28 February 1961 did not produce an agreement in price and a unilateral change order was issued in the amount of $1,824,007.

SHOCK MOUNTING AND TESTING OF EQUIPMENT

Design criteria of the Titan I Launcher complexes contemplated construction of a "Hardend Complex" capable of withstanding the tremendous force generated by thermonuclear blasts and to initiate and complete retaliatory launch of their missiles.

Resolution of the shock effect of thermonuclear blast forces on the complex resulted in separation of the shock effect into zones designated "A", "B" and "C", which dictated design of the various structures and components. In general, zone "A" was assigned to structures in direct contact with the surrounding earth. Zone "B" was assigned to contain substructures in direct contact with the zone "A" components. Zone "C" was assigned to major structural components which were mounted with springs, spring beams and other devices so as to permit independent movement of these components.

The shock zone in which equipment was to be located

determined the type of shock testing required. The magnitude of the tests was specified in the contract specifications which also provided that shock tests would not be required for equipment certified by the manufacturer and approved by the Contracting Officer as complying with the foregoing requirements.

Subsequent to award of the contract it was determined that the provisions for testing equipment to be installed in zone "C" were inadequate. Revisions to the shock testing specifications were made, correcting the deficiency. The principal change was regarding shock testing of all electrical and electronic equipment in zone "C" to specifications, requiring a shock test equal to a 3g, 0.165 sec. half sine wave input pulse (+10%) applied in both directions parallel to each of the 3 principal exes. Tests with power off and applied were required.

The revised changes were incorporated into the contract by change orders priced in excess of $300,000.

CLEANING RP-1 FUEL

The Government Air Force-furnished RP-1 fuel, supplied to the contractor, did not meet the cleanliness requirements, and to forestall contamination of the RP-1 fuel system at all three complexes, the fuel was cleaned by circulating through filters above ground prior to introduction into the systems. It was estimated that this delayed the delivery of fuel sixty days at Site A, thirty days at Site B and no delay at Site C.

WORK STOPPAGES

Work Stoppages due to labor problems were minor for a

project of this magnitude and are shown in detail in Fig. 100.

JOINT OCCUPANCY

Beale Area Office and SATAF recognized the complications, increased costs and possible claims which would arise out of any joint occupancy situation. Both agencies continually exerted every effort to reduce the amount of joint occupancy occurrence by extensive coordination between the Beale Area Office and SATAF offices and by following through to keep the respective contractors informed of changing situations in their schedules. Additionally, every attempt was made to complete the various structures and transfer these facilities to the using agencies by or before actual associate contractor "need access" dates. In this manner joint occupancy problems were kept to a minimum and this established well defined dates when the custodial and maintenance responsibility would be assumed by the using agency. This procedure also established an effective control for permitting access to facilities. In brief, if a structure had not been transferred to the using agency, then access control to that structure rested with the Area Engineer and the Construction Contractor; conversely, if the structure had been transferred, access control was the responsibility of the SATAF and the USAF contractor. In effect this caused the construction contractor to exert material effort to meet the need dates.

The following joint occupancy problems were experienced:

1. Missile Silo Joint Occupancy - When silos were transferred to USAF the RP-1 fuel cribs and PLS cribs were

excluded from the transfer. USAF contractors began operations in the transferred silo areas. Some of these operations such as opening and closing silo doors, removal of scaffolds and providing less adequate scaffolding denied the construction contractor free access to work in the crib areas. This disruptive influence resulted in the contractor's claim for delays.

2. Propellant Terminal Joint Occupancy - Before Propellant Terminals were transferred, USAF-SATAF requested that a crew of approximately six people be allowed to work for about a one week period in each terminal. The available work area was small and even the addition of this small crew created a disruptive influence for which the contractor made claim for delays.

3. Entry Portal Joint Occupancy - Both before and after the Entry Portal structure had been transferred to USAF, the associate contractors required men and material access through the portal structure to perform work elsewhere in the complex. Before the transfer this impeded the construction contractors' progress toward completing this structure and after transfer some denials of free access slowed the contractors' work on other features.

4. Above Ground Joint Occupancy - Prior to USAF contractors moving onto above-ground areas, the construction contractor had almost unrestricted use of the complex ground area for his operations. After USAF contractors began to arrive at the site certain areas were allocated for their uses, thus restricting the contractors' operations to some extent and creating a quas-joint occupancy condition. Additionally, the contractor was required

to perform certain grading operations at a different time than originally scheduled and to install concrete pads as a modification to the contract.

5. PLS Testing Joint Occupancy - The fact that USAF contractors were conducting their operations in missile silos at the same time as both PLS and RP-1 testing was being accomplished created interference with the smooth conducting of these tests. These testing requirements increased modification costs due to joint occupancy interferences.

6. Power at Complex 1B - At Complex 1B the amount of commercial power was limited and when USAF contractors initially moved onto the job site there were several problems created by their joint occupancy because of the limited amount of power available.

The above discussion has applied to Contract No. DA-04-167-eng-2140, the principal construction contract. The other construction contract cost increases were not excessive or more than ordinarily anticipated on normal construction contracts. The total costs of these contracts are shown in Section 16.

PIPE SUPPORTS

Numerous changes to the pipe supports occurred during the construction period. Most of them were initiated after a substantial portion of the piping had been installed or fabricated, either with the original supports or temporary supports. This seriously affected the scheduling of not only the piping but other related work such as electrical, painting and testing. Several examples are as follows:

Pipe supports were added or revised in the PLS Propellant Terminal, LOX Tunnel Area and Missile Silos. A substantial number of these supports was of stainless steel. These changes were a result of the A. D. Little Company analysis of the Propellant Loading System.

Pipe supports for the Firewater, Utility and RP-1 systems on the Missile Silos were revised during the latter stages of the contract, due to inadequacies of the original plans and specifications.

The total cost of these changes was approximately $2,500,000.

VALIDATION TESTS

In order to validate the design and to verify the function of the various facilities under operational conditions, a complete validation test of one complex, mechanically and electrically, was added to the contract. This was in addition to the validation testing required of all complexes under the original contract. The contractor was furnished detailed procedures for accomplishing the additional tests well in advance of scheduled commencement.

However, these procedures were revised by no less than nine addenda, thereby adding to the complexity and increasing the cost. A modification for an anticipated cost of $500,000 will be issued for the additional tests. The contractor has taken exception to certain tests considered to be part of the original contract requirements and will submit a claim for these tests.

24. TOTAL COST

ORIGINAL TOTAL COST ESTIMATE

The original total cost estimate including support facilities consisted of the following:

1.	Basic Contract Cost	$ 35,700,000.
2.	Land	327,000.
3.	Unawarded Work	600,000.
4.	Contingencies	6,500,000.
5.	Government Cost	3,300,000.
	Total CCE	$ 46,427,000.

FINAL TOTAL COST ESTIMATE

The final total cost estimate, as of 30 March 1962, comparable with the above, is as follows:

1.	Basic Construction Cost	$ 36,759,094.
2.	Land	326,000.
3.	Modifications	10,088,495.
4.	Claims Settled & Validated	9,451,718.
5.	Unawarded Work	778,000.
6.	Contingencies	523,379.
7.	Government Cost	4,537,787.
	Total CCE	$ 62,464,473.
	Potential Claims	5,000,000.
	Total Program	$ 67,464,473.

The final current cost estimate shown above contained a reserve for future work, claims, including potential claims, accrued costs and forecasted costs to completion of the project.

The large increase of CCE from the original estimate of $46,427,000. to $67,464,473. was almost completely attributable to the large number of modifications issued for changed and additional work due to the concurrency concept, the delays in receipt of Government furnished equipment and the minimum amount of time extensions granted so as not to delay or extend the final completion date.

25. ADMINISTRATIVE PROBLEMS

There were no serious administrative problems at Beale Area Office. The major problem or problems occurred or were related to the change of supervision from the Sacramento District to CEBMCO.

The change of command was expected to cause some confusion and require a period of adjustment.

The strict compliance with the Area Organization Chart recommended by the Titan I Directorate required some time for adjustment.

The lack of clear cut operational procedures or policies from CEBMCO delayed the Area Office in assuming its back-to-normal operating procedures after takeover. The circulars and operating procedures issued by CEBMCO and the Titan I Directorate in some instances were not received until the latter part of the job.

The need for obtaining CEBMCO and SATAF approval for acceleration costs and particularly time extensions was a time consuming procedure. Obtaining this approval delayed the completion of some modifications as much as three months.

Due to the close surveillance and follow-up by CEBMCO and the urgency of this project, numerous special and one time reports were required, necessitating a large amount of additional work and overtime by the Area staff.

26. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the following recommendations are proposed:

It is recommended that the Contract Administration Branch be adequately staffed to take care of the large number of Modifications and Claims. Dependence should not be placed on key field personnel filling the need for additional personnel required for processing claims during the latter stages of the project. It was the experience on this project that the field personnel that did become available provided a substantial contribution to the claim effort, but should have arrived three to six months earlier.

Contract Administration Branch should maintain close liaison with the Resident Offices and the status of work in progress, in order to keep abreast of status of contract modifications.

It is recommended that the Contract Modifications Section establish a procedure for entering on a form, immediately after each modification is completed, pertinent data needed for numerous reports required as the job progresses. The form should include but not be limited to the following: Authority for change with date, brief description of change, date of notice to proceed, date proposal requested, Government estimate with date, contractor's proposal with date, date negotiations started and completed, amount of acceleration, hours of labor for each trade, overtime or premium time, time extension, etc. This information would provide a ready reference for the numerous special one-time reports that must be prepared generally on an overtime schedule and if this information were available, the reports could be prepared by the

Reports Section without disturbing the modification personnel.

The responsibilities of the Area Office with regard to funds control and budgetary information have not been clearly defined. It is recommended that consideration be given this subject and a circular be published by the Directorate to the Areas, and a representative of the Directorate visit the Area Offices to clear up any questions.

It is recommended that a representative of the Contract Administration Branch attend the field change order conferences with the Using Agency, to provide liaison to the Contract Administration Branch and also advise the Area Representative regarding contract administration.

PART IV

MISCELLANEOUS

The topics discussed in this Part are the following:

- Government Costs
- Project Visitors
- Relationship with SATAF
- General Problem Areas and Recommendations

27. GOVERNMENT COSTS

The Beale Area Office was under the Sacramento District from the start of the project in February 1960 to October 1960, the date of takeover by CEBMCO. A substantial amount of the work accomplished by Government personnel prior to takeover was accomplished in the District Office.

This work consisted of the functions normally taken care of in a District organization, such as personnel actions; supply actions for procurement; contract administration and expediting; construction, engineering, safety and legal surveillance and advice. In addition the District checked and approved shop drawings and accomplished considerable liaison work with other Government Agencies, etc. The Area Office strength, not including District Office personnel at the time of takeover was 91. The Government costs accumulated to the time of takeover was 7.5 percent of the construction costs for the equivalent period.

At the time of takeover, the District support functions were reduced to a minimum and wherever practicable, personnel performing these duties were transferred to the Area Office with the function. This increased the area strength but it did not provide sufficient increase to meet the Area requirements. Additional recruitment was necessary and a peak strength of 122 was reached in February 1961 and continued to May 1961, then gradually decreased to 100 in December 1961, and continued to decrease to final phase out. In order to accomplish critical work for which Government

personnel could not be obtained, the services of estimators and testing personnel were obtained by contracts with private organizations. All of the Government surveying was accomplished with construction survey contract personnel. (See Section 21)

The close tolerances and cleanliness requirements dictated the need for more field inspection personnel than are normally required.

The large number and complexity of changes, the detailed reporting procedures and the close follow-up required on this project increased the personnel strength requirements. The duration of completing the paper work after completion of construction was prolonged due to the large number of claims and the submittal of a substantial number of these claims to the Area Office at such a late date. Transportation costs were higher than normal due to the frequent trips to CEBMCO (Los Angeles) required of Area personnel; training of PLS personnel at Denver and Vandenburg; and the transportation of new hires from outside sources for relatively short durations. The overtime costs were excessive due to the critical nature and urgency of the work, both in the field and office.

The total Government costs are anticipated to be $4,537,787 but this figure may be exceeded due to the apparent increase in time required for settlement of claims, and subsequent delay of phase out. The total estimated Government cost of $4,537,787 represents 7 percent of the estimated total project cost of $67,464,473 which compares favorably with construction projects of this magnitude.

28. PROJECT VISITORS

CEBMCO BEALE AREA

6 Sep 1960	S.P.Div	Mr. John E. Ott	Inspect Concrete
6 Sep 1960	S.P.Div	Mr. D. A. Leslie	Inspect Concrete
6 Sep 1960	S.P.Div	Mr. R. D. Geahbeard	Inspect Concrete
6 Sep 1960	O.C.E.	Lt. Col. R. Shreder	Inspect Concrete
6 Sep 1960	O.C.E.	Mr. W. P. Waugh	Inspect Concrete
6 Sep 1960	O.C.E.	Mr. J. P. Sale	Inspect Concrete
6 Sep 1960	W.E.S.	Mr. T. B. Kennedy	Inspect Concrete
4 Mar 1961	McClellan Committee	Mr. Paul J. Tierney	Labor Investigation
4 Mar 1961	McClellan Committee	Major Charles Counts	Labor Investigation
30 Mar 1961	Sheppard Committee	Mr. James Kendall	General Inspection
30 Mar 1961	Sheppard Committee	Mr. Ben Gillas	General Inspection
30 Mar 1961	Sheppard Committee	Major James Bower	General Inspection
30 Jun 1961		Mr. Koski	Foundation Validation
19 Jul 1961	State Assemblyman	Mr. Edwin Z'Berg	Orientation of Construction
19 Jul 1961	State Senator	Mr. Ronald G. Cameron	Orientation of Construction

19 Jul 1961	State Senator	Mr. Albert S. Rodda	Orientation of Construction
24 Jul 1961	Defense Dept.	Mr. Thomas D. Morris	General Inspection Missile Sites
24 Jul 1961	Defense Dept.	Mr. Davis	General Inspection Missile Sites
24 Jul 1961	OSAF	Mr. Alan I. McCone	General Inspection Missile Sites
24 Jul 1961	AFOCE	Maj. Gen. A. M. Minton	General Inspection Missile Sites
24 Jul 1961	AFBSD	Maj. Gen. T. P. Gerrity	General Inspection Missile Sites
24 Jul 1961	AFBSD	Brig. Gen. A. C. Welling	General Inspection Missile Sites
24 Jul 1961	OCE	Brig. Gen. J. B. Lampert	General Inspection Missile Sites
24 Jul 1961		Brig. Gen. Curtis	General Inspection Missile Sites
27 Jul 1961	CEBMCO	Mr. G. Brunstad	Power Plant Testing
7 Aug 1961	CEBMCO	Mr. G. Branzuela	Powerhouse Test Monitoring
7 Aug 1961	CEBMCO	Mr. L. Zingmond	Powerhouse Test Monitoring
7 Aug 1961	CEBMCO	Mr. E. M. Glass	Claims Data
8 Aug 1961 11 Aug 1961	CEBMCO	Mr. Miles E. Robertson	Staff Internal Review of Financial Operations
11 Aug 1961	CEBMCO	Miss Marie Parlante	Inspection of Files
11 Aug 1961	CEBMCO	Miss Ann Davis	Inspection of Files

11 Aug 1961	Sacto.Dist.	Mr. George Rivera	Inspection of Files
4 Oct 1961	CEBMCO	Mr. William Koidal	Facility Transfer Operations
4 Oct 1961	CEBMCO	Mr. Charles Tiersch, Jr.	Facility Transfer Operations
11 Oct 1961	CEBMCO	W.O. R. D. Lucas	Security
30 Jan 1962 2 Feb 1962	Dept.Defense Audit Team	L. D. Leeper, C.F.Braun & Co.	Audit C.O.
30 Jan 1962 2 Feb 1962	Dept.Defense Audit Team	A.E.Peterson, Arthur Anderson & Company	Audit C.O.
30 Jan 1962 2 Feb 1962	Dept.Defense Audit Team	J. Depauw, Arthur Anderson & Co.	Audit C.O.
13 Feb 1962	Eng.Insp.Gen. S.F.Fld.Off.	Col. E. L. Grider	Annual I.G.Inspection
13 Feb.1962	Eng.Insp.Gen. S.F.Fld.Off.	Mr. A. H. Mangelson	Annual I.G.Inspection
13 Feb 1962	CEBMCO,I.G.	Mr. M. E. Robertson	Annual I.G.Inspection
13 Feb 1962	I.G. Los Angeles	Col. H. R. Howell	Annual I.G.Inspection
11 Apr 1962	Titan II CEBMCO	Mr. F. J. Geiger	Electrical Inspection

29. RELATIONSHIP WITH SATAF

RELATIONSHIP

Relationships between the Area Engineer Office and SATAF were superior throughout the project. In general, both offices continually worked together on the interpretation of contract conditions, with SATAF recognizing that it was the Corps of Engineers' responsibility to interpret the contract. Both agencies recognized that facilities should be transferred at such time as they were complete, even though minor items remained as incompleted work. When a structure was ready for transfer the appropriate officials of the Area Engineer's office, SATAF, Base Civil Engineers office, the Prime Contractor and the Martin Company met in the field, inspected the facility to be transferred, agreed on items of work remaining and consumated the transfer, simultaneously transferring custodial and maintenance responsibility for the facility.

DEPUTY FOR CONSTRUCTION - DUTIES

1. The Area Engineer (Deputy for Construction,under SATAF) was responsible to the SATAF Commander for assuring the timely accomplishment of the construction operation for the site activation program.

2. Operated as the field representative of the Construction Director.

3. Administered construction contracts. Inspected work under his jurisdiction; gathered and recorded contract data; prepared reports and contractor's payment estimates.

4. Assured compliance with contract requirements, including modifications. Accomplished construction in accordance with approved progress schedules and contractual completion dates.

5. Recommended changes to drawings, mainly to conform with local conditions.

6. Enforced labor provisions of his construction contracts. Examined contractor's payroll data and took action with contractors to correct discrepancies, if required.

7. Issued change orders on approved changes and prepared cost estimates for modifications. As contracting officer's representative, negotiated costs of modifications and processed contractor's claims.

8. Enforced safety provisions of the contract. Cooperated with contractors' top supervisors in establishment of safety program and followed through during life of the contract to insure compliance therewith.

9. Provided the Deputy for Engineering with continual data reflecting actual field conditions for incorporation into as-built drawings.

10. In conjunction with the SATAF Commander, worked out joint occupancy agreements.

11. Scheduled pre-final and final acceptance inspections.

ORGANIZATION CHART

See Figure 4 for organization chart for the local SATAF with key personnel listed.

30. GENERAL PROBLEM AREAS AND RECOMMENDATIONS

Due to the concept of concurrency construction, development, manufacture and test of the missile were to be accomplished simultaneously and many unusual problems were anticipated. This concept generated major design changes and revisions to changes to a design that was already complex.

Specific major changes were the redesign of the Powerhouse floor slabs supporting the Diesel generators which resulted in extensive revisions to the electrical and mechanical work; the extensive changes to the PLS and RP-1 fuel system supports, etc; the delays in the work caused by the large number and complex design changes and the late delivery of Government furnished equipment. Not withstanding the originally established tight work schedule and the addition of the large number of changes and delays, the objective of meeting the contract completion date was not changed.

The late arrival of Government furnished equipment, the failure of the Government furnished equipment to meet the cleanliness requirements of the specifications, and the discrepancies in the specifications presented more administrative problems than normally encountered in a construction contract.

By perseverance, determination and hard work the large number of modifications were processed individually as they would normally under sound, fixed price contract administration.

Recommendations developed from the experience gained during this project are as follows:

PROJECT STAFFING

The need for an Area Office for this type of project, to be properly staffed by qualified personnel, can not be over emphasized. In order to accomplish this, advance planning must be done to anticipate when the various types of personnel will be required. Personnel with the qualifications required are not always available; therefore, consideration should be given to selection of personnel that have qualifications for more than one phase of construction, then train the available personnel for future positions that will be difficult to fill by advance planning.

OBTAINING ADEQUATE INFORMATION FROM THE RESIDENCIES

The Resident offices should be staffed to be able to provide adequate information to the Area Office in a timely manner. Due to the urgency of the project, numerous records and reports on status of construction are required. The numerous changes and revisions to the contract and coordination of problems with the Air Force necessitate more detailed logs and records than are normally required on construction projects.

APPROVAL OF SHOP DRAWINGS

The services of the Architect Engineer were used to augment the Area staff in approving shop drawings. This service was generally good but became progressively poorer as the job progressed. This is attributed to the introduction by the construction contractor of mechanical layout drawings prepared by Huntoon Engineering Co. of Los Angeles, California. The Architect Engineer had originally agreed to check any and all shop drawings within

five working days, but this agreement broke down when they were faced with the checking of the Huntoon drawings and thereafter more than half of the drawings required thirty calendar days or more. The need for the Beale Area Office Engineering Branch to review the Architect Engineer's checking became more pronounced as the work progressed. In some cases only 50% or less of the errors were discovered by the Architect Engineer prior to the Beale Engineering Branch recheck.

To improve progress by Huntoon and to obtain prompt and accurate checking by the Architect Engineer, it was necessary to arrange coordination meetings in Los Angeles between the Architect Engineer, Huntoon Engineering Co., Kiemech Inc. the mechanical subcontractor, and Corps of Engineers representatives. The Corps of Engineers retained, for approximately sixty days, the services of a mechanical engineer employed by the Architect Engineer. His job was that of coordinator and his duty station was the Huntoon office. His job was to ascertain current problems and resolve them, either through his own knowledge or by contacting his home office to obtain answers. Although this man was employed at the request of Kiemech Inc., their subcontractor, Huntoon Engineering Co., would not take any direction except from Kiemech, and therefore the value of this employee was questionable.

The first of the Huntoon drawings was received 29 June 1960 and the 139th and last transmittal was received 9 August 1961. These drawings were considered very poor in the majority of cases. They were often made as an overlay on a reproducible from some

other Titan Base which did not meet Beale conditions. This office and the Architect-Engineer, Daniel-Mann-Johnson-Mendenhall and Associates, generally could not approve the Huntoon drawings until major changes were made. Kiemech Inc. terminated their contract with Huntoon and completed the submittal of mechanical transmittals, using their own forces. The contractor, Peter Kiewit Sons' Co., was generally prompt in furnishing all of their transmittals.

It is strongly recommended that the Area Office be staffed to accomplish as many of the shop drawing approvals as possible, and the services of Architect Engineers be kept to a minimum.

Consideration might also be given to staffing the Directorate's office to check shop drawings applicable to all Areas, thus avoiding duplication and allowing the Directorate first hand information on problem areas.

AREA OFFICE FUNCTIONS

The establishment of the CEBMCO organization eliminated certain eschelons of the conventional Corps of Engineers organization. This also increased the responsibilities of the Area Office to approach that of a District Office. Individuals within the Area Office often overlook this and fail to properly document their activities commensurate with these responsibilities. Also, unless definite coordination responsibilities are assumed by key personnel in the Area staff, each branch will drift into an independent operation, causing unnecessary confusion and critical work being duplicated or overlooked.

PROCESSING CLAIMS

The Area Office was not staffed to work on claims until construction was almost complete and the contractor was equally deficient in his organization; consequently the contractor would submit letters stating that he would make claim but the justification and amount of claim was not submitted until later. If the Area Office had been staffed earlier to work on claims, pressure could have been exerted on the contractor to make timely submittals of these claims with justification and subsequently processed so that the heavy work load on claims at the end of the job could have been alleviated.

CONCLUSION

The reflection on the past two years' experience reveals that a Missile project is complex, is constructed at an accelerated rate and generates numerous changes with subsequent modifications and claims. Notwithstanding all of the above, there is no reason why sound, fixed price, contract administration policies used on normal contracts can not be followed, provided the Area is staffed adequately for the duration of the project. Furthermore, if the Area Office is able to keep abreast of the work using normal procedures, many of the difficulties of crash or panic situations, with their inherent loss of efficiency, will be avoided.