THE ATLAS F OPERATIONAL SUITABILITY TEST FACILITY NUMBER 2 (OSTF-2)

PREPARED FOR USE IN

THE CIVIL ENGINEERING CENTER

EXECUTIVE ENGINEERING PROGRAM

by

Bertrand L. Hansen
The Ohio State University
Defense Management Center
College of Commerce and Administration

FOR OFFICIAL USE ONLY

TABLE OF CONTENTS

Outline

TABLE OF CONTENTS, CONTINUED

ILLUSTRATIONS

PART I

INTRODUCTION

The purpose of this case is to provide a medium for analysis and discussion of project management of a typical missile system facility installation. Because management is influenced by the political and organizational environment peculiar to the weapon system program, a general discussion of this environment is also included.

Part II provides the setting for discussion of the case. It considers the emergence of facilities as part of the weapon system in contrast to historical relationships between the weapon and the ground environment. General organizational characteristics peculiar to procurement of weapon systems are shown. It also provides a brief survey of the typical programming and control problems encountered. Finally, Part II considers the impact of close tolerances and rigid design requirements on the ability of construction contractors to produce to meet these requirements.

Part III deals with the major design and hardware features of the Atlas F OSTF-2 facility. It provides a bird's eye view of the magnitude of the construction effort involved in a project of this type.

Part IV provides a retrospective composite and varied picture of the OSTF-2 program as seen through the eyes of top-management representatives of the various organizations involved in management and construction of OSTF-2.

Part V consists of excerpts from a history of operational site construction and some comments by the author of the history. This section was included to provide some views on the construction of OSTF-2 as it affected the operational site construction program.

The case writer interviewed a total of twelve persons from the principal organizational units involved in the program. Their names, with titles and affiliations possessed at that time are as follows:

Representatives of USAF - The Ultimate User

Brigadier General William E. Leonhard, Deputy Commander for Facilities, Ballistic Missile Division, USAF

Colonel Maurice A. Christadoro, Atlas F Program Director, Ballistic Missile Division, USAF

Colonel Robert H. Farwell, Chief, Design Branch under Deputy Commander for Facilities, Ballistic Missile Division, USAF

Lt Colonel Page Cowart, Chief, Atlas F Facilities Design Branch under Chief of Design, Ballistic Missile Division, USAF

Lt Colonel John Everhart, Chief of Civil Engineering, Engineering Branch, 6595th Test Wing, Ballistic Missile,Division, USAF

Major H. B. Arnold Jr., Chief of Facilities Design, SATAF/WAHOO, Lincoln AFB, Nebraska

Representatives of Corps of Engineers - Construction Contracting Agency

Mr. Raymond Hole, Deputy Chief and Chief, Engineering Division, Corps of Engineers, Ballistic Missile Construction Office

Mr. Charles Zleizy, Project Engineer, Corps of Engineers, Ballistic Missile Construction Office

Representatives of General Dynamics Astronautics - The Integrating Agency

Mr. William Van Horn, Manager of Long Range Planning, Convair Division of General Dynamics

Mr. Eugene McFadden, Atlas F Project Engineer, Convair Division of General Dynamics

Representatives of Bechtel Corporation - Designer and Constructor

Mr. Robert Myers, Manager of Military Facilities Design, Bechtel Corporation

Mr. S. Roy Oliver, Assistant Project Manager, OSTF-2, Bechtel Corporation

The questions asked of these persons were of five main types - contractual, organizational, facilities design, construction quality, and project performance with regard to delivery and cost. Each person was asked to comment on any or all of the following general questions if it was his desire to do so. Because of the nature of the OSTF-2 program, some of the questions were much more popular than others and some concerned did not generate much comment because they were items which were not at all controversial or were not applicable. Space limitations percluded using all of the answers to all the questions, however, an attempt was made to include the views of one person from each participating agency.

System Planning and Contractual Requirements

1. What were the specific objectives of OSTF -2?

2. What were the major policies at the beginning of the contract and how were they changed during the contract?

3. What type of contract was in effect? Why?

4. In retrospect, were the contract requirements adequate and specific in:

a. Schedule requirements
b. Construction requirements (tolerances, methods, equipment, etc.)
c. Changes to contract and specifications

d. Quality Standards
e. Penalty clauses

5. What planning measures were taken to preclude problems in schedule adherences, construction, and performance? Were they adequately spelled out in the contract?

6. What effect did past experience of site construction have on schedule, construction, and performance aspects of the OSTF-2?

Management Organization

1. What type of management organization was used for the OSTF-2? Was the organization adequately structured with defined responsibilities and authorities?

2. What problems, if any, do you feel might be ascribed to the structure of the management organization? Conversely, what benefits were derived from the structure?

3. What about the communications between parties as a result of the organization? Was communication more of a problem than usual?

4. What effect did the organization have on the attitudes of people involved in the program?

Design Criteria, Concepts and Development

1. What design requirements existed that were new to most contractors?

2. Was the value engineering concept used in the design?

3. In retrospect, were the design requirements about right, too stringent, or too loose? What is your basis for making this judgment?

4. How would you rank the parameters of performance, time, and cost in order of project importance as they existed. In retrospect, do you feel that they were ranked correctly?

5. What aspects of design of previous site facilities had contributed to changes which made up the original design of the OSTF-2? In looking back over other site constructions, had there been a fair amount of learning about design of exotic facilities which contributed to precluding design change problems in OSTF-2.

Project Performance - Design and Function

1. Do you feel that construction was up to the standard of the design requirements? If not, why not? If so, why?

2. Was the original quality of work up to standard? Was the rework rate

abnormally high? If so was it due to poor design, or inadequacies of equipment, personnel, or construction management?

3. What effect did design changes have on ability to adhere to design or functional requirements?

Project Performance - Time and Cost

1. What types of disruptions caused either schedule slippages or added resource costs?

a. Changes? How many? How serious? How costly? Compare to other big non-defense construction jobs.
b. Labor disputes? Primary causes and effects?
c. Improper utilization of work seasons, equipment, personnel, new methods?
d. Effects of concurrency?
e. New materials and methods?
f. Snowballing effects of a design change? How serious?

2. Was the cost parameter relaxed more often than that of the time parameter?

3. Were critical path (PERT) methods used in planning and scheduling? If so, how helpful were they?

Project Control and Evaluation

1. What control methods were used?

2. When disruptions occurred, were effects on all parameters considered?

3. Was the management structure adequate to control and evaluate efficiently?

4. Was it quick to respond to arising needs?

5. What provisions were made for carrying learning over to new projects?

During the conduct of the interviews there was much discussion that was spontaneously generated. Such discussions, while not having a bearing on the questions at hand, were encouraged nevertheless for the values that would accrue regarding understanding of the total weapons system installation problem.

While some of the questions directed to respondents by the case writer may appear to be flavored with bias, such is not the case. He had no "irons in the fire" either in the selection of original questions or in the pursuit of questions which developed more or less spontaneously. The original questions were selected because the light answers to them would bring to bear on the problems of weapon systems project management. If the questions elicited controversial answers, so much the better. When this was evident, the controversial positions were examined in greater depth for the obvious values to be obtained. It should also be understood that the views given by the persons interviewed do not represent the official position of the Air Force.

The case writer wishes to extend his gratitude and thanks to each of these persons for their frank and open comments and opinions about the management of the OSTF-2 project. It is this type of honest discussion of problems which sheds light on them so that they may be either avoided or minimized in future projects. Also, it is hoped that it provides something of value to case study participants, especially those who may one day find themselves taking real roles as members of a weapons system facilities installation project management team.

PART II

*CHARACTERISTICS OF THE ICBM FACILITIES PROGRAM

A. SCOPE OF THE ICBM WEAPON SYSTEM FACILITIES PROGRAM

The airplane, traditional weapon system of the Air Force, featured mobility and a relative freedom from interface problems between the airborne system and the ground facilities. In a gross way, the only critical interface was and is the mating of tires with the airstrip on take off and landing. Contrasted to this, the bulk of the ICBM system consists of a launching facility which remains on and in the ground. Requirements for resistence to atomic attack have also caused additional problems in ingenuity of design, tighter specifications, improved reliability, faster reaction time, etc. Add to this the management, organizational, and documentation problems which arise from an effort of the magnitude of the ICBM program and immediate and future challenges to the facilities engineer becomes starkly evident.

In the ICBM program the target dates for operational capability had been dictated by national policy. The "fly-before-you-buy" concept had to yield to a policy of "concurrency." The concept of concurrency in the ICBM program required that ground support equipment requirements be determined as soon as possible in the conceptual phase of facility study, and that design proceed concurrently with the development of the airborne portion of the weapon system. With such a policy it must be recognized immediately that changes in design with construction were inevitable - thus causing ultimate costs considerably higher than planned at the inception of the program. As the state-of-the-art advanced, performance improved also, giving more impetus to cost escalation.

The facilities portion of the ICBM program was the largest single program within the Air Force civil engineering field comprising $1.4 billion through fiscal year 1961. Involved in this massive facilities program was the siting, design, and construction of several hundred separate launch facilities and related technical support facilities.

The exacting requirements for reliability and operational usage introduced a number of problem areas not encountered in design and construction of

*Adapted and abridged from Volume III, Operational Facilities, Operational Deployment Configuration and Site Selection, Design and Construction, WDGP-60-25, 19 August 1960. Where opinions are given herein, they represent collective Air Force opinions and do not reflect views of the author of the case. Also, present tense is maintained in the abridgement even though policies and organizations may have changed since the date of the original paper.

facilities in support of other weapon systems. An example is the extraordinary pressures that the propellant loading system must withstand to accomodate the high rates of flow of unusual propelling fluids. Another is the requirement for what borders upon surgical cleanliness of the entire system. The requirements for blast and radiation resistant enclosures for protection against nuclear attack increased considerably the problems in siting facilities as well as in designing and constructing them. In some cases environmental control is extremely critical - so critical that there is no commercially designed equipment that will suffice. These complexities introduced the need for skills in management, quality, design, and construction not heretofore encountered in military or commercial construction. Thus, some of the contractual and management practices normally used may have obsolesced with regard to applicability for procurement of these types of facilities.

It was stated previously that changes were inevitable. There are many examples to show the dynamic nature of the program. For one, in the Atlas program there were four different configurations for the first seven squadrons. This puts extreme pressures on designers and constructors in attempts to meet schedules. Another example concerns an operational site where a decision to disperse launchers on a one by nine basis was received the day before the original three by three configuration was to be released to advertize for construction bids, yet the construction completion date was not changed.

Such stresses as the above would put pressures on even the most highly organized project management structure. Consider then, the effects on a management structure which, for a variety of historical, military, political, and economic reasons consists of the following organizations:

Office, Assistant Chief of Staff, Guided Missiles

OSD Ballistic Missile Committee

Air Force Ballistic Missile Committee [1]

Office, Director of Installations - administers the allocation and control of funding and Air Staff surveillance of construction through the Air Force Regional Civil Engineer.

[1] The first three committees were established for the sole purpose of responding to the dynamic requirements of the ICBM program. The committees retain responsibility for significant approvals regarding facilities design, construction, area siting, force structure, major configuration changes, budgetary ceilings, annual programs and development plans.

Air Force Ballistic Missile Division [2]

Space Technology Laboratory [2]

Associate Contractors [2]

Ballistic Missile Division - responsible for staff cognizance of construction surveillance, in addition to tne procurement of A and E services for feasibility studies, concepts, criteria, design, redesign, field support to construction contracts, and "as built" drawings for the launch site.

Strategic Air Command - responsible for operational site selection and initiation of acquisition of real estate. Also participated in design review from the standpoint of operational and maintenance criteria.

Air Force Ballistic Missile Division Field Office - under operational control of the AMC Site Commander with responsibility for processing of facility modifications, performing technical review of shop drawings, interpreting design and resolving design deficiencies.

Air Materiel Areas - responsible for procurement and supply of spare parts and for maihtenance of technical data in current status.

Corps of Engineers - as the construction agent, has responsibility for contracting for construction and direct supervision of the area Corps of Engineers offices in their activities of supervising and inspecting construction.

Further discussion of the functioning of this multi-headed and multi-bodied organization will be considered in B of this section.

The programming and fund allocation process is also slightly different from other Air Force construction. Based on Headquarters, USAF approved force structure, AFBMD develops and defends a military construction program before the various review agencies and congressional committees. Authorization has customarily been secured in bulk rather than on a line item basis and each year the Congress is advised of the detailed use of the funds appropriated. To accomplish this programming and reprogramming, AFBMD prepares a development plan which is revised periodically and kept within budget ceilings. This plan is presented and justified before Air Force and OSD review agencies and, when

[2] These three organizations are responsible for the development of the weapon system, including facilities. Members of this team provided guidance to the facility designer and retain a continuing interest in the facilities until turnover to SAC. Within AFBMD, the Office, Deputy Commander, Facilities provided principal direction of the design.

approved, forms the basis of fund apportionment and allocation. Design funds are allocated to AFBMD and the construction agency, normally the Corps of Engineers. With respect to programming, problems have primarily been associated with delays in announcing sites, numerous program accelerations and expansions, and a continuing evolution of weapon system configuration, particularly that associated with level of hardness and dispersal.

Normally, operational site selection is a responsibility of the user (SAC), subject to USAF approval of geographic area. AFBMD, supported by BMC contractual action, technically validates the feasibility of constructing at the proposed specific location. After site area approval, a field survey is conducted jointly by SAC, AFBMD, and the construction agency. Specific possible sites are selected for preliminary topographic and soils data analysis. Following this, firm siting is established. Action to acquire real estate is then initiated. History has been that approximately three months have been required from Headquarters, USAF approval of siting to initiation of design. Problems associated with this phase of the program are of the hardening and dispersal type. Hardening limits the number of acceptable sites while dispersal multiplies the problems associated with site selection. Also, late changes in site selection may result from community or political pressures. The tradeoffs between ease of access and economy of construction present difficult decision alternatives. Also, late finalization of criteria - particularly safety and distance - results in late resolution of specific limits of land-taking.

For the ICBM program responsibility for design has been specifically assigned to AFBMD as contrasted to the normal procedure of yielding this responsibility to the construction agency. Design is accomplished by A and E firms selected by Boards including representatives of BMC and the construction agency. The selected A and E firm is accorded associate contractor status with the weapon system test and integrating contractor. Designs progress successively from concept stage through preliminary and final plans and specifications, subject to review by interested agencies. The plans and specifications are then furnished to the construction agency for continuance of action. AFBMD maintains cognizance of all matters affecting design until facilities are finally turned over to the using agency. Design changes are processed in a similar manner and though design schedules have, in general, been maintained, the concurrency aspects of the program have generated some problems in this area, namely evolution of deployment concepts, continual changes in technical and operational criteria, late program accelerations and resiting. For a typical hardened squadron, facility design time is normally five to six months.

Construction of ICBM facilities in the majority of projects, is accomplished for the Air Force by the Corps of Engineers. The Corps participates in the development and review of plans and specifications primarily to assure that the proposed design is feasible for construction. The completed plans and specifications are furnished to the Corps for advertisement and contract award to the lowest responsible bidder. A field office of AFBMD and an area office of the Corps of Engineers is established at the site of construction to perform Air Force surveillance and Corps supervision and inspection of construction. Concurrently with the above actions, release of funds is secured by Headquarters USAF and allocated to the Corps of Engineers through the AFRCE for use by the contracting officer in awarding the contract. During construction, the AFBMD Field Office and Corps Area Engineer are also involved in the review and approval of contractor schedules, shop drawings, material submittals, etc. They also process field changes and implement design changes approved by AFBMD. Supervision and inspection of construction is conducted by Department of Army civilian employees and Air Force surveillance is primarily accomplished by the Associate Contractors under the direction of the Field Office. As soon as possible, projected plans for installation of ground support equipment, checkout and validation of the weapon system by the Associate Contractors are integrated with detailed construction schedules so that requirements for beneficial occupancy and possible joint occupancy can be established. Completed facilities are turned over to the Air Force and assigned to the Associate Contractor for completion of the site activation task.

The experience has been that a number of factors have served to delay completion of construction, escalate costs, and contribute to slippage in the attainment of operation goals.

1. Construction contractor selection

Present contracting procedures for ICBM facility construction provide for the award of contracts on an advertised lump-sum basis. Contractors with marginal qualifications and no demonstrated experience but with a low bid and the necessary financial backing have been able to secure contracts. The risks are great operating under such a policy. In one case, many problems arose, primarily caused by management incapability of the contractor. The project would not have been completed had it not been for virtual assumption of all direction of the work on the part of the government.

2. Subcontractor selection

The normal policy of the construction agency does not provide for subcontractor approval by the contracting officer. Control of same is believed to be essential even though it brings with it the added responsibility for possible poor performance on the part of an approved subcontractor. AFBMD advocates this added control as a matter of policy.

3. Equipment and components

The use of an "or equal" clause in specifications has resulted in the installation of direct mission support equipment failing to meet essential needs of the weapon system. Normally, the construction agency contracting procedures encourage maximum competition in the securing of items of equipment. AFBMD feels there should be more sole or limited source procurement for vital elements of direct mission support systems.

4. Quality control

In the ICBM weapon system, real property installed equipment (RPIE) is, in most instances, an integral part of the weapon system and must, therefore, meet much more exacting specifications than normally encountered. AFBMD feels that the inspection services of the contracting agency, geared to normal military construction, has not proved satisfactory for this task. Numerous instances are cited of repeated violations in dimensions, tolerances, in cleanliness standards in the propellant loading system, and in the acceptance of substandard equipment. All of this has contributed to delay and higher costs. Current actions are directed toward requiring the construction agency to utilize the inspection services of the design A and E in lieu of D/A civilian employees. It is believed this will be advantageous in obtaining higher caliber, engineering type personnel for assuring quality and in placing with a single firm the technical responsibility for design, evaluation of system performance, and development of validation procedures which will be published and used by the construction agency for performing system validation with the Associate Contractors prior to acceptance of the facility.

5. Change orders

The dynamic nature of the ICBM program has caused the introduction of numerous facility change requests and resultant change orders to construction which have, in turn, caused increased cost and requests for time extensions. This is due to the accepted policy of the course of concurrency. Stabilization of weapon system development and screening-out procedures for identifying unnecessary changes have contributed to a reduction in facility change requests. Nevertheless, improvement in management and communication is needed to provide more timely procedures for determining cost and delay implications of changes in construction.

6. Labor-management disputes

Work stoppages have occurred which have resulted in measurable delays to the program. They are caused for a variety of reasons - jurisdictional disputes, protests over working conditions, and as a consequence of failure to negotiate satisfactory union contracts. A critical phase of problems of this type occurred during the steel strike in 1959 when, during joint occupancy periods, there was a required mixing of industrial and building trades unions performing similar work at different wage rates. An April 1960 report on the impact of work stoppages to the ICBM program, indicated that approximately 36,000 man-days were lost from all activities in a total of seventy five strikes during the period July 1959 to April 1960. The problems causing the results remain unsolved. Representations to the Department of Labor must be continued to (1) clarify application of the Davis-Bacon Act in the installation and check-out phase, (2) encourage or require cooperation of labor and management in the elimination of work stoppages because of jurisdictional disputes and to (3) continue work while disputes are being settled by arbitration.

7. Performance, scheduled versus actual

The first four Atlas squadrons slipped schedule by from two to four months as effects of the above indicated causes. In this sense, the Atlas facility provided the proving ground for Titan II and Minuteman because many of the problems associated with design and construction were well identified by the time the Atlas operational program was well underway.

B. ORGANIZATIONAL CHARACTERISTICS

This section covers the organizational characteristics of the ICBM program giving coverage to the organizations involved in the design and construction of facilities and certain of the organizational problems that have existed.

At Headquarters, AFBMD, the Deputy Commander for Ballistic Missiles has three principal mission directorates: Atlas, Titan, and Minuteman. The Deputy Commander for Facilities is organized to support each mission directorate. The AFBMD Facilities Office, under the Deputy Commander for Facilities, is responsible for the establishment of line item requirements, estimating costs, for same, and consolidating requirements for budgeting and programming. This office, in coordination with Headquarters, SAC, is involved in site selection for new ICBM bases and launch positions and is directly responsible for the preparation of topographic and geographic studies. This is accomplished by contract with A and E firms under management and supervision of the cognizant facilities office supporting each weapon system. As a function of field support, the AFBMD Facilities Office provides technical assistance in testing and validating real property installed equipment and systems, particularly with regard to propellant loading systems, and through a senior panel of civilian consultants, reviews and shop drawings of critical facilities components such as shock isolation devices.

The organization for dealing with changes is unique. A change may be proposed by designer, builder, or user to a liaison group composed of members of these same organizations plus a representative from the design A and E. This group studies the change proposal and submits an impact report to the local change board which includes representation from all associate contractors for a given weapon system. The recommendations of this board are referred promptly to the Configuration Control Board which is chaired by the Weapon System Program Director and includes representation from STL, BMC, SBAMA, SAC and ATC. Decisions of this board then are reflected either to the associate contractor for missile or ground support equipment re-design or to the AFBMD Facilities Office for design and change order action to the construction contractor.

With regard to field organizations, in July 1960 an arrangement was adopted where a clear line of responsibility exists from Headquarters, USAF to AMC to BMC to each site activation commander who exercises operation control over attached units from AFBMD, SBAMA, and the Western Contract Management Region. These on-site detachments are served and supported by parent organizations but operate under the direction of the site commander.

The Corps of Engineers, agency for construction was originally organized on a regional basis. For the four weapons systems configurations (Atlas, Titan, Minuteman, and Space facilities) there are eleven District Engineers (contracting officers) supervised by five Division Engineer organizations. For example, the project at Forbes was handled by the Kansas City District Engineer, under the Missouri River Division. The same District Engineer had Schilling in the Atlas F configuration of six squadrons there were six separate contracting officers, supervised by three Division Engineers. Noting that construction firms such as Morrison-Knudsen have contracts for five Atlas and Titan Squadrons and that Kaiser has contracts for three, it is obvious that there exists a situation where there are more contracting officers than contractors. Such an arrangement makes it possible for the contractor to play off one against the other in negotiations for time and cost extensions. Contractors can also receive conflicting interpretations and instructions which are potential sources of delay.

The large number of organizations involved in the program makes problems of coordination inevitable. Organizational coordination is one of the vital tasks in management's pursuit of an objective. As a result of efforts to stimulate Corps reorganization by the Air Force, a central office was established at Los Angeles (CEBMCO) having sole responsibility for the ICBM program.

C. ICBM FACILITIES DESIGN CHARACTERISTICS

The design of ICBM facilities may be broken down into the following areas:

1. Research and development studies for new types of facilities.

2. Development of criteria and concepts for new design.

3. Studies of continental U.S. to determine geographic and geologic areas suitable for locating groups of squadrons considering potential support bases.

4. Studies of selected areas approved, as a result of 3 above, to locate operational squadrons, launching sites, and launch control centers around a selected support base. Studies include site surveys, geological sampling and testing, site evaluations, documentation for real estate acquisition, etc.

5. Updating of criteria and concepts by constant liaison within AFBMD and with STL and weapon system associate contractors and by a continuing evaluation of the test and training facilities at Vandenberg Air Force Base.

6. Design of facilities at selected support bases to maintain and supply operational facilities for satellite squadron sites.

7. Design of multipurpose facilities at Vandenberg Air Force Base to provide research and development training, operational and maintenance training, and operation facilities.

8. Design of facilities to support individual training facilities.

9. Design of facilities for operation squadrons.

10. Services to incorporate field and design changes into construction contract documents, such changes being the result of concurrent research, development, and production generated changes to the missile and its general support equipment.

11. Field advice on design construction conflicts, inputs into requirement 5 above to correct design deficiencies or to resolve interface problems with the missile and its ground support equipment.

12. Identification of spare parts requirements.

13. Securing of basic equipment data and preparation of operation/ maintenance technical instructions.

14. Upon completion of construction of facilities by Corps of Engineers the installation and checkout phase is initiated. During this phase, modifications must be made to facilities construction to resolve interfaces with the missile and its ground service equipment. These requirements are unknown until the installation and checkout period. To accomplish these modifications and additions, the services of the A and E are required for preparation of construction drawings. These services extend from the completion of construction and acceptance of the facility, to the time that SAC accepts the facility as an operational facility.

15. Usage by Architect and Engineer firms of outside consultants under their contracts where such services are required to resolve special problems.

AFBMD has design responsibility for all facilities funded from appropriations set aside for the ballistic missile program. Because of the required close coordination between research, development and production of ballistic missiles and their support equipment with the design of facilities, it is the policy of the Air Force to retain the A and E firm during construction to incorporate into construction contract documents those changes to facilities generated during construction. He is also retained after the completion of construction for the reasons cited under 14 above. Considering the requirements placed upon the A and E firms for the activities cited above, it is essential that their management and technical capabilities be of the highest order. AFBMD has instituted strict A and E selection policies to insure quality of A and E work. These policies of selection are built around basic procedures established by the Department of Defense on 30 September 1954, and used by all DOD agencies. Each time AFBMD has a requirement to accomplish design an evaluation board is established to recommend the selection of a firm or firms to accomplish specific work. The board is made up of senior government engineers, military and civilian, from various sections of the United States. Over three-hundred A and E firms, from all sections of the U.S. have submitted DOD Format 1071 outlining their capabilities and capacities and indicating a desire to accomplish work for AFBMD. Each board reviewed these formats, and using an evaluation process established by the Secretary of Defense and approved by the engineering profession, selects a firm or firms that it believes best capable of performing the design under consideration. These evaluation factors are:

1. Professional qualifications - quality and diversity of capability of people in both engineering and management.

2. Specialized engineering and management experience of the firm in the field of required design.

3. Capacity of firm to accomplish design within the required time - sufficient competent personnel in the fields of endeavor required.

4. Past engineering and management experience with respect to performance of design for the government.

5. Location of the firm.

The first three choices of A and E firms are then forwarded to the Contracting Officer for contract negotiation. AFBMD receives blanket authority to enter into A and E services on an annual basis, except where the contract exceeds $1,000,000 and except where the services are similar to those outlined in 12 and 13 above under design of ICBM facilities. In these cases, Headquarters, USAF insists on an individual finding and determination for each situation.

Immediately following retention of one of the three selected A and E firms pre-design conferences are initiated by the AFBMD Weapon System Facilities Directorate exercising technical direction for design in accordance with the following:

1. The first predesign conference is convened with the top management representatives of the selected firm present, along with the Deputy Commander for Facilities or his deputy, the Director of Engineering, and other agencies which might be invited to sit in. Topics considered are the A and E's relationship with the organizational elements of AFBMD, establishment of design, and the organization to be committed to the project by the firm.

2. The second predesign conference is called with the selected A and E firm to discuss concepts, criteria, channels, points of contact, review procedures, packaging for design and construction, and schedules for design and construction. Offices participating are the appropriate AFBMD facilities and technical offices, STL, the field office of the Corps of Engineers, and other appropriate agencies which might be invited to sit in. At this conference the A and E is required to furnish such data as are shown on the work statement as "Government Furnished".

3. Next, a concept conference is convened at such time as the A and E firm can furnish to AFBMD information on how the firm interprets concepts, criteria, and engineering standards covered during the second predesign conference, and how the firm will apply these interpretations to design. Represented at the conference is the appropriate facilities office, AFBMD technical management office, SAC, STL, and the construction agency. Normally, the A and E will demonstrate the following at the concept conference:

    a. A site plan showing the orientation and location of the facility, its relation to surrounding conditions, method of access, and proposed connection of utilities.

    b. Floor plans of all areas with room or area names or functions spelled out within the area on the plan - not coded to an accompanying or adjacent list.

    c. Evaluations with all materials indicated and a general statement of materials to be used inside and out.

    d. Sections showing interior spaces and proposed structure.

    e. A simple perspective sketch clearly showing the form of the solution.

f. A general statement of how the mechanical and electrical functions of the facility are to be carried out.

g. Plans, sections, and elevations with general dimension and scale indicated.

Distribution of plans for review is made to the following:

AFBMD Weapon System Facilities Directorate

AFBMD Facilities Engineering Group

AFBMD Technical Management Office

Space Technology Laboratories

Strategic Air Command

Associate Contractors

Numbered Air Forces

Division and District Offices of the Corps of Engineers

AFBMD reviews plans for correctness of design, economy, compatibility with and adherence to, engineering and construction standards and practices.

The constructing agency reviews plans for construction feasibility and contract suitability. Review is made by other offices for functional suitability and for adherence to operational concepts and requirements.

Design review conferences are normally held at the preliminary and final stages of the project subject to the requirements of the project at hand. Normally, these conferences would consist of: reviews for functional acceptability and compatibility of interface with GSE and GOE; and engineering review for purpose of insuring compliance of design at a given stage of progress with the technical facility requirements and for construction feasibility.

The acceptability of comments made by reviewing offices is decided at these conferences. Direction for incorporation is made to the A and E by the appropriate AFBMD Weapon System Facilities Directorate. After incorporation of the review comments into final plans and specifications, the project is approved and issued for advertising. AFBMD then issues a construction release to the appropriate AFRCE who, in turn, directs the constructing agency to proceed with advertising and award of the construction contract.

With regard to shop drawings, operating manuals, and spare parts lists, the area or district office of the constructing agency accomplishes the necessary reviews. An A and E firm may be retained for this service. AFBMD reviews certain shop drawings if requested by the constructing agency, and may request a review of specific drawings such as shock mountings and cryogenic vessels.

During the final stages of design, the A and E is requested to formulate a suggested schedule of critical milestones, including dates of contract award, construction completion, Beneficial Occupancy Date, Joint Occupancy Date, and construction schedules. The schedule of critical milestones is normally inclosed as part of the construction release.

Changes, modifications, and additions may be effected by addenda, change orders, supplemental agreements, or other appropriate means which originate as a result of revised ground support equipment (GSE) layouts and/or corrections to facility hardware, changes in operational and maintenance concepts, changes in engineering design criteria because of the research and development nature of the program and/or adjustments to actual field conditions. The addenda and supplemental agreements are processed in the same manner as the original design.

The procedure for processing change orders to the existing construction plans and specifications is based on the source and type of change. Change requests are categorized as field changes or design changes and may be initiated by any office having responsibility for criteria, design, construction, review, or operation. Regardless of origin, all modifications are recorded in a register of changes maintained by the A and E.

A field change is an alteration that doesn't effect the currently approved requirements, the basis for design, or operating capability of the facility, but is necessary to clarify, correct, or make minor revisions to the contract plans or to adjust to actual field conditions encountered in order to provide a safe and operable facility.

Regardless of origin, all field changes are approved by the AFBMD Field Office. Redesign in the usual sense is not involved. The change can be effected by the constructing area or project engineer, after coordination with the AFBMD Field Office and without further coordination with AFBMD, the associate contractors, or CEBMCO. The monetary value of a change has no effect on the determination of whether a change should be of the field or design type. Sufficient copies of approved field change orders are forwarded to appropriate AFBMD organizational units. The A and E firm includes the approved field change in the change record.

A design change is defined as an alteration that does effect the currently approved requirement, basis for design, existing scope of the contract plans, or operating capability of the facility. Redesign <u>is</u> involved. Design effort, under jurisdiction of AFBMD, is either necessary or the change requires further coordination with associate contractors, operational units of AFBMD, or the construction agency. Design change orders are implemented by convening change order conferences to determine the action to be taken by all interested agencies on the requested change. Construction agency offices concerned, AFBMD Facilities Engineering Group, and the appropriate AFBMD Weapon System Facilities Directorate participate in the conference. Conferences are normally held at AFBMD or at the site, depending on the nature of the change and the status of construction and/or procurement. Unless impractical, conferences are called within 24 hours of receipt of the requirement for the design change order by the office responsible for calling the conferences. The conferees discuss the scope and character of the change, effect of the change on going construction, contract actions, schedule for redesign and design review, method of implementation and the effect on completion schedule and costs. Data relative to design changes originated outside the cognizance of the AFBMD Field Office is not referred to the district office of the construction agency unless such referral is made by the approving office of the construction agency. Conferences at the site are called and monitored by the AFBMD Field Office. The district office of the constructing agency arranges for the contractor and for other constructing agency participation. Conferences held at AFBMD are called and monitored by the Facilities Construction Operations Group, with adequate notice given to all participants. The approving office of the construction agency arranges for other constructing agency participation. As appropriate, the Weapon System Facilities Directorate, SAC, associate contractors, and the A and E, who advises on the change involved, are participants in the conference. The following are determined at the conference: Status of construction effected by the change, scope and character of the change, effect of change on going construction, construction contract action, schedule for redesign and design review, the date change will be implemented, effect on completion schedules and costs, and special provisions and/or methods.

Design changes are made by the A and E to the appropriate documents. Revised plans and specifications resulting from the conference flow through the same approval channels as the original plans and specifications require the same approval.

Because the design of ground support equipment and its installation by the associate contractors is proceeding concurrently with construction, any change in plans and specifications for construction which effect interface with the GSE must be known as soon as possible. Additionally, the system of maintaining and distributing current plans and specifications requires a reference list to assure the recipient of the validity of the information in hand.

The A and E maintains the original drawings as record drawings by revising them to reflect addenda, field changes, or design changes, and submits revised reproducibles to the constructing agency for distribution. Along with final plans the A and E submits a register of drawings. The register is maintained in current status by the A and E with updating of monthly information to all original recipients of the register. The district office of the constructing agency distributes revised plans and specifications to all recipients of the original plans and specifications.

After completion of I and C, the A and E submits original drawings through the AFBMD field office to the Base Civil Engineer as a record of "as built" drawings.

A limited number of A and E technical representatives made available to the AFBMD field office to serve as consultants in the interpretation of plans and specifications and to assist in processing changes and in construction surveillance.

It is a requirement of the contract that associate contractors maintain appropriate representation at each construction site to perform facility construction surveillance of GSE interface problems and to provide and assessment of the adequacy of construction and compliance with technical or weapon design criteria.

AFBMD consulting panels meet periodically with representatives of the A and E firm, AFBMD, and STL to proivde consultation and guidance.

A Senior Advisory Panel comprised of approximately seven of the top men in structures, foundations, geology, physics, and dynamics is employed to provide general guidance to AFBMD regarding concepts and parameters to be used in the design of hardened facilities.

A Shock Isolation Panel consisting of approximately six American Experts in the fields of mechnical engineering and industrial shock mounting, convenes periodically to furnish guidance in the best methods to be used for shock mounting of equipment in facilities and to help determine the response that systems will have to exhibit in order to survive attacks.

A Radiation Panel comprised of approximately five specialists associated with the AEC, Armed Forces Special Weapons Project, and other agencies involved in development and test of nuclear devices convenes periodically to air AFBMD in establishing radiation dose and flux outside facilities under attack conditions, to determine tolerance levels of equipment and personnel, and to furnish necessary guidance.

PART III

TECHNICAL DESCRIPTION OF ATLAS F OPERATIONAL FACILITIES
Adapted and Abridged from
Bechtel Corporation Technical Description of Facilities, Undated.

The two basic structures at a site are the launching silo and the launch control center. The launch control center and silo are 100 feet center to center distance. (See Figure 1 for operational site plan and Figures 2 and 3 for views of silo launcher and launch control center). The launching silo is a reinforced concrete cylinder with its top flush with the ground surface. It has a 52 foot inside diameter and is 174 feet from ground surface to the top of the base slab. The doors at the top open to allow raising and firing of the missile. The roof and upper walls are 9 feet thick for resistance to atomic attack. The overhead door is constructed of reinforced concrete 2 foot 6 inches thick and has two leaves each of which is hinged at its outer edges. The door is operated by a single hydraulic cylinder. The 2½ foot door thickness provides necessary nuclear radiation protection for silo equipment. The doors are provided with rubber seals which provide protection from the over-pressure generated by explosion.

The lower walls of the silo are 2 foot 6 inches thick. Two types of foundation may be used. The first is a reinforced concrete dome 3 foot 6 inches thick, designed to resist the forces of ground water around the silo. The second type is a flat reinforced concrete slab 6 foot thick with drainage material under the slab. This second type will drain groundwater into a pump from which it is pumped to a safe disposal area at the surface. The choice of which type of foundation to use is based on an economic study of all factors involved at each site.

The silo crib is constructed of structural steel. It is suspended within the silo shell by four pairs of coil springs which attenuate the ground shock from a weapon explosion. The acceleration limit of this crib is 0.4 g vertical and 0.1 g horizontal. The springs are locked in an extended position immediately prior to raising the missile. The crib is equipped with three hydraulic positioning cylinders located at the top which place the rib exactly under the door before the missile is raised. The steel frame work of the crib is 150 feet high and is octagonal in plan. It has a large truss between the fourth and fifth levels which distributes the load from the four support points of the springs to the columns. Three open spaces extend from the top to the bottom of the crib. These spaces contain the facility elevator, launch platform and missile and the launch platform counterweight. (See Figure 4 for the equipment located at each level of the crib).

The major components of the crib are as follows:

1. The launch platform - a structural steel framework which supports the missile and contains certain items of equipment directly associated with the missile. The platform is raised and lowered by a drive system equipped with electric motors, gear reducers, cable drums, steel cables and counterweights. The counterweight is sized to minimize power requirements during missile raising.

2. Thermal insulation paneling - for isolation of the missile area and for maintenance of constant temperature. The RP-1 fuel is stored within the missile constituting a hazardous area.

3. Multi-level work platforms - hinged and operated by hydraulic cylinders which fold out of the way when the missile is being raised.

The missile is equipped with an all internal guidance system. During ready periods in the silo, gyroscopes which provide the reference plane during flight, are kept from drifting by an optical alignment system. The main component of this system is a collimator mounted on the silo wall which shines a light beam to the missile thereby providing a reference beam for the missile guidance system. Bench marks on the silo wall and an auxiliary theodolite at ground surface are used to check the collimator for proper alignment. A sight tube connects the collimator and the theodolite at ground surface.

The silo shell is penetrated at two points by an air intake and an air exhaust port. Incoming and outgoing air are conducted to and from the ground surface by reinforced concrete shafts on the outside of the silo. The interior of the silo is protected from overpressure by vent closures mounted on the silo shell. A weapon explosion actuates a sensing device by either light or radio waves generated. The sensing device relays a signal to the air cylinders at the vent closures causing the cylinders to close the vents before arrival of overpressure. Total closing time takes 0.20 second. Timing devices keep the vents closed for a set period of time and then allow them to reopen after the overpressure wave has passed.

The overhead doors are operated by hydraulic cylinders. Nitrogen gas is pumped to a high pressure and stored in accumulators. The gas is used to pressurize hydraulic fluid which, in turn, drives the hydraulic cylinders. This system also actuates the work platform cylinders and the cylinders used to lock the launch platform in its raised and lowered positions.

The silo is connected to the launch control center by a tunnel. The tunnel has flexible connections at its ends to provide for differential settlement between the launch control center and the silo. The tunnel is equipped with two interlocked blast doors at its silo end to protect occupants of the launch control center from overpressure when the silo is open. The tunnel also carries all interconnecting utilities between the silo and the launch control center.

The main entrance to the facility is at the launch control center. The entrance is protected from overpressure by two interlocked blast doors at the top of the shaft adjacent to the launch control center. The stairway portion of the entrance is not designed to resist a weapon explosion; however, the bends provide nuclear radiation protection for the occupants of the launch control center. An emergency escape hatch is provided in the roof of the launch control center so that occupants can leave if the entrance stairway is destroyed. The escape hatch is blast proof.

The launch control center is also a reinforced concrete cylinder. Its top is approximately 6 foot 6 inches below ground surface. It has a ten foot inside diameter and is 27 feet from ceiling to floor. Dimensions and configuration of the launch control center are shown in Figures 5 and 6. The floors in the launch control center are suspended from four shock hangers. Shock attenuation is provided by air spring cylinders. The acceleration transmitted to the floors is limited to 0.4 g vertical and 0.1 g horizontal. All of the operations necessary to load, raise, and fire the missile can be controlled from the launch control center. This control is concentrated in two consoles - one for facility equipment and one for ground support equipment.

The function of OSTF-2 is to test the operation of equipment in the complex. As such, it has devices installed which are able to raise the silo crib and drop it to simulate ground shock conditions. Normal day to day operation of the OSTF is on commercial power. However, it is equipped with one diesel operator to be used during simulation exercises. In the layout of the OSTF site the interconnecting tunnel is eliminated due to increased hazard of missile explosion in the silo. Also, the OSTF has two auxiliary buildings -an instrumentation building for housing instruments necessary to monitor the extensive testing program, and a utilities building.

The propellant loading system serves to transfer and store the propellants and auxiliary fluids from the supply source to the missile. The propellant loading system starts at grade level with the fill lines and vents and terminates at the elevator disconnect assemblies. The propellant consists of liquid oxygen and RP-1 fuel. Auxiliary fluids are liquid nitrogen, gaseous nitrogen, gaseous helium, and compressed air. The propellant loading system has the following design features:

1. Fuel is stored in the missile.
2. Liquid oxygen is loaded rapidly from hard storage in the silo.
3. Pressure is used to transfer cryogenic fluids and gases.
4. The missile is filled with RP-1 directly from surface trailers.
5. High cleanliness
6. High reliability

In order to achieve the above design features the propellant loading system is supplied to subassemblies which can be fabricated under controlled conditions not obtainable in field fabrication. Materials of construction are stainless steel for cryogenic lines stainless steel and copper for cleanliness, and structural steel and plate for non-critical areas. Prefab and subassembly items are listed as follows:

1. Liquid oxygen fill prefab
2. Liquid oxygen control prefab
3. Liquid nitrogen prefab
4. Pressurization prefab
5. Instrument air prefab
6. Fuel prefab
7. Vessels for storing auxiliary liquids
8. Helium heat exchanger
9. Inter-connecting piping, valves, and fittings.

In installation the liquid oxygen fill, liquid oxygen control, liquid nitrogen, pressurization and instrument air prefabs are located in the crib structure on the seventh level. The fuel prefab is located at the bottom of the missile enclosure between the seventh and eighth level. There is interconnecting piping between prefabs, between crib and silo wall and for surface connections.

The mechanical systems are composed of the following:

1. Heating, ventilating and air conditioning for heat removal and environmental control (See Figure 7)
2. Outside air system for cleaning and cooling of engine generator rooms and silo.
3. Air conditioning systems for the launch platform, control cabinets and the launch control center.
4. Chilled water system for air-conditioning and pod cooling.
5. Cooling water system - refrigeration condensers, diesel jacket water, cooling tower and emergency supply.
6. Heating system - recirculated air. Diesel exhaust boilers to provide hot water to launch control center and thrust section heater.
7. Exhaust system - for general use and to purge gases and fuel.
8. Water supply system - for utilities, drinking and storage.
9. Fire protection consisting of a fog system and hose stations.
10. Compressed air system for use in blast closures, launch control center suspension and diesel starting.

The electrical work for each silo site includes a diesel power plant, power distribution feeders, motor controls, lighting, communication raceways, grounding and alarm systems for the launching silo, launch control center and site facilities. (See Figures 8 and 9).

The power plant consists of two diesel generators, located on the fifth and sixth levels of the launching silo. Each generator is rated at 500 KW 480 volt, three phase, 60 cycles at 0.8 p.f. Each is capable of supplying the complete load requirements for the silo and launch control center. The second unit serves as a 100% standby source. Synchronization and control of the generators is possible both locally and at the power remote control panel located in the launch control center.

The 480 volt generator and feeder switch gear located on the fifth level of the silo contains the following:

1. Two electrically operated, drawout type, air-circuit breakers for generator feeders.
2. One electrically operated air circuit breaker for the non-essential motor control center feeder. This breaker provides disconnection of non-essential loads during launch platform rise, thereby considerably reducing the generating capacity required. The breaker will be controlled by Convair's logic units, also at the 480 volt switch gear and at the power remote control panel.
3. Three manually operated circuit breakers serve the launch control center, launch platform and essential motor control center feeders.
4. Electrically operated air circuit breakers utilize 48V d.c. tripping and 120V a.c. closing.

The station battery is rated at 48 V d.c. and provides power to trip the switch gear breakers and operate the diesel engine controls.

Power feeders to the essential non-essential and launch platform motor control centers in the silo and the motor control center in the launch control center are interlock armored cables in trays.

The motor control centers contain all controllers for 480V facility and ground support electrical equipment except for the 50HP water chillers which have their controllers integral with the equipment.

The essential motor control center feeds the following silo equipment.

1. Control cabinet air conditioning and the dehumidifying unit.
2. One air conditioning water chiller and pump.
3. Thrust section heater coil and fan, 120/208Volt critical power for launch control equipment.
4. Battery charger supplying power to the facilities 48V d.c. distribution panel and batteries.

5. Ground support equipment consisting of 28 Volt d.c. power supply, 400 cycle motor generator set, nydraulic pumping unit and missile pod coolings.

The non-essential motor control center feeds the following silo equipments, the launch platform and the main silo supply and exhaust fan, standby air conditioning chiller, air conditioning water pumps, cocling tower, silo sump pumps, vacuum pumps, air compressors, defueling pump, facility elevator, silo lighting transformer and receptacles for checkout trailers and propellant trailers.

The motor control center in the launch control center supplies power to the ventilation system, lighting, sewage pumps, and water wells.

The missile platform motor control center contains controllers for the missile lifting system.

The grounding system for the silo and the launch control center consists of a network of vertical 4/0 ground cables at the perimeter of the silo with ground rods laid horizontally. The cables are connected to the crib structure. The steel crib structure is a basic element of the ground system and all equipment, piping, and electrical raceways are bonded to this structure. The ground systems at the silo and the launch control center are similar and interconnected.

The facilities interface cabinet, (see Figure 10) combines all facilities, propellant loading system and launch platform interface signals with the Convair missile logic system at one panel on the third level adjacent to the logic units. The panel contains the shake-proof terminals and matching receptacles to enable Convair to plug in their own connections.

Lighting in all areas of the silo is supplied from general purpose incandescent fixtures except the missile enclosure which has vapor tight fixtures. Flourescent flighting is used in the launch control buildings.

Emergency lighting is supplied from self-contained units consisting of storage battery and charger.

The fire alarm system consists of detectors, manual stations, alarm bells, and a fire alarm panel in the launch control center. Detection of fire at any station causes all alarms to sound.

Communication raceways are provided for the communications systems in the launch control center and the silo. Outlets are provided for installation of telephones and public address speakers.

Vent closure devices in the supply and exhaust air systems for both silo and launch control centers for blast protection are controlled from a blast sensing device.

Hazard classifications in the silo are Class 1, Division 2, for the missile enclosure area; and Class 1, Division 1, at the fuel prefab. All other areas in the silo and launch control building are non-hazardous.

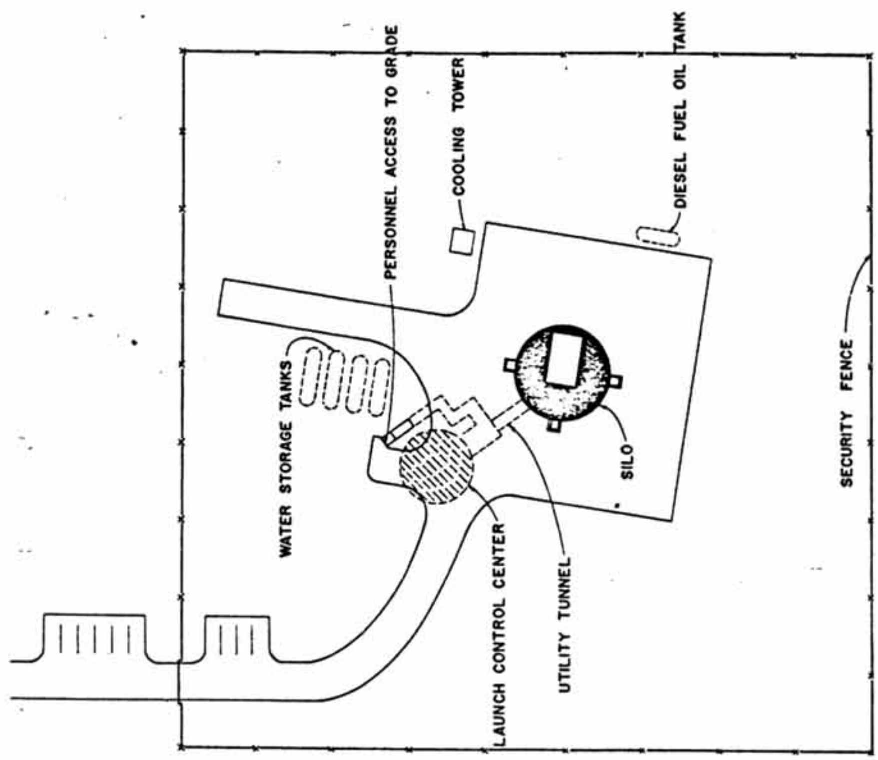
Gas detection systems for RP-1 fuel, liquid oxygen, and diesel fuel vapor are located in the silo and are interconnected to their various ventilating and purge systems.

Television for area surveillance is provided with the camera located on a pole adjacent to the entrance to the launch control center. The camera is soft, therefore, is not for post-blast use. Another camera is located at the gate for personnel identification. Monitors for these cameras are located in the control room of the launch control center.

The water supply is controlled automatically to keep the storage tanks full.

Security gate is controlled electrically from launch control center.

The facility remote control panel contains a trouble section, a ready section and a control section. The trouble section contains annunciators for the diesels, control cabinet air conditioning and hazard detectors. The ready section monitors the air intakes and exhausts, doors, power, and fog system. The control section operates the diesels, non-essential M.C.C., area warning system, security lighting, blast door test and missile area fans.



OPERATIONAL SITE PLAN

AF-WP-O-DEC 63 150

FIGURE 1

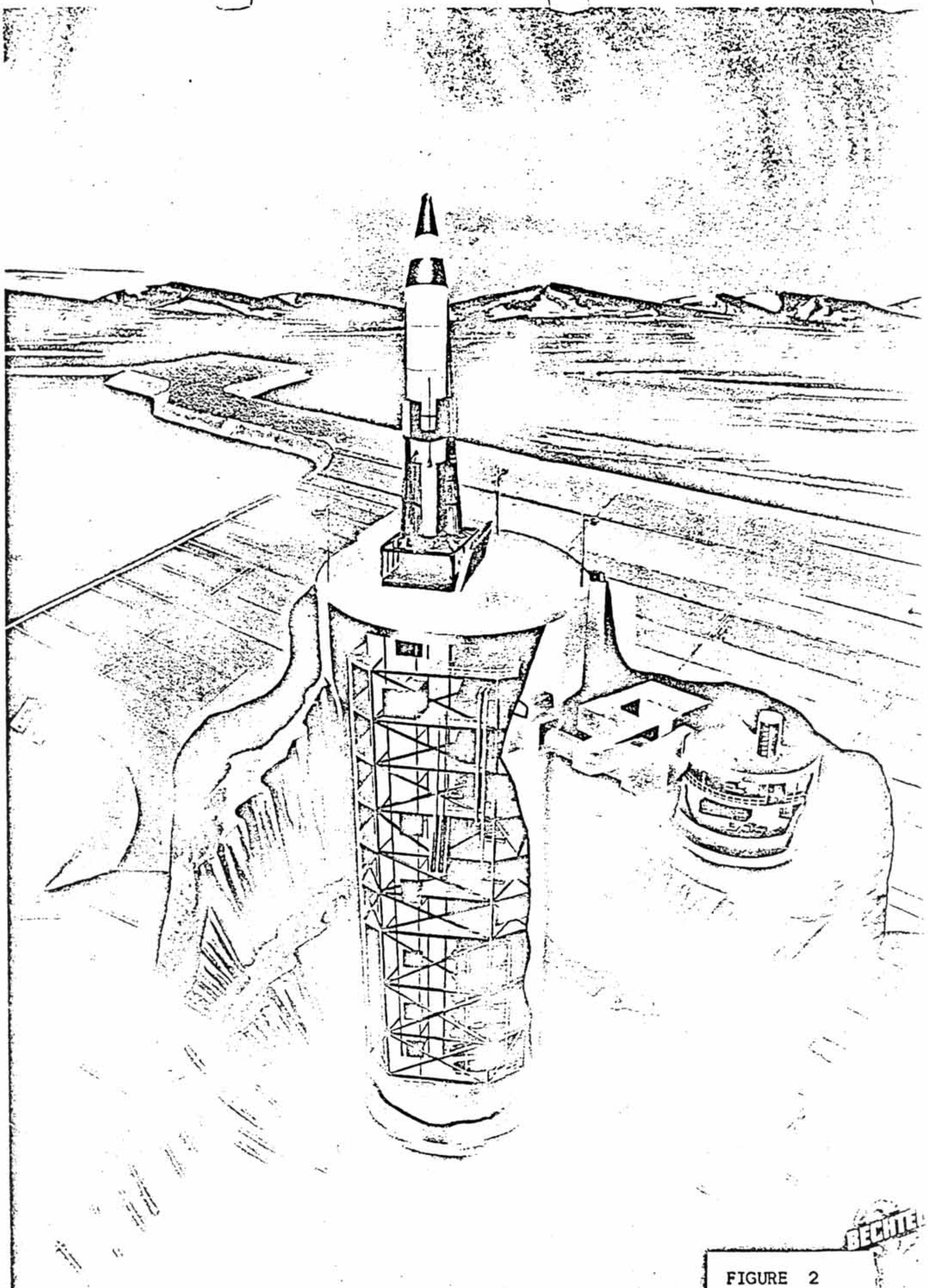
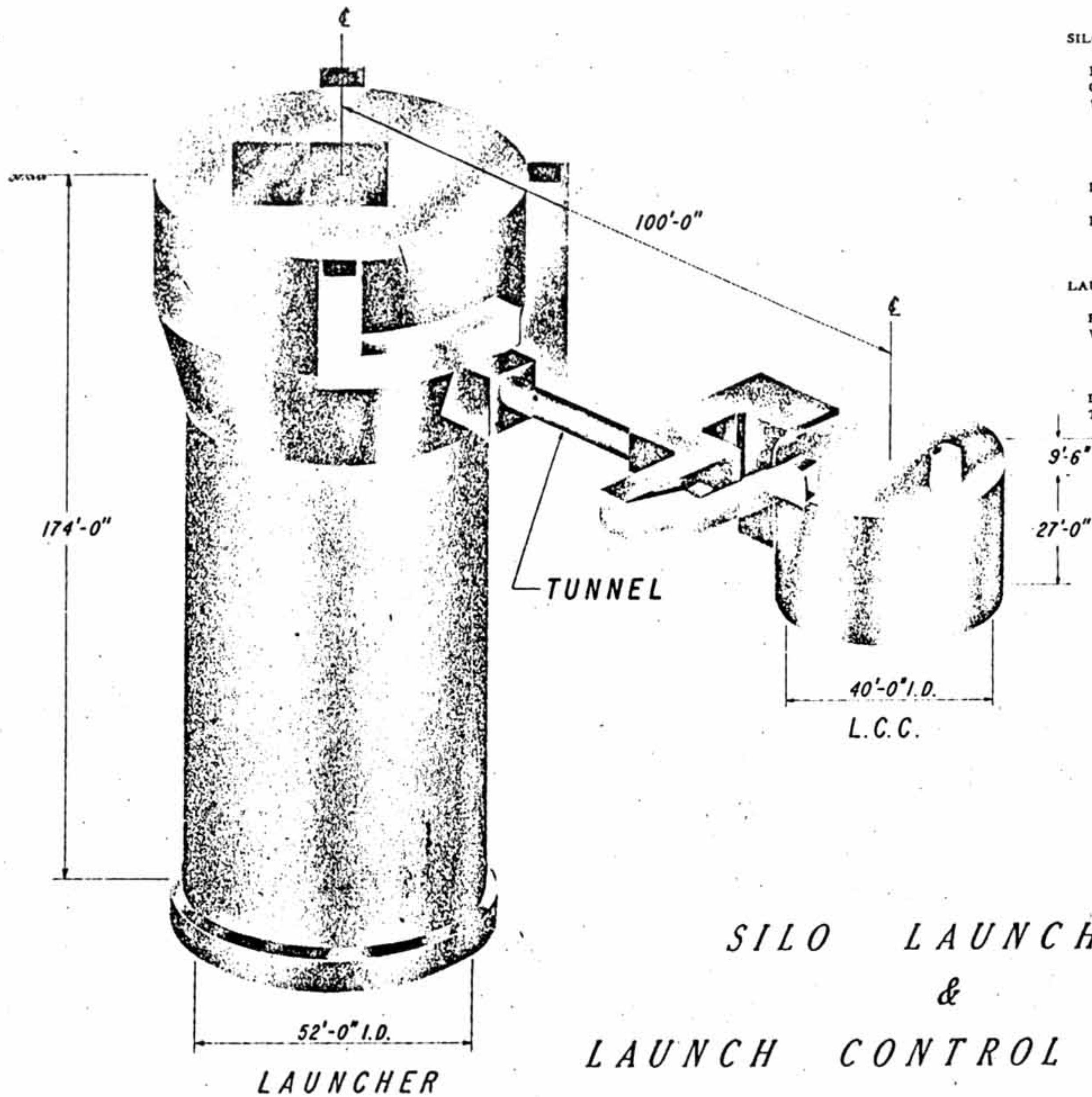


FIGURE 2

PHYSICAL DIMENSIONS

SILO LAUNCHER	
Roof	9'-0"
Overhead Door	2'-6"
Walls	
Thickness Upper 29'-0"	9'-0"
Thickness Below 55'-0"	2'-6"
Inside Diameter	52'-0"
Depth (to top of base slab)	174'-0"
Base Slab Thickness	
Type I Porous Slab	6"
Type II Dome	3'-6"
LAUNCH CONTROL CENTER	
Roof	3'-0"
Walls	
Thickness	2'-3"
Inside Diameter	40'-0"
Clear Vertical Span	27'-0"
Depth of Overburden	6'-6"
Total Height	33'-6"

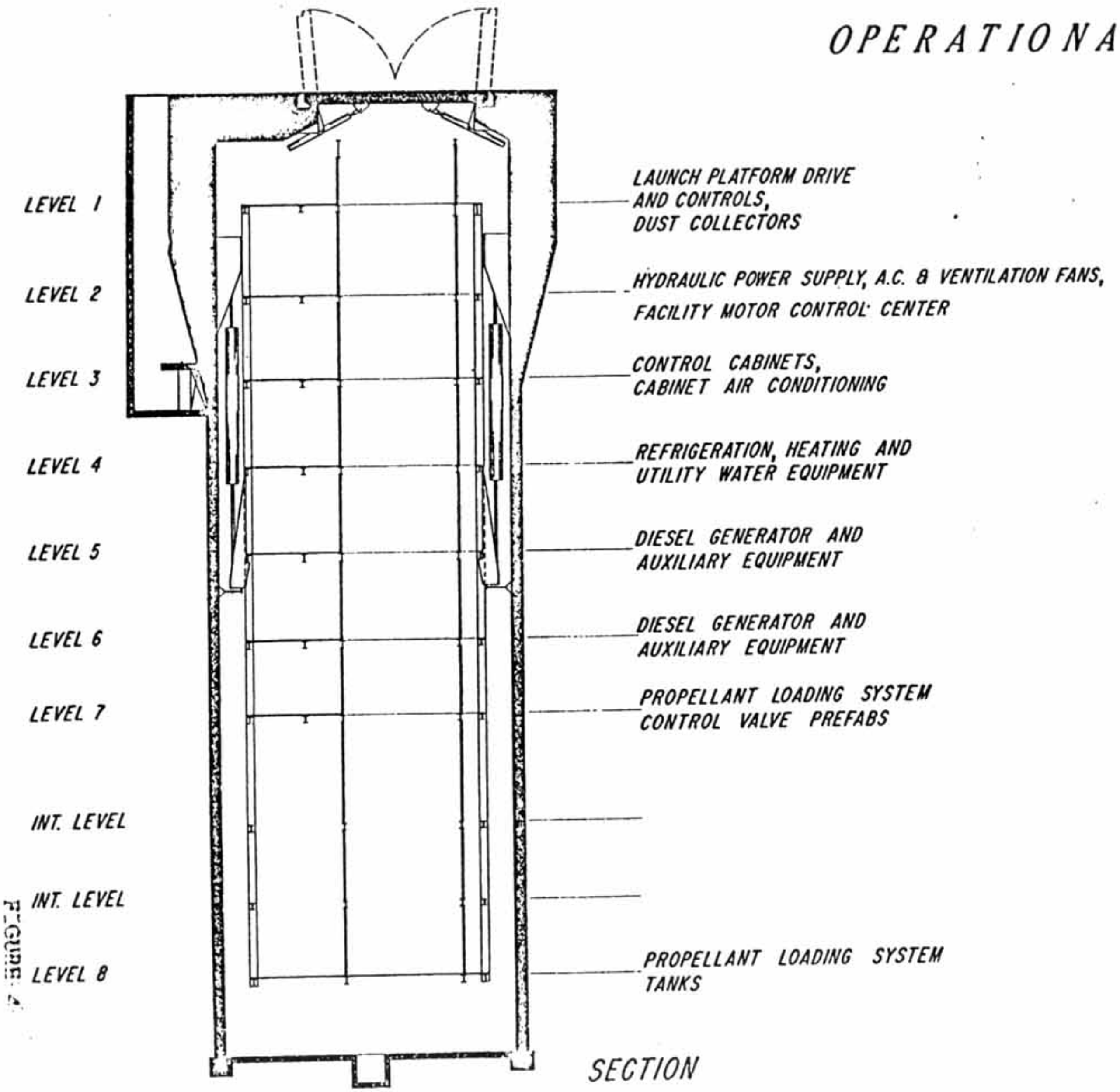


SILO LAUNCHER
&
LAUNCH CONTROL CENTER

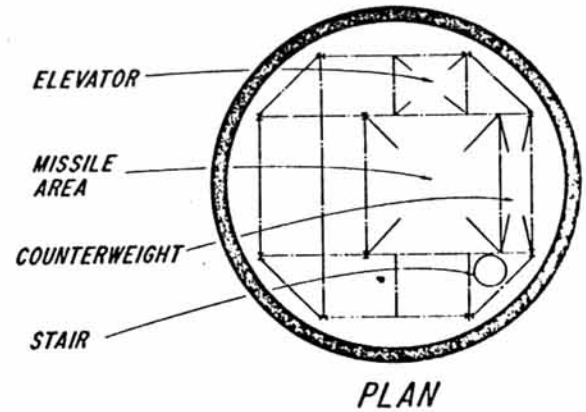
FOR OFFICIAL USE ONLY

FIGURE 3

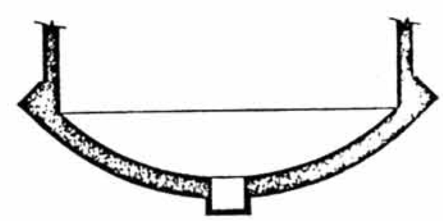
OPERATIONAL SILO



SECTION



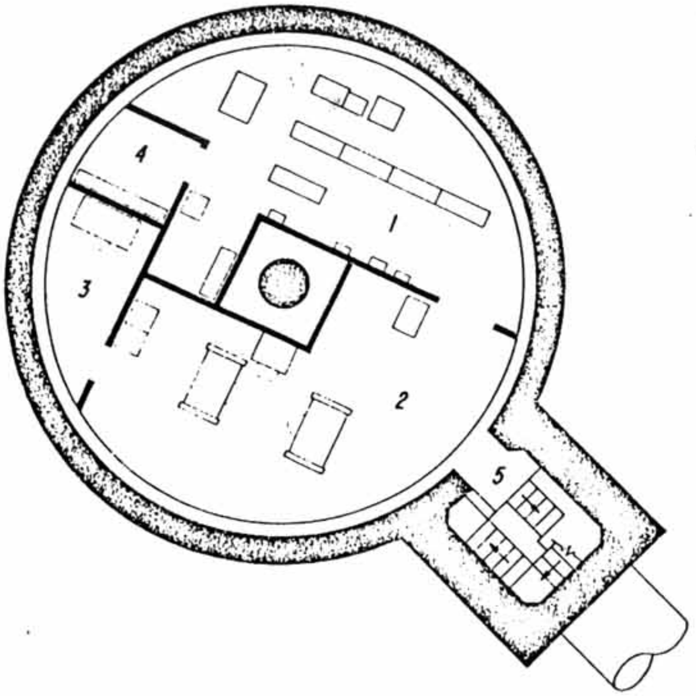
PLAN



ALTERNATE BASE SLAB

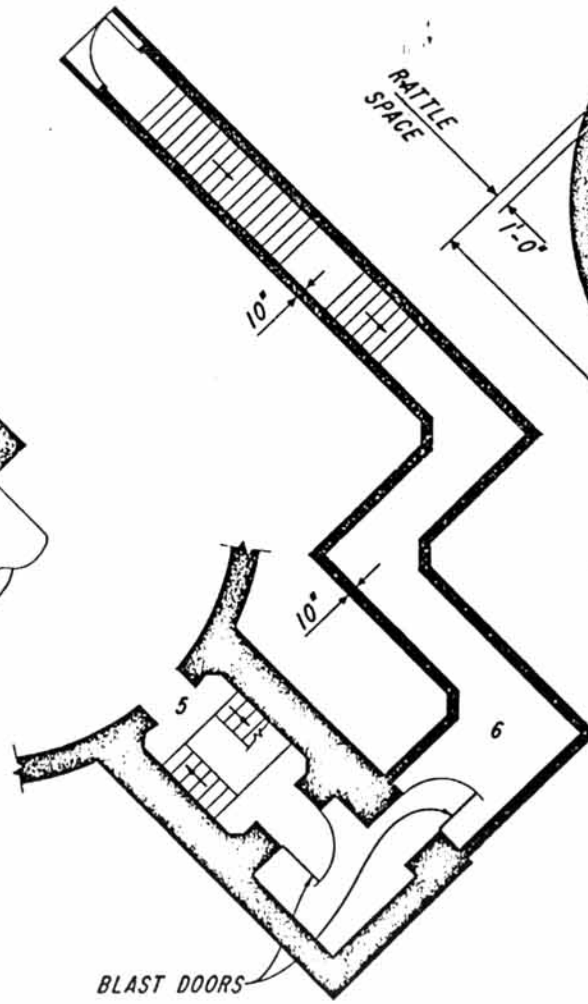
FIGURE 4

LAUNCH CONTROL CENTER — OPERATIONAL SITE

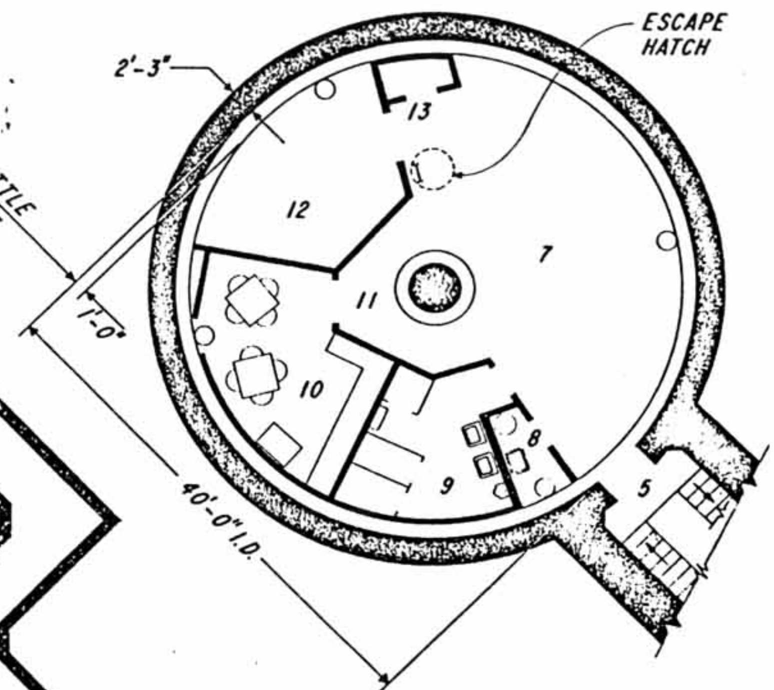


2 ND LEVEL

1. COMMUNICATION EQUIPMENT
2. LAUNCH CONTROL ROOM
3. OFFICE
4. BATTERY ROOM
5. STAIRWELL
6. STAIRWAY TO GRADE



STAIRWAY TO GRADE



1 ST LEVEL

7. READY ROOM & STORAGE
8. JANITOR'S CLOSET
9. TOILET
10. KITCHEN & MESS
11. HALL
12. H.V. & A.C. ROOM
13. MEDICAL SUPPLIES

FIGURE 5

LAUNCH CONTROL CENTER — OPERATIONAL SITE

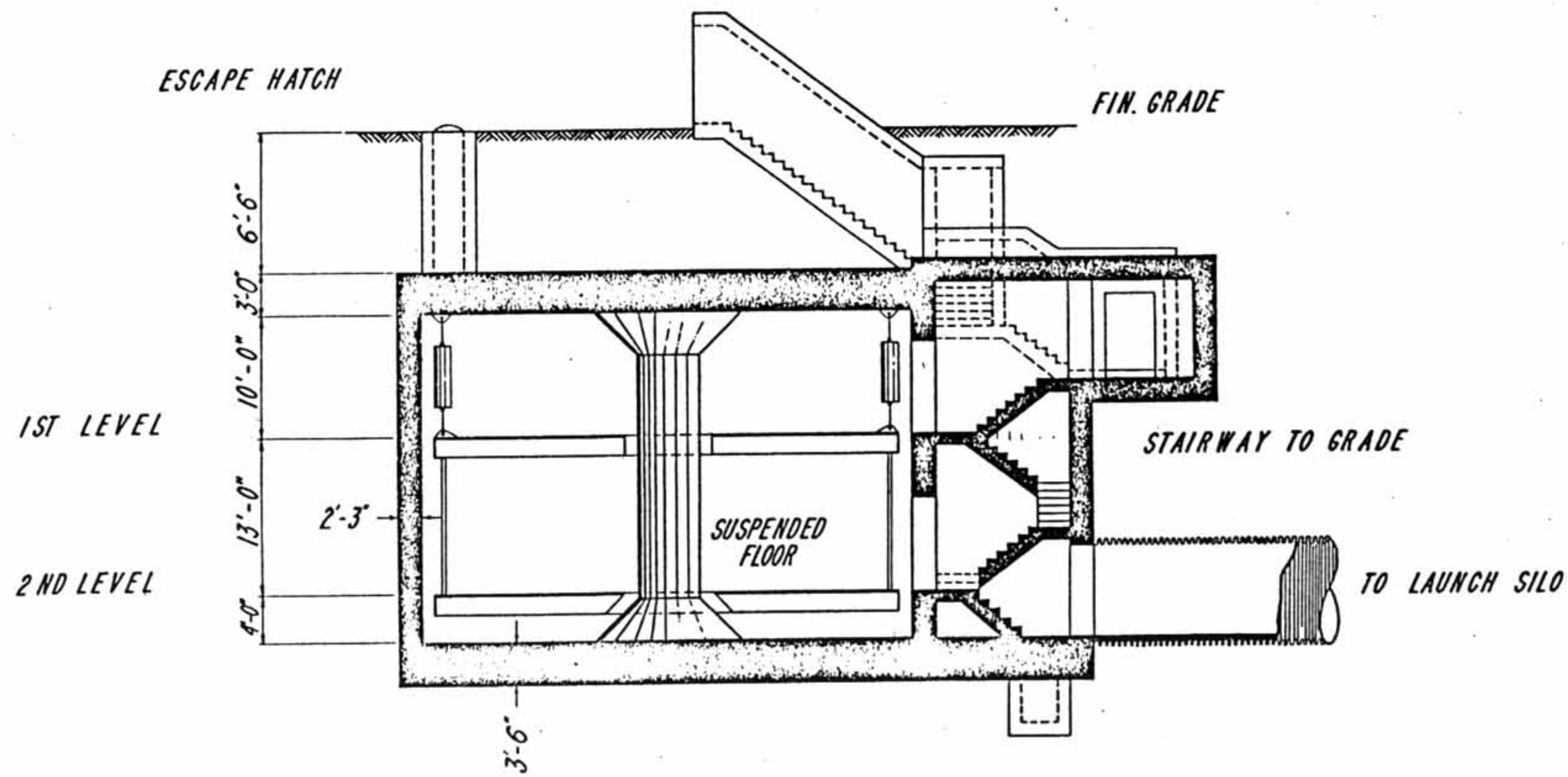


FIGURE 6

HEATING, VENTILATING & AIR CONDITIONING

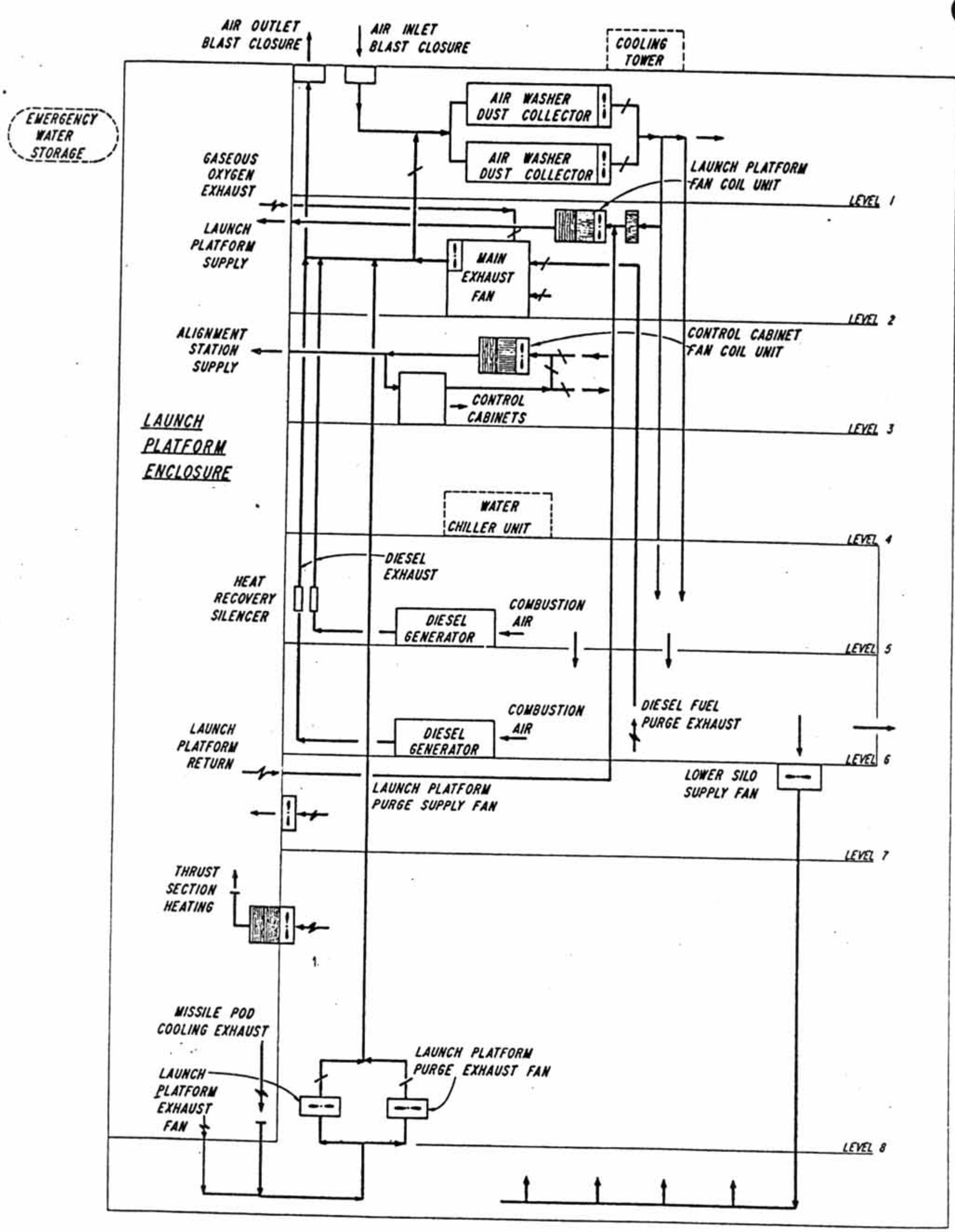


FIGURE 7

ELECTRICAL RISER DIAGRAM

POWER

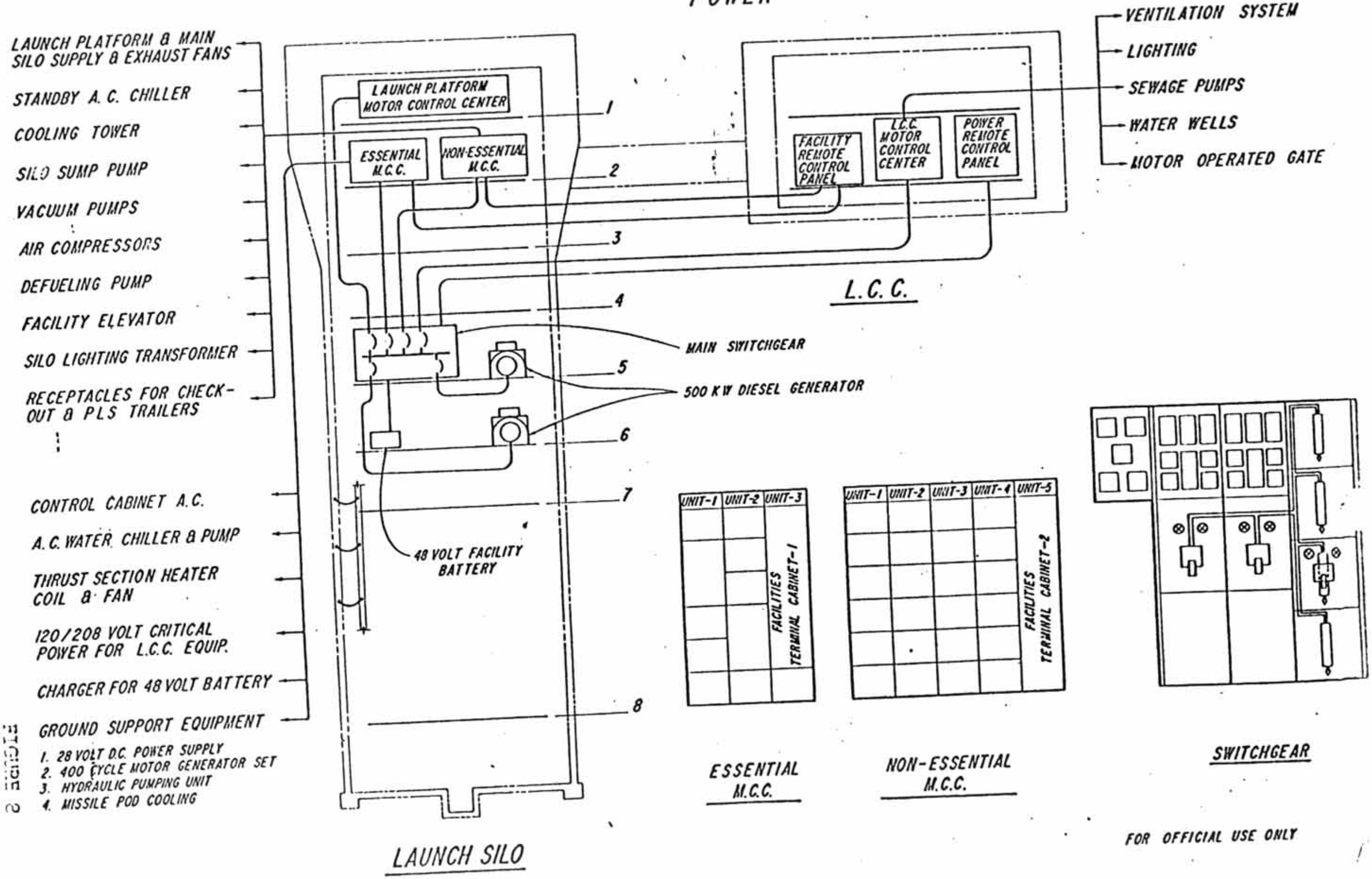


FIGURE 8

FOR OFFICIAL USE ONLY

ELECTRICAL RISER DIAGRAM

LIGHTING, COMMUNICATIONS AND DETECTION DEVICES

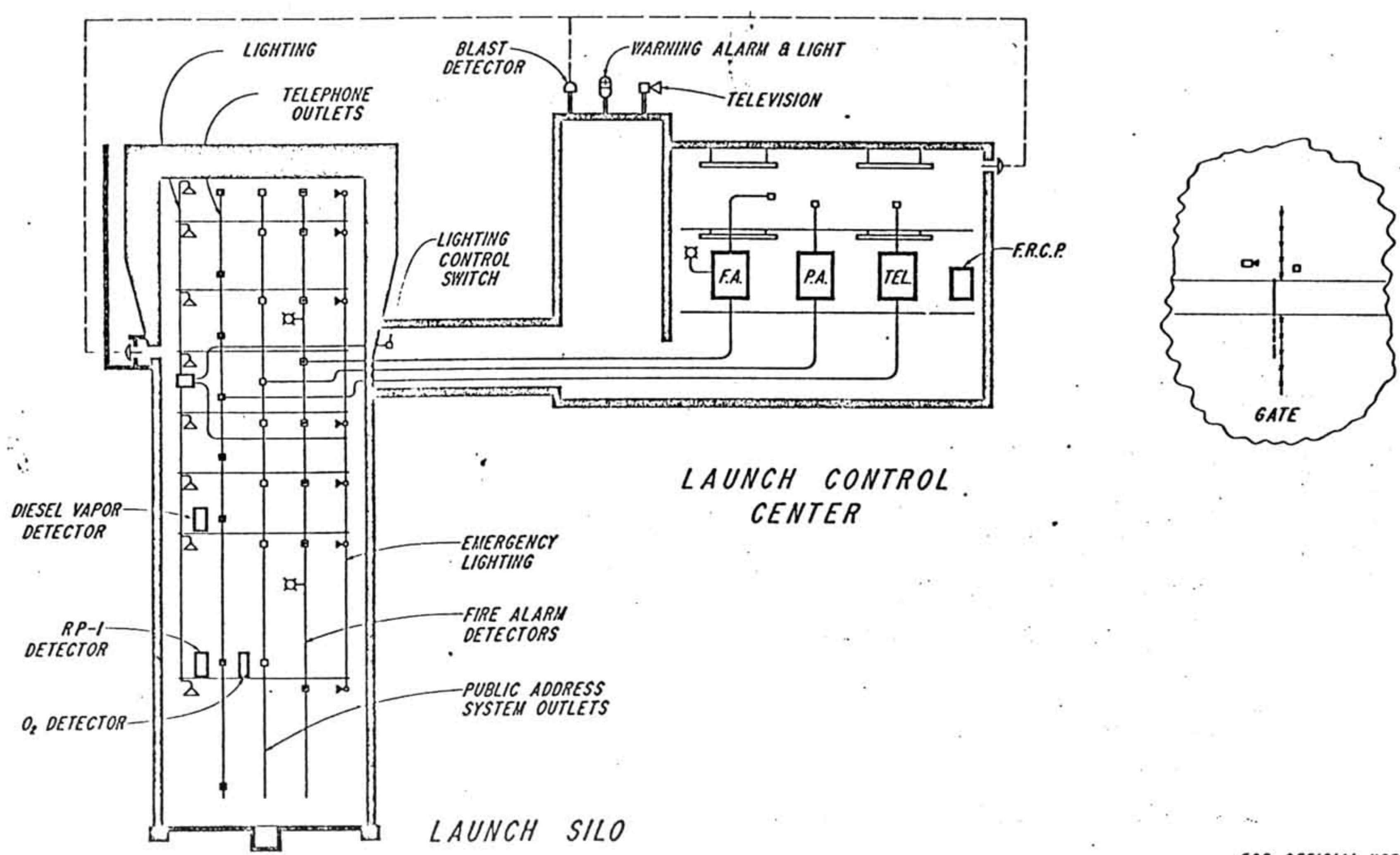


FIGURE 9

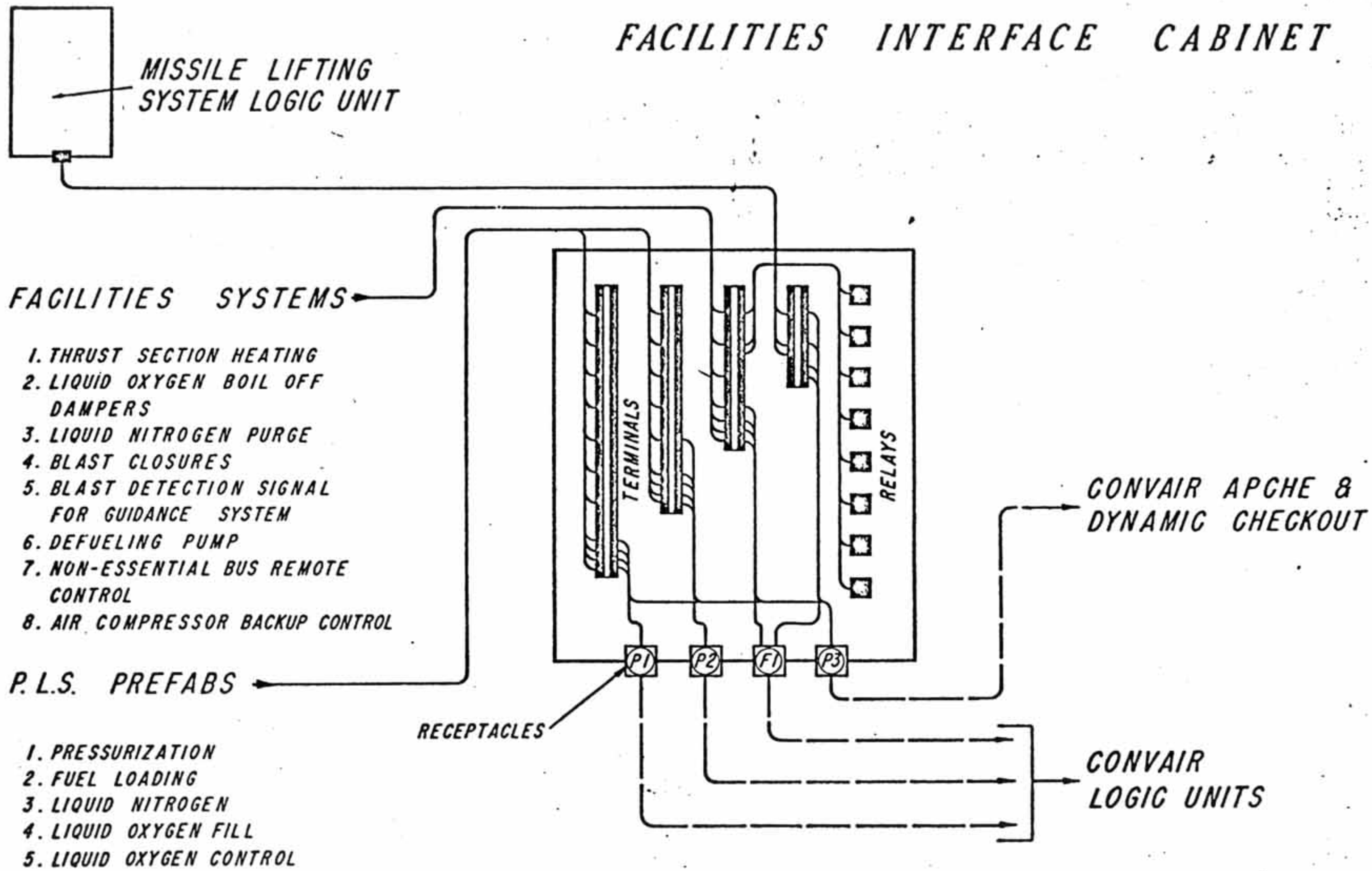

FACILITIES INTERFACE CABINET
MISSILE LIFTING SYSTEM LOGIC UNIT
FACILITIES SYSTEMS
1. THRUST SECTION HEATING
2. LIQUID OXYGEN BOIL OFF DAMPERS
3. LIQUID NITROGEN PURGE
4. BLAST CLOSURES
5. BLAST DETECTION SIGNAL FOR GUIDANCE SYSTEM
6. DEFUELING PUMP
7. NON-ESSENTIAL BUS REMOTE CONTROL
8. AIR COMPRESSOR BACKUP CONTROL
P.L.S. PREFABS
1. PRESSURIZATION
2. FUEL LOADING
3. LIQUID NITROGEN
4. LIQUID OXYGEN FILL
5. LIQUID OXYGEN CONTROL
TERMINALS
RELAYS
P1
P2
F1
P3
RECEPTACLES
CONVAIR APCHE & DYNAMIC CHECKOUT
CONVAIR LOGIC UNITS

FIGURE 10