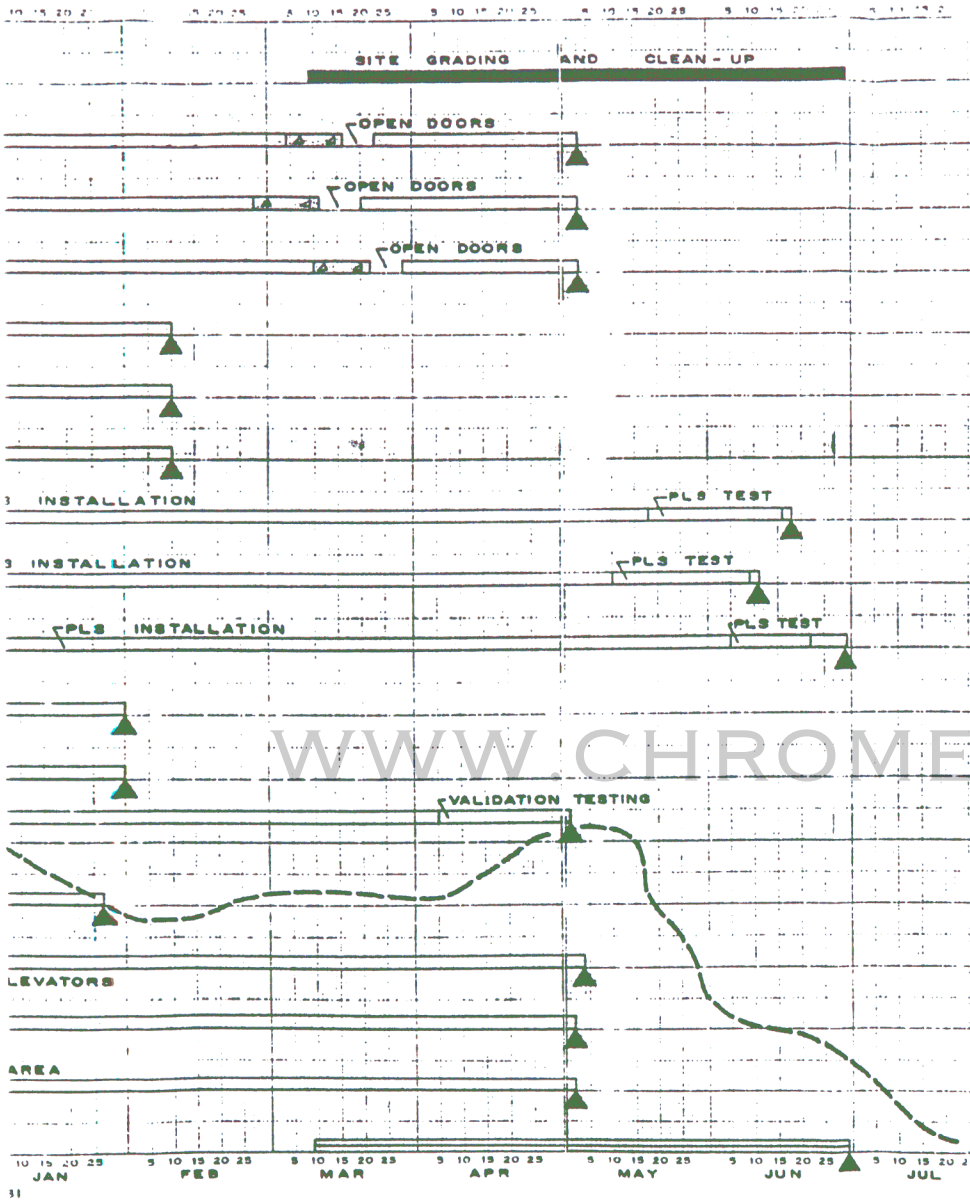


ACTUAL PROGRESS OF CONSTRUCTION

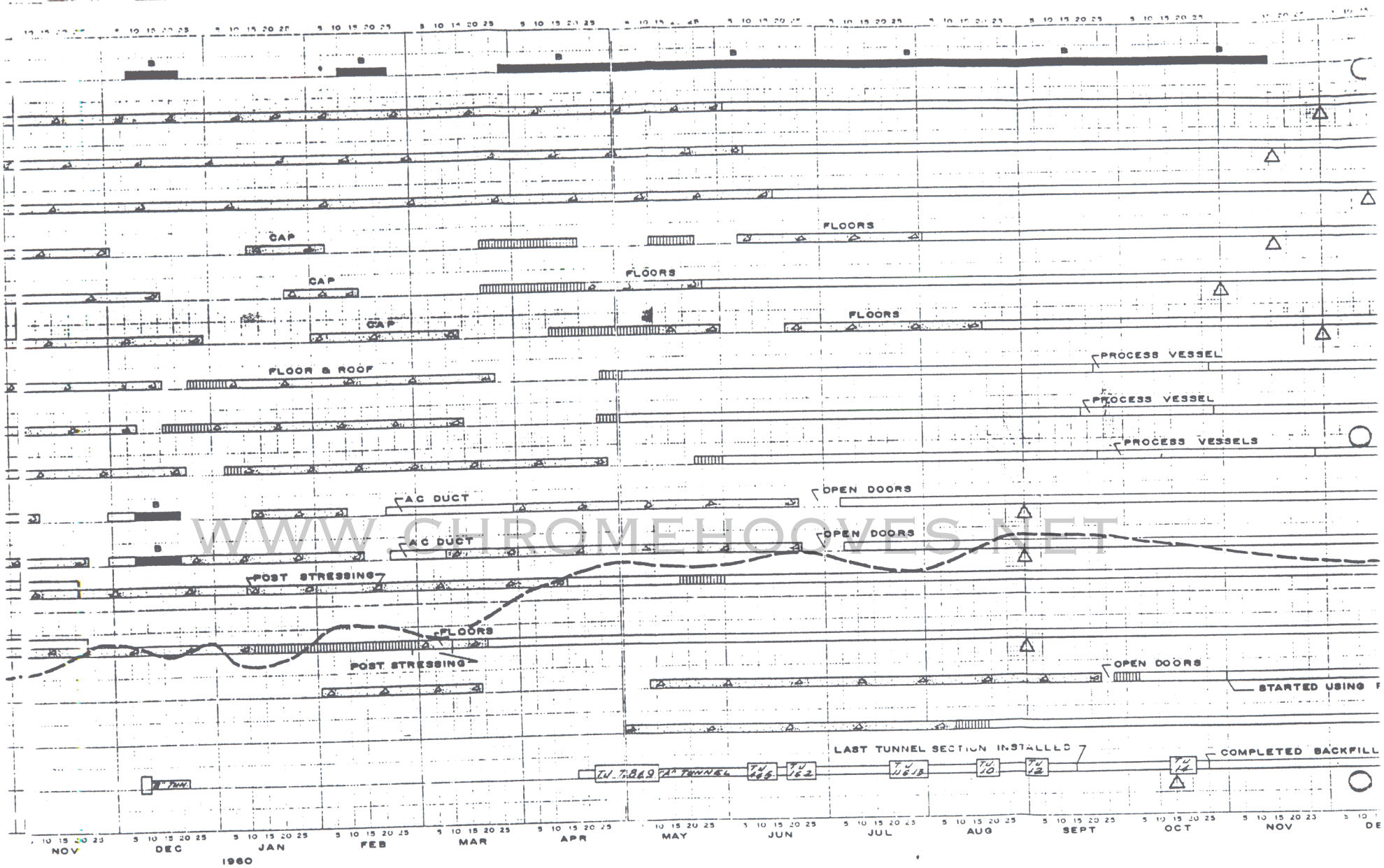
TYPICAL OPERATION

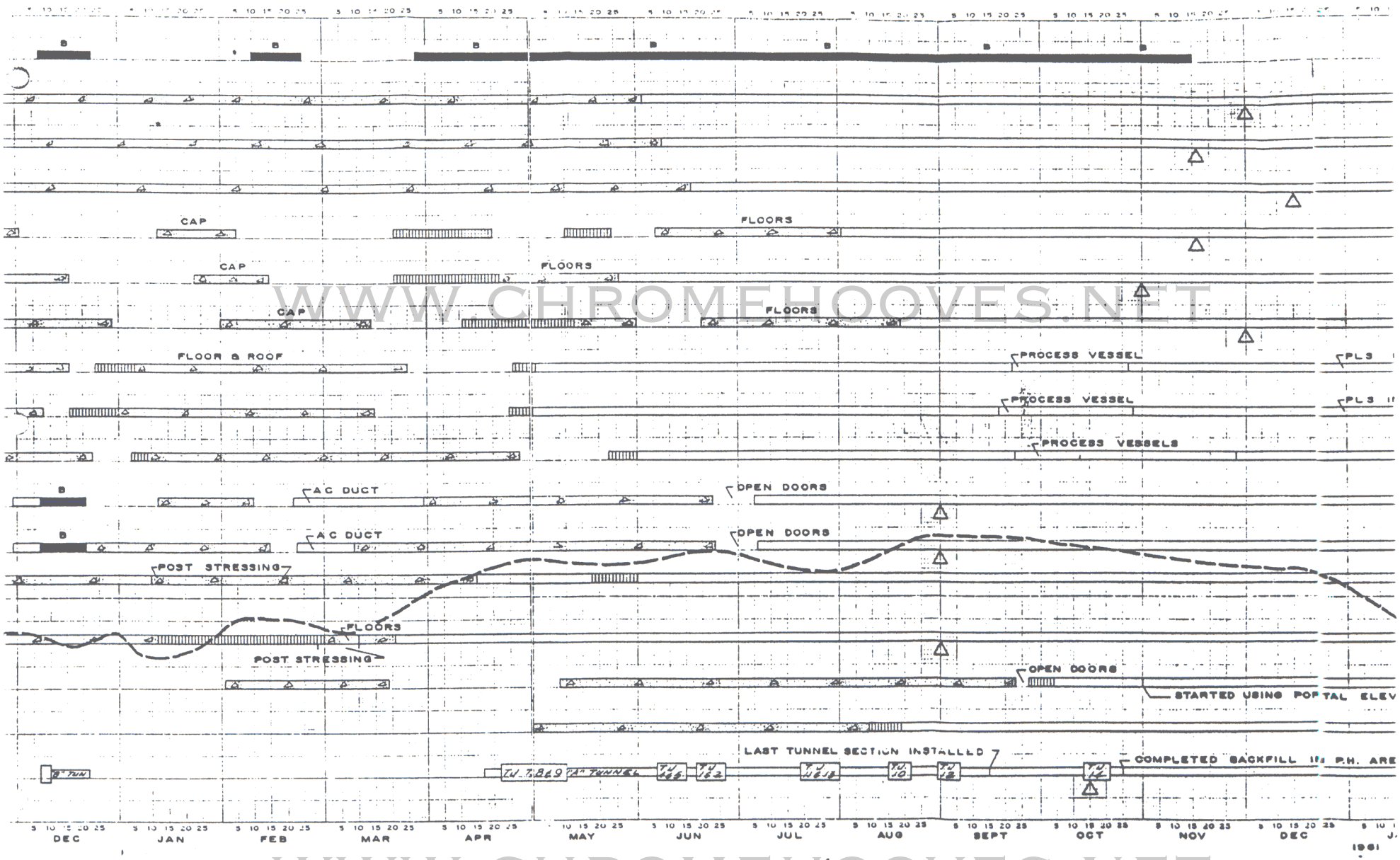
COMPLEX I-C

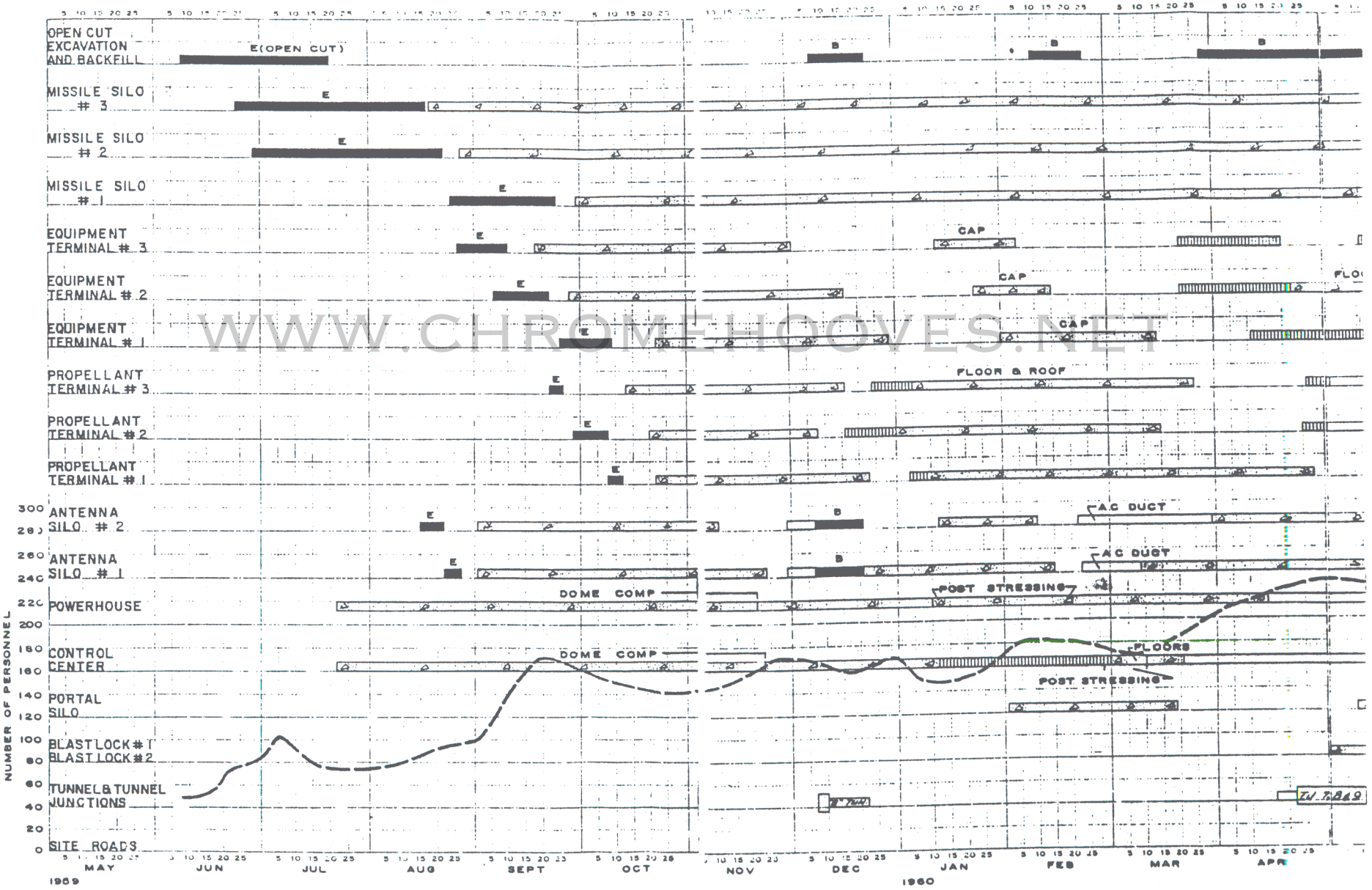
LEGEND

- E — EXCAVATION
- B — BACKFILL
- STRUCTURAL INSTALLATION
- ELECTRICAL AND MECHANICAL INSTALLATION
- CONCRETE PLACEMENT
- TUNNEL & TUNNEL JUNCTION INSTALLATION
- SITE ROAD
- △ — J.O.D.
- ▲ — TURNOVER
- NO. OF CONTRACTOR PERSONNEL ON SITE

CHART NO. 19







PROBLEM AREAS

Modification No. 1 to Contract No. DA-25-066-eng-5558 was issued within 60 days after award of the contract, revised some 409 drawings, issued 39 new drawings, deleted 15 drawings, and issued 562 pages of specifications. This modification delayed normal contract administration activities until the modification was settled at a cost of $4,937,373 on 27 August 1960 over 16 months after award of the contract. Most of the Area Office's estimating and negotiating talent was devoted to this modification until settled.

Modification No. 7 to Contract DA-5558 was issued 7 July 1959, changed the design of the lower part of the Equipment Terminal, delayed project construction, involved lengthy negotiation, and was not settled until 2 March 1960 at a cost of $639,127 although originally estimated by the Air Force not to exceed $150,000.

Modification No. 8 to Contract DA-5558 was issued 31 July 1959, revised 312 drawings, issued four new drawings, totalled 89 pages of specifications, and being controversial, was settled unilaterally on 11 November 1960 at a cost of $3,728,592. The contractor has filed a claim for an additional $1,774,027, which was not settled at the time of this report.

Numerous major changes to the construction contracts created heavy contract administration loads.

Total modifications processed by contracts were as follows:

CONTRACT	MODIFICATION NO.	MODIFICATION VALUE
DA-5558	230	$25,454,724
DA-5654	216	17,058,788
DA-6160	29	251,330
DA-6311	10	23,045
DA-5405	7	168,532
DA-7113	2	3,507
DA-5346	7	(Net Credit) 1,659
DA-6125	4	19,816
DA-5177	5	8,528

Numerous duplication of change order directives required constant surveillance to insure duplicate modifications were not issued. Numerous cases of changes to changed work complicated estimating and negotiating. Changes were authorized and issued up to and after beneficial occupancy.

The abnormally large number of changes caused a work load much greater than could have been reasonably anticipated, and resulted in a shortage of qaulified personnel to process the contract administration.

Numerous investigations by GAO, IG, Senate Subcommittees, House Subcommittees, OCE, Air Force, plus special reports, further hampered the operations of the Area.

Assignment of Contracting Officer Authority on 15 April 1960 to the Area Engineer presented the problem of publishing modifications

initially by an inexperienced field office. This also imposed the problem of maintaining official files, and overruns of designated sureties' capacities.

Acceleration of work by trades and payment for the premium portion of this time worked imposed a large record keeping workload for payment of acceleration.

Nationwide steel strike of 1959 called for extra reporting and record keeping as well as procurement problems and expediting problems.

Revisions of completion schedule and JOD schedule from that in the original contract to that of incremental need dates required by the Air Force presented a very difficult problem.

Changeover of higher headquarters (from Omaha District to CEBMCO on 15 September 1960) caused a change in procedures for modifications and maintenance of official files.

The confusion and lack of coordination in the issuance of drawings for the pipe support modifications (Mod 171, Contract DA-5558, and Mod 160, Contract DA-5654) was a major problem. Normal channels of issuance by SATAF thru CO-Dens or issuance by CEBMCO thru change order conferences were by-passed. Drawings were issued to Morrison-Knudsen Company, Inc. and Associates in the field by the A. D. Little Co., bypassing SATAF and the Corps of Engineers. Coordination in the identification of drawings was lacking in the

A. D. Little and DMJM&A design effort.

Preliminary estimates by DMJM&A on proposed changes thru the change order conference route were always extremely low, indicating a failure to consider field problems, field conditions, and Denver costs rather than Los Angeles' costs.

Personnel participating in change order conferences in Los Angeles were not always knowledgeable of field conditions or work progress.

Research and development and design was accomplished concurrent with construction and created a major problem in scheduling and performance.

Subsurface investigations made prior to preparation of plans were adequate and logs of borings accurately predicted conditions found upon excavation. Ground water was not a serious problem at any of the six complexes. At Complex 2C there was some difficulty with ground water in silo excavations, but no more than generally anticipated from the boring logs. Conventional use of construction pumps was sufficient to control ground water infiltration.

At Complex 2A, a lignite seam was encountered at the level of the powerhouse footing. This seam was shown on the boring logs but the hardness of the lignite was not known until the area was excavated. It was found necessary to remove the lignite seam to obtain a foundation with satisfactory bearing value for the powerhouse and control center foundation materials. These tests were promptly made, the

data reviewed by the architect-engineer, and approval given for construction prior to placing each structure. Foundation material at the planned grading was satisfactory for all structures except the powerhouse at Complex 2A (mentioned above) and the powerhouse at 2B. The 2A lignite seam was removed and at 2B a thin strata of unsatisfactory clay was removed prior to construction of the footings.

Contract documents, particularly for Squadron I, were apparently released without a thorough detailed review from one drawing to another and a review between the contract drawings and specifications. This resulted in many conflicts which were necessary to resolve during construction. To accomplish this, a representative detachment of architect-engineer personnel were scheduled at the job sites to work with personnel from the Corps of Engineers. These men had ready access by telephone to the design engineers in Los Angeles. Discovery of conflicts was made by persons responsible for various aspects of the construction. All conflicts discovered were reported to the Corps of Engineers either by the prime contractor or by architect-engineer personnel and resolution of the conflict was made and information to the contractor disseminated by the Area Engineer so that appropriate control was written under the construction contract.

Many conflicts were reported by suppliers during preparation of shop drawings. Considerable technical effort was required to determine whether items reported were truly a conflict or were efforts by suppliers to obtain approval on equipment which did not meet responsible

specifications. Each problem was separately resolved because there was no general resolution that could be applied. Also entering into considerations were the requirements of associate contractors to place equipment in spaces that were already crowded with electrical and mechanical equipment being installed by the facilities contractor. At times, resolution of these conflicts was vitally important to construction progress. One of the most effective efforts to resolve such conflicts was a series of meetings in April, 1960, attended by representatives of the design architect-engineer, associate contractors, Corps of Engineers, the prime contractor, and local Air Force representatives. In preparation for these meetings, the contractor had prepared layout drawings of equipment terminals, powerhouses, and missile silos. These layouts were used at meetings extending over a period of two weeks and many detailed conflicts were eliminated and beneficial changes in contract plans were accomplished. All of this work was done at the Area level and necessary changes to contract plans were authorized by the Air Force and processed by the Area Engineer.

The design architect-engineer was appointed as the official Contracting Officer's Representative for approval of shop drawings. The contractor was authorized to submit shop drawings direct to the architect-engineer. Copies of the drawings were not received by the Contracting Officer or the Area Office until an approval sufficient to initiate manufacture had been received by the contractor. This procedure left the personnel at job level with little knowledge of occurrences on procurement of equipment during the period when suppliers were making their shop drawing submittals. In some cases,

successive denials of approval were made and the contractor's natural reaction was to criticize the architect-engineer. Procurement of some items was stalemated by this procedure until a system was worked out with the contractor whereby the Area Engineer was furnished with copies of shop drawings upon which approval had been successively denied. This is not to imply that the Area Engineer interposed in favor of the suppliers in all instances. In many cases, disapproval was entirely justified and the Area Engineer's staff by being informed was able to convince the prime contractor that the supplier should take the necessary steps to furnish both satisfactory shop drawing submittals and a satisfactory product. The architect-engineer cooperated with Government personnel by holding conferences in their office on the more complex shop drawing problems. The most important of these conferences were attended by Corps of Engineers representatives.

One of the principal problems with regard to shop drawing approval was to obtain satisfactory tests and certificates for shock resistance. The specifications provided generally that items of standard manufacture were to be supplied, but were to comply with the shock resistant requirements. In many cases, this dual requirement was easily met. In other cases, items of standard manufacture did not meet shock requirements and suppliers were forced to either make revisions to their products or provide special shock attenuation. This resulted in many new and difficult technical problems which were inherent in procurement of material for the first "hardened" missile silos.

The hardened base required certain flexible connecting structures, particularly between shock mounted equipment and connecting piping and electrical conduits. To obtain this flexibility all pipe lines were provided with flexible hose and rigid conduit was provided with lengths of flexible conduit at critical locations. A highly technical design problem arose in selecting these flexible components. To accomplish the design need, hoses were required which did allow for relative movement in all directions. This was not particularly difficult to obtain in flexible electrical conduit. The principal problem was to obtain hose for utility pipe lines which would provide sufficient movement along the axis of the pipe. Rubber hose was specified. Satisfactory products were finally obtained after several conferences with suppliers.

Several other special problems were generated by the shock requirements. These included mounting cribs for LOX fuel piping on specially designed springs in the missile silo; completing construction of all installations on the spring mounted propellant terminal floor; supporting piping and ducts on structure floors adequately to withstand a shock of 50g; and maintaining rattle space between shock mounted and rigid portions of the structure and equipment. There was no general solution which could be applied to any of the above special problems. Under the terms of the contract all equipment was selected and procured by the prime contractor and he was given considerable latitude to either provide equipment to withstand the required shock or provide special shock mountings. With this latitude went the responsibility to provide the necessary rattle space and to devise the construction procedures.

Government representatives, the Area Engineer, the Air Force, and the architect-engineer assisted the contractor in solving the many detailed problems which arose during the construction.

ACCELERATION AND JOINT OCCUPANCY

In making contract price adjustments for the Lowry Titan I Squadrons under Contracts Nos. DA-5558 and DA-5654, Lowry Air Force Base, Denver, Colorado, the following policies concerning acceleration and joint occupancy were followed.

ACCELERATION

The Contractor was directed to work designated trades in designated structures and areas on an overtime basis in order to avoid granting to the Contractor additional completion time to which the Contractor was entitled resulting from the issuance of a vast amount of change orders which concerned changes and additional work. The Contractor was compensated for the premium portion of the overtime. It should be noted that the initial amount of the basic contract was increased nearly 70% due to changes.

The Government recognized that a continued overtime operation results in a loss of productivity. This loss was negotiated with the Contractor and was applicable to all hours worked for those personnel who worked in excess of 48 hours per week in those trades for which acceleration was directed. The determination was that when an employee works in excess of 48 hours, the hourly rate of production decreases. For those personnel who did not work in excess of 48 hours per week, no loss of productivity was recognized by the Government. Payment was

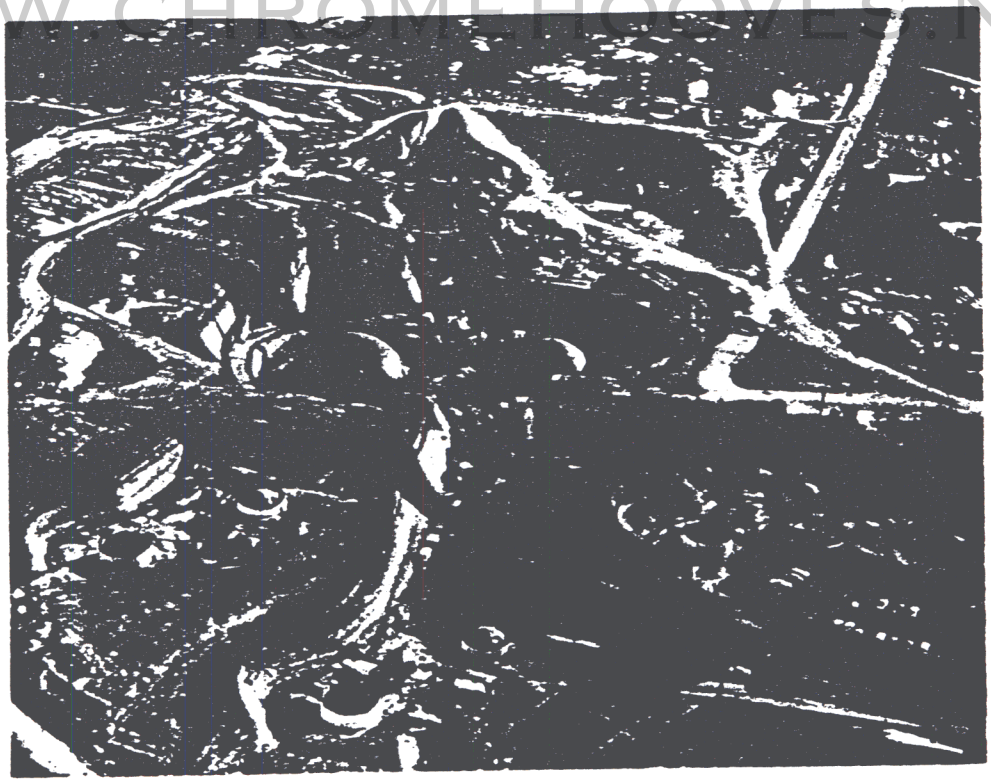
based on a review of payrolls which indicated which men had worked in excess of 48 hours per week with the loss of productivity factor computed thereon.

JOINT OCCUPANCY

As a result of the vast amount of change orders involving changes and additional work and the necessity to have Associated Contractors on the Air Force administered contracts begin their operations prior to the completion of the Corps of Engineers' contract, the Associated Contractors and the Corps of Engineers' prime Contractor and sub-contractors were forced to work under adverse conditions, in crowded areas with limited ingress and egress which prevented an orderly sequential operation of trades.

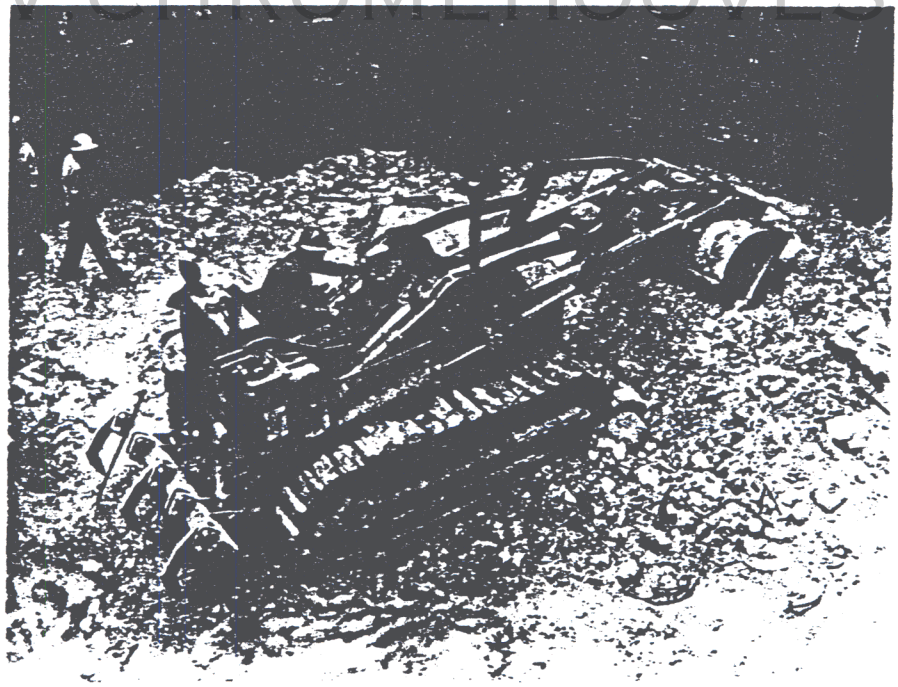
The Government's action did cause the conditions above described and equitable adjustments were determined on the basis of individually affected sub-contractors and the prime contractor. Negotiations as to equitable adjustments were held. The equitable adjustment was based upon field records, job conditions, and payrolls. As the various contractors' conditions were different, it was not feasible to establish a norm to apply generally to all of the sub-contractors and the prime contractor. Therefore, each negotiation was based upon the individual pertinent facts elicited.

Aerial view of a typical complex under construction showing open cut excavation for construction of silos, powerhouse, and other facilities. Upon completion, all features will become underground facilities with only access hatches being visible.

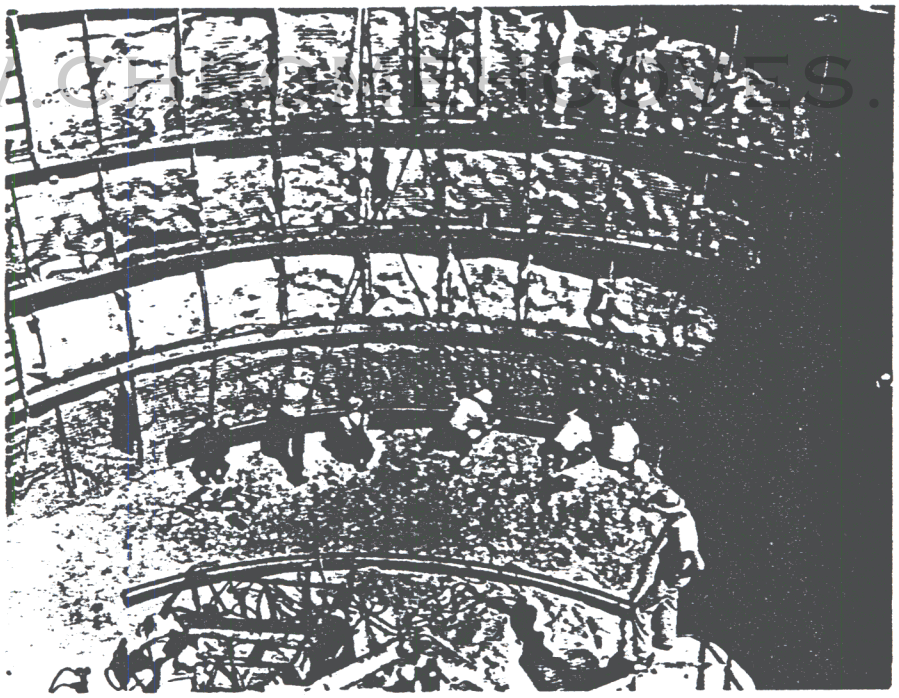


Typical aerial view showing progress. Prefab tunnel not in place. Taken approximately 1 March 1960.

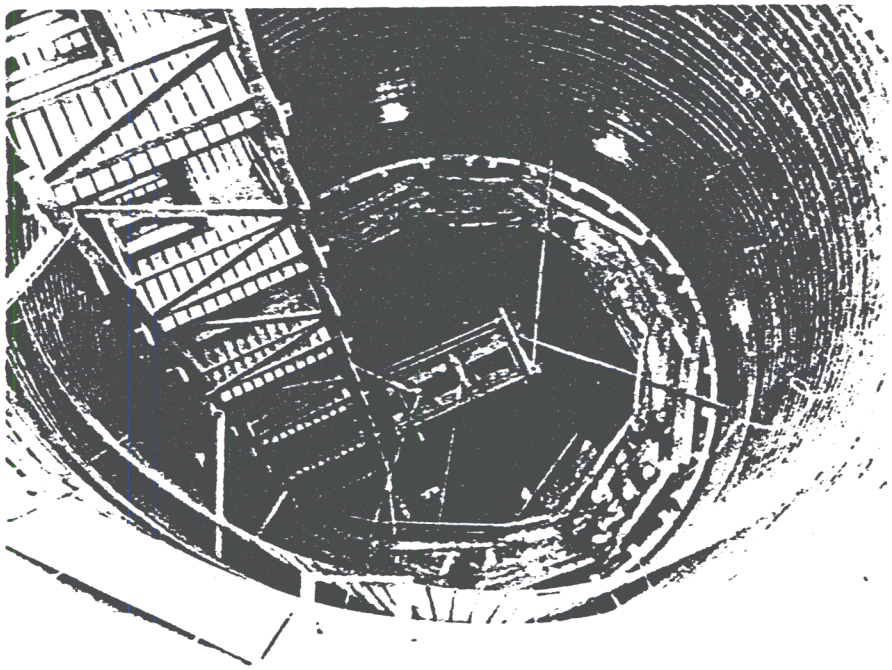
Typical aerial view showing progress to August 1960 showing much of tunnel in place and backfilled. Remaining prefab tunnel sections and junctions in foreground are awaiting placement.



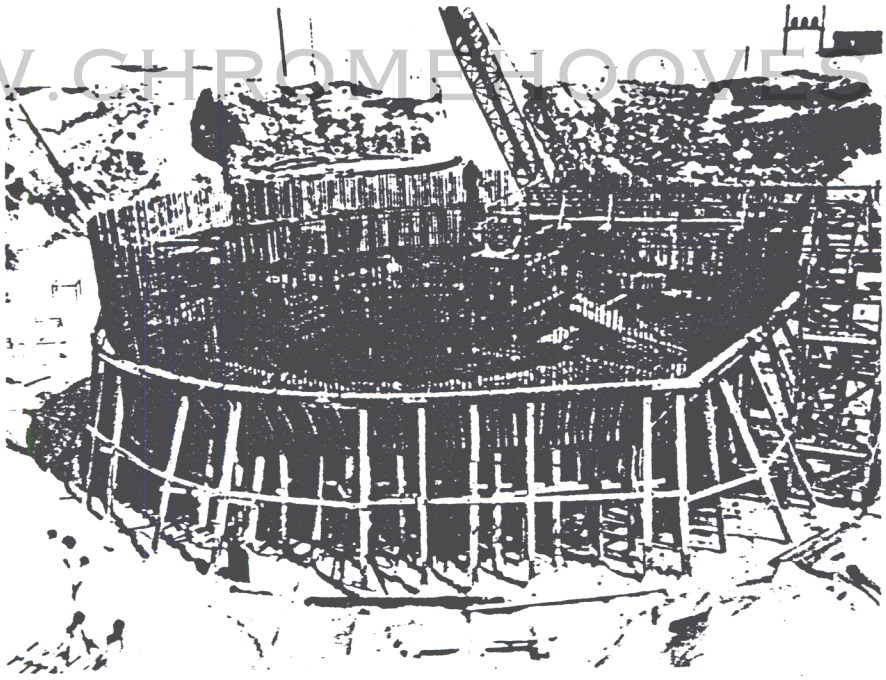
View of typical mining operations for excavation for various silos constructed at each complex. Note the use of ring beams to prevent excavation failure.



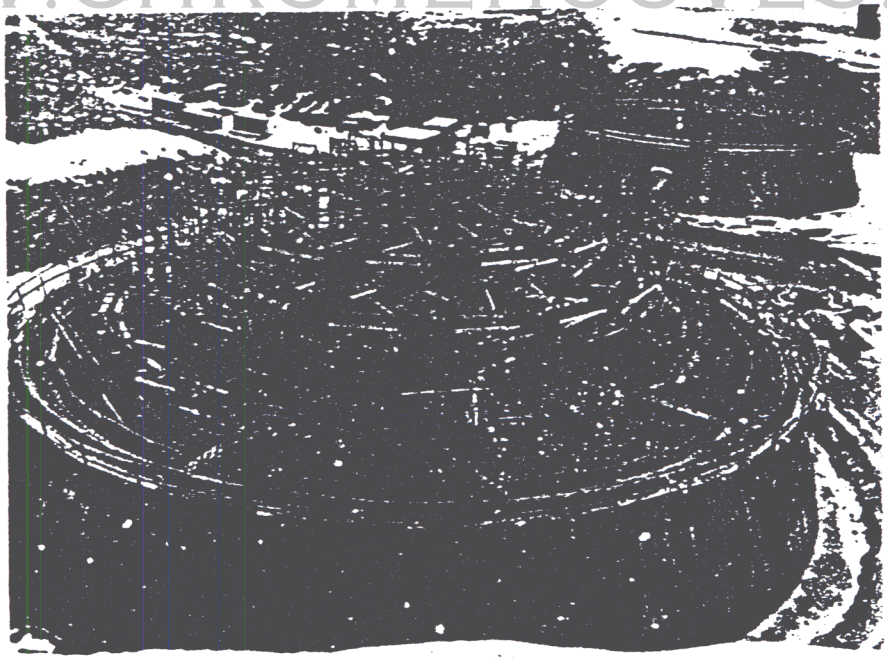
View typical of ring beam placement as mining operations continue downward. Note placement of mesh and gunnite to prevent sloughing of excavation.



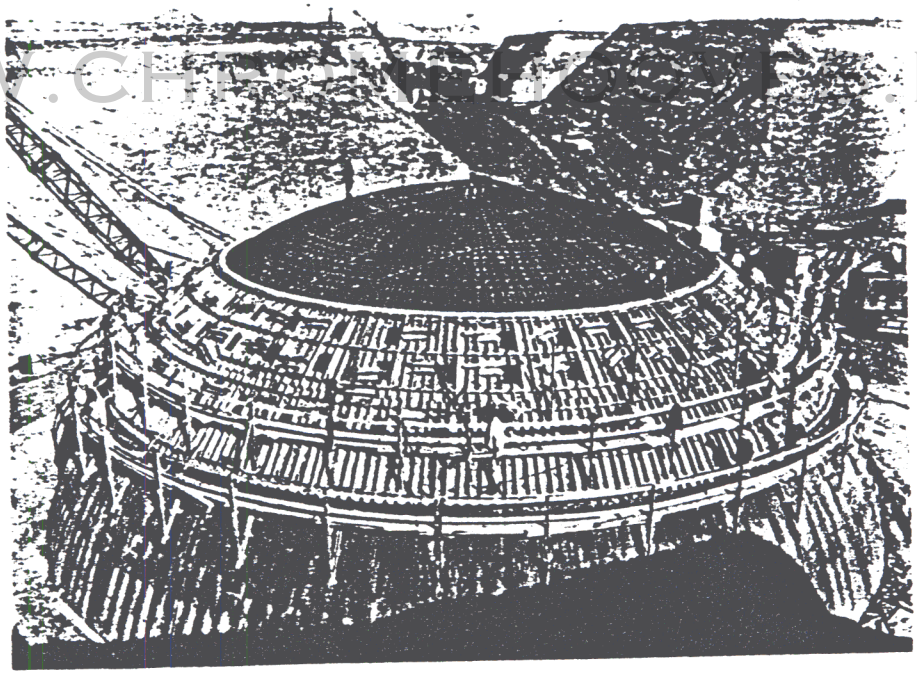
Placing of reinforcing steel and concrete forms in missile silo. Note personnel access stairway, scaffolding and steel placement. Working depth 155 feet below finish grade.



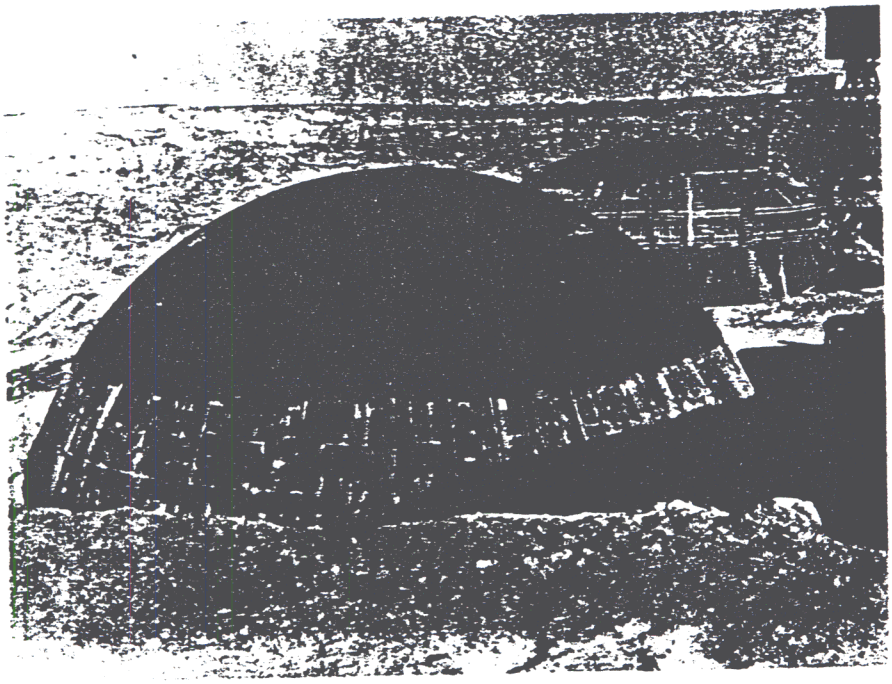
Closeup view of forming for pour #9 and placing of reinforcing steel for typical missile silos showing the silos at point of flaring out approximately 30 feet down from finish elevation.



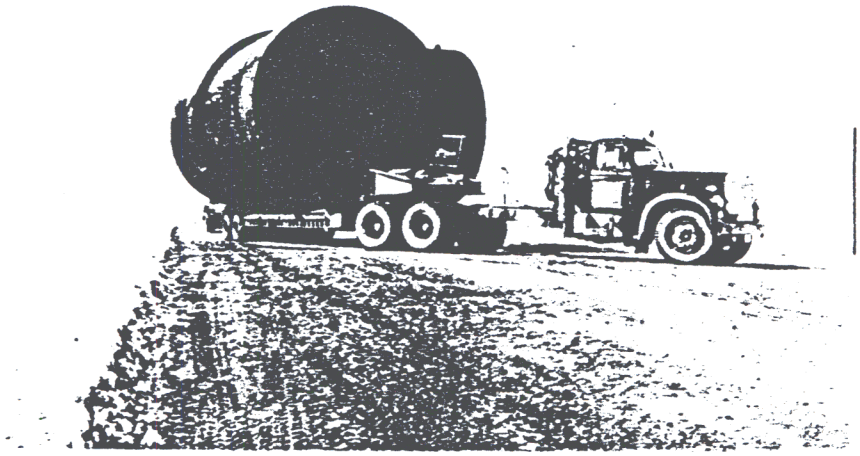
Scaffolding for powerhouse dome construction. Forms have been removed from lower lift and placement of forms for remainder of dome is incomplete in this view.



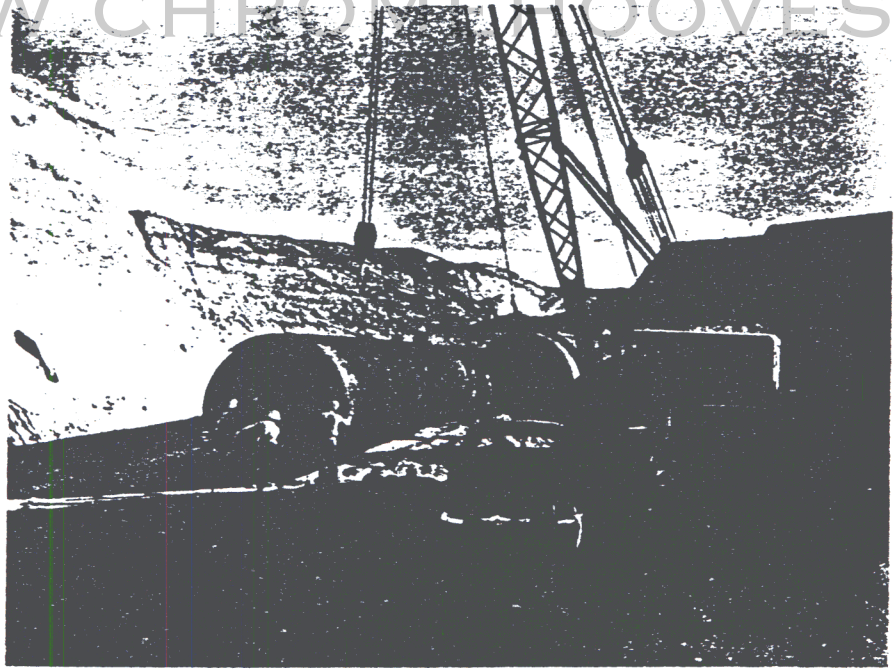
Typical view showing reinforcing steel and forming in place for upper dome area for powerhouse or control center.



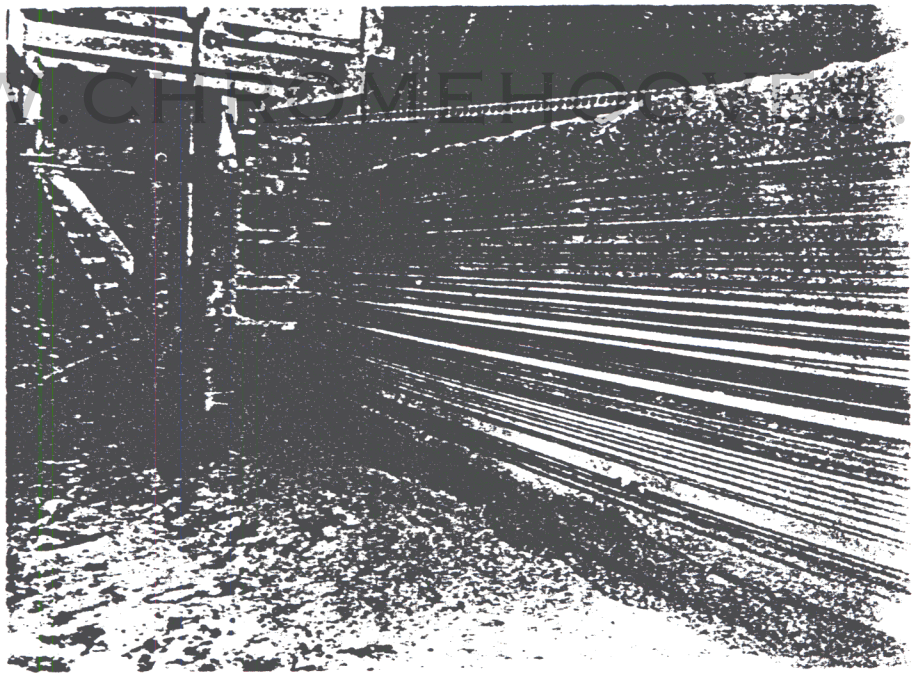
Waterproofing being placed on control center dome. Most materials and equipment for interiors to be brought in through tunnel which connects to opening on floor side.



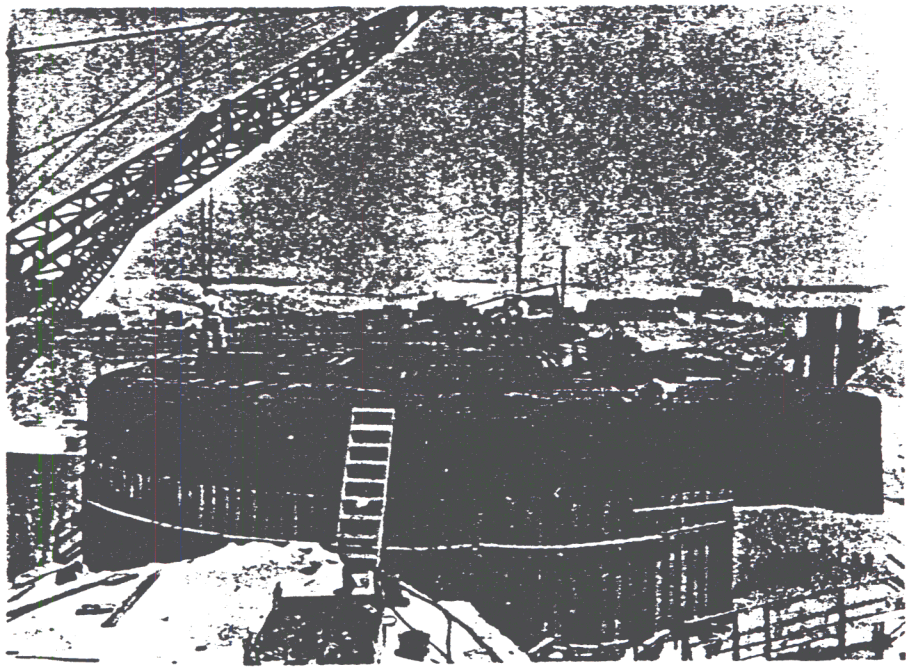
A typical prefabricated tunnel junction being transported to a complex construction site for placement and backfilling.



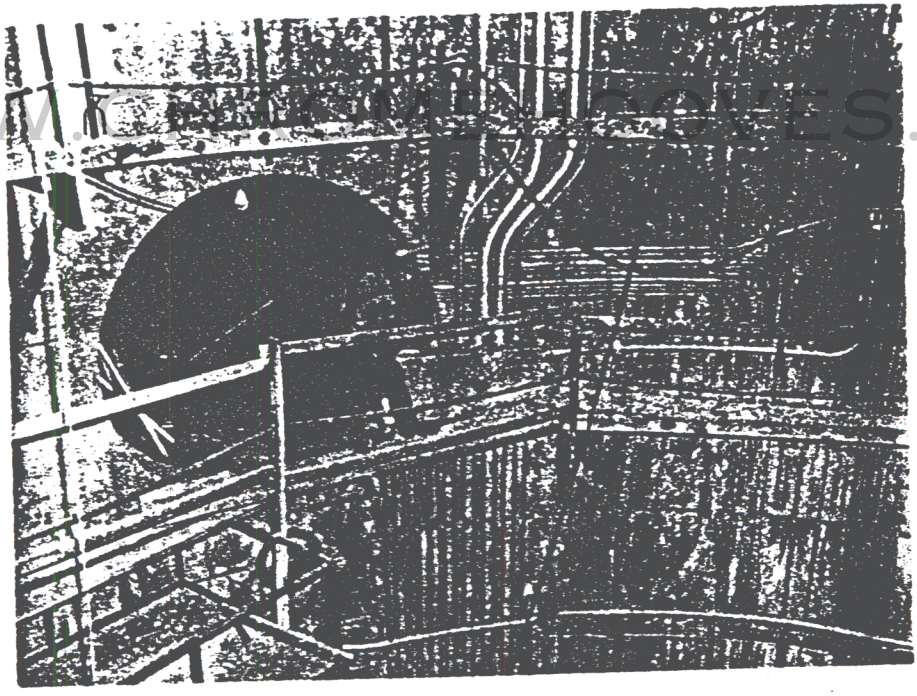
Placing and aligning of prefabricated personnel tunnel junction sections prior to backfill operations. Note open cut excavation option elected by contractor for construction of tunnels.



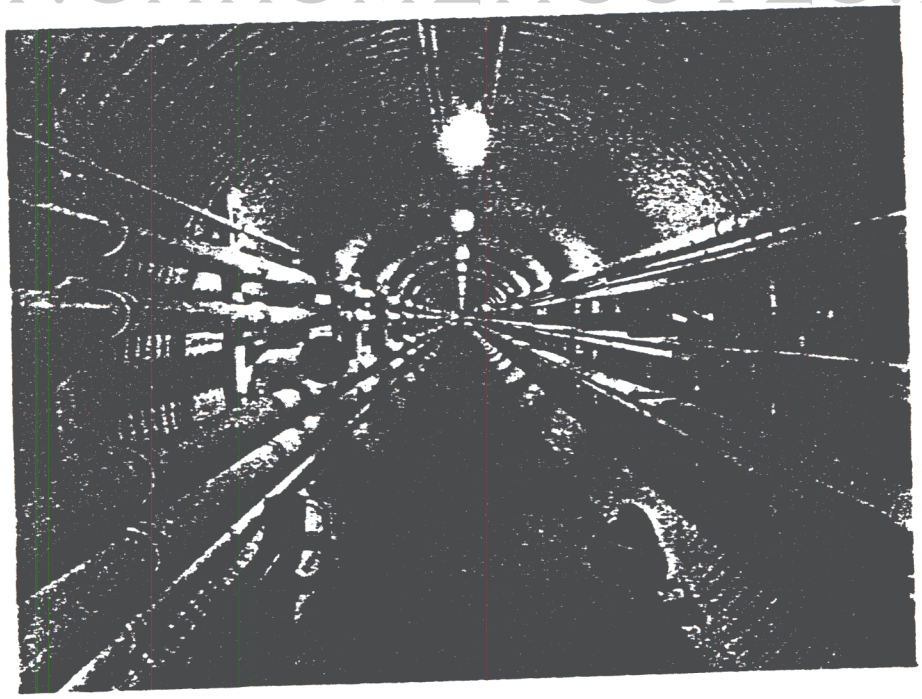
Typical view of prestressing machine wrapping #18 prestressed wire aroung base of powerhouse prior to backfill.



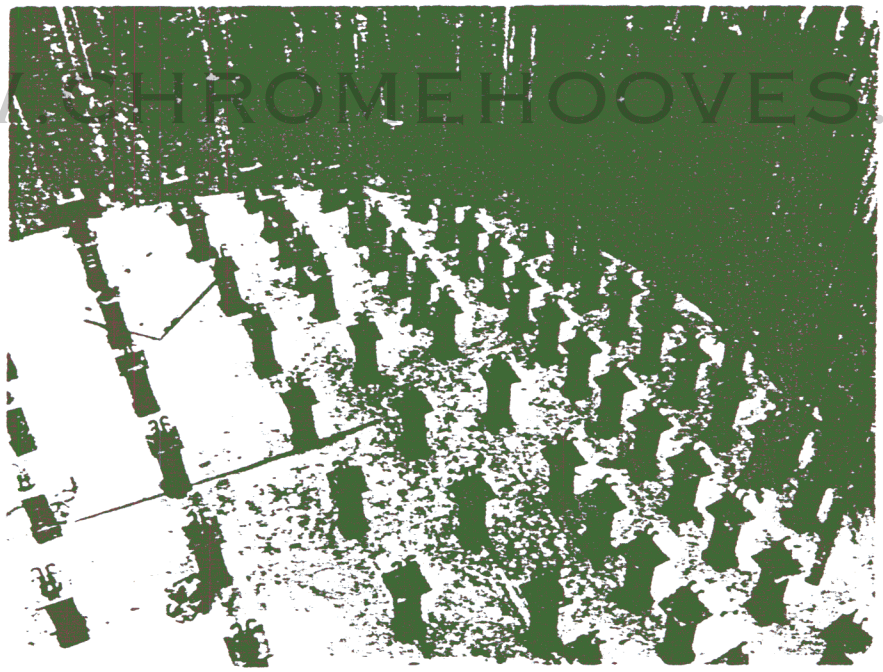
Typical view of reinforcing steel placed prior to #12 Missile Silo pour, or topping out of missile silo.



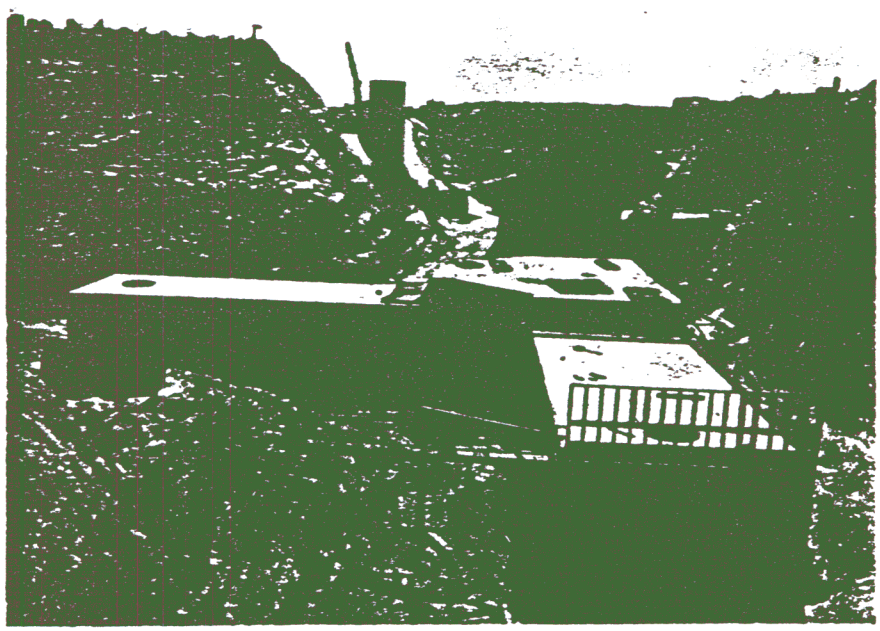
Electrical conduit installation in a missile silo. This installation is followed by PLS, fuel piping, air conditioning, and elevator.



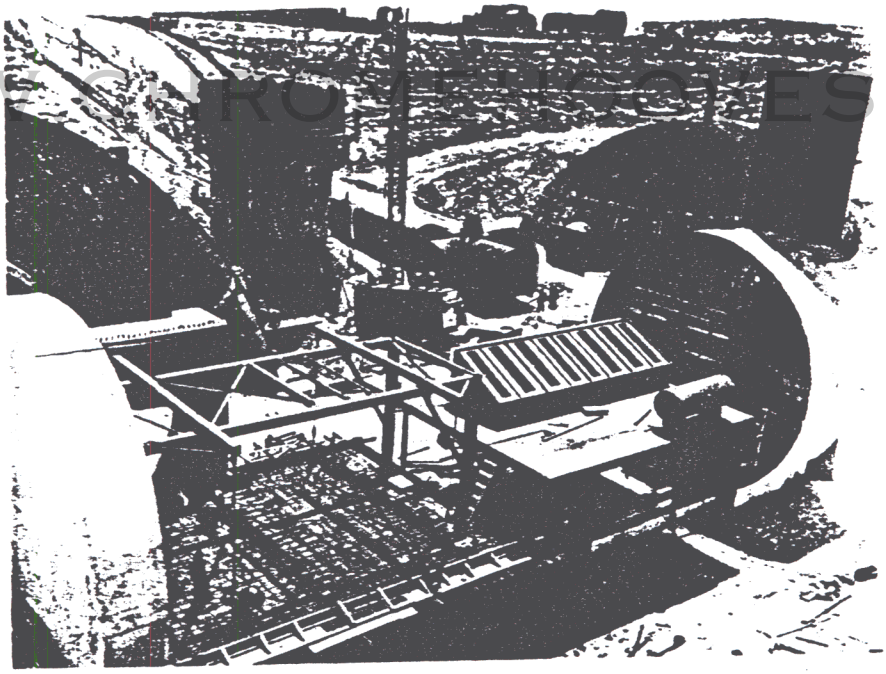
Typical view of piping and cable trays in tunnel run between antenna terminal and powerhouse - Control Center Area



Springs in place for shock mounting of floor beams in propellant terminal.

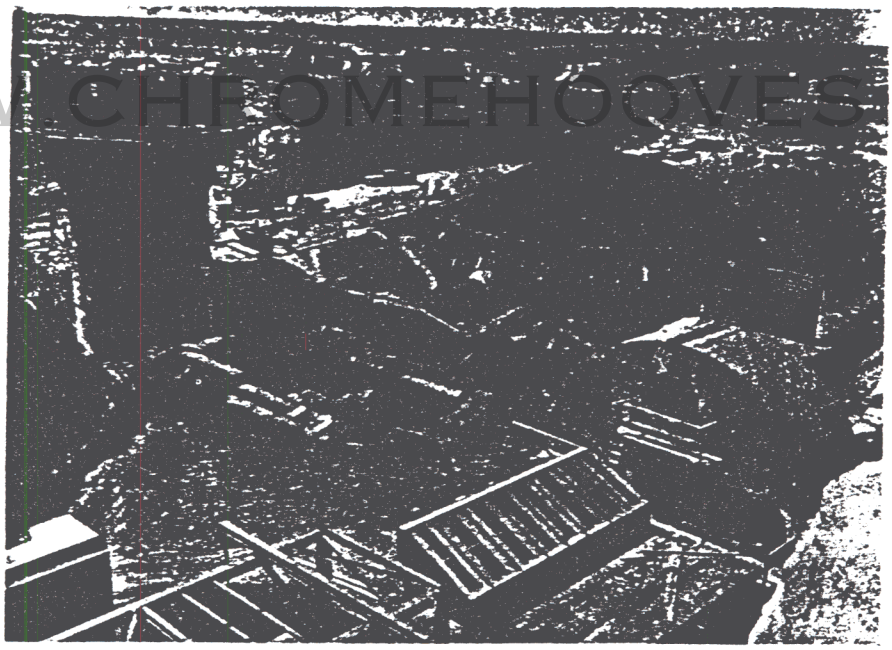


Blast Lock No. 1 placed. Note forming for Blast Lock No. 2 in background.

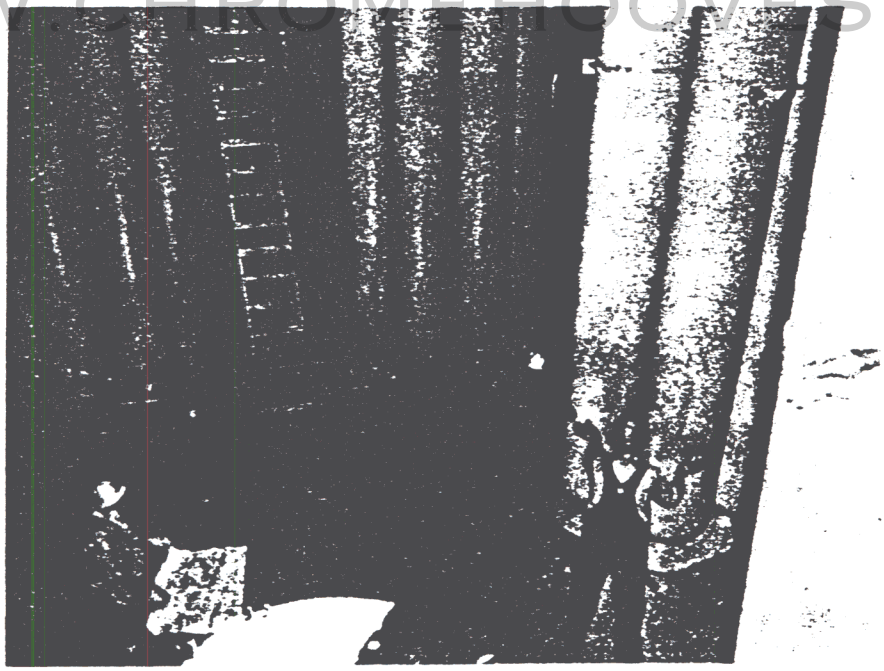


View showing typical air filtration structure under construction. Also note tunnel junction placed at powerhouse and control center and portal silo under construction.

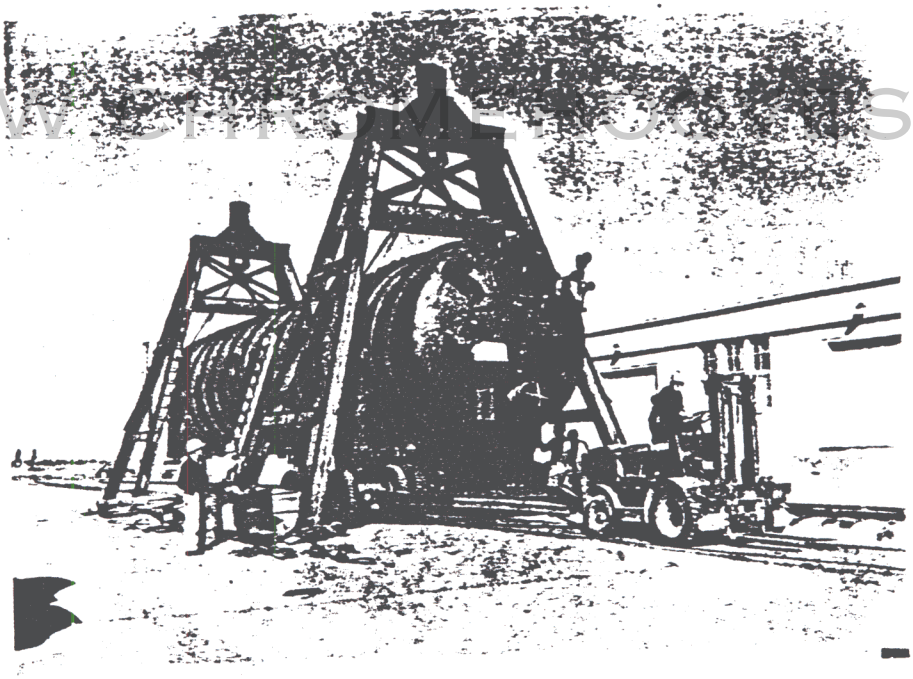
Antenna silo doors installed and tied open. Finish grade will be top of concrete for silo.



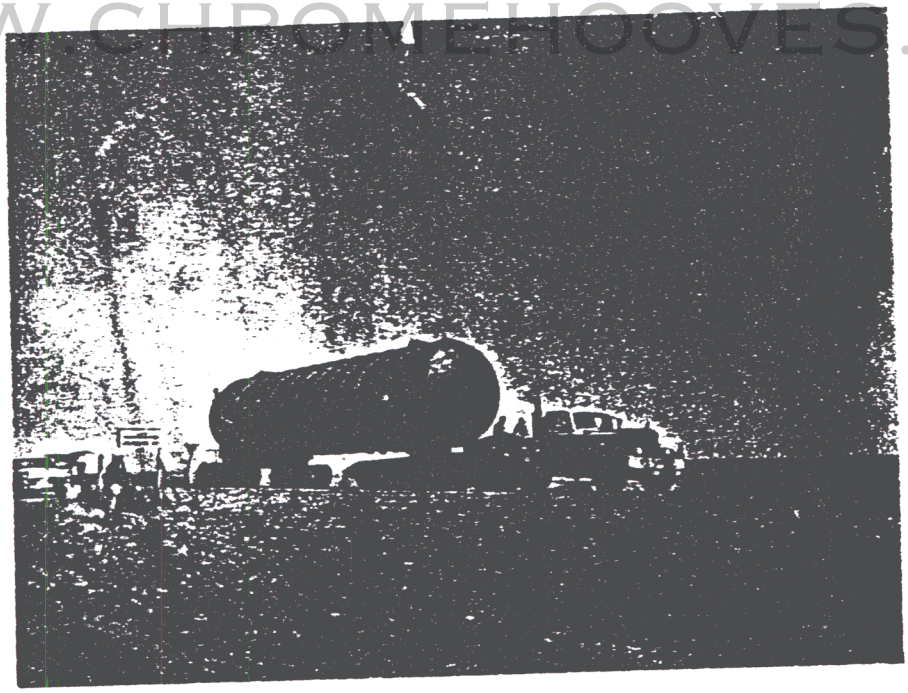
Portal Silo under construction prior to backfill. Note tunnels and fuel tanks in place.



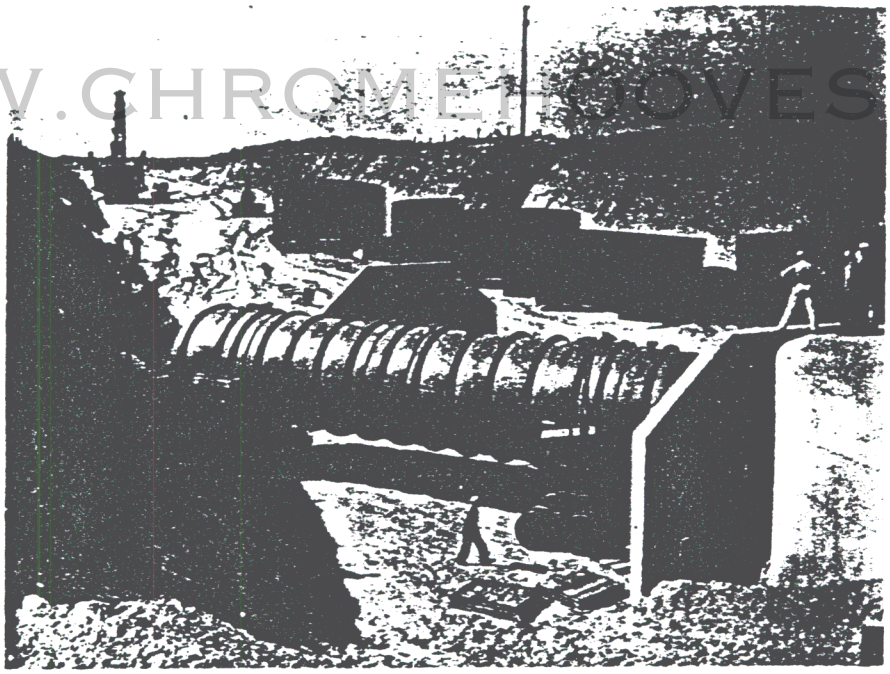
Installing high pressure nitrogen tanks in the propellant terminal.



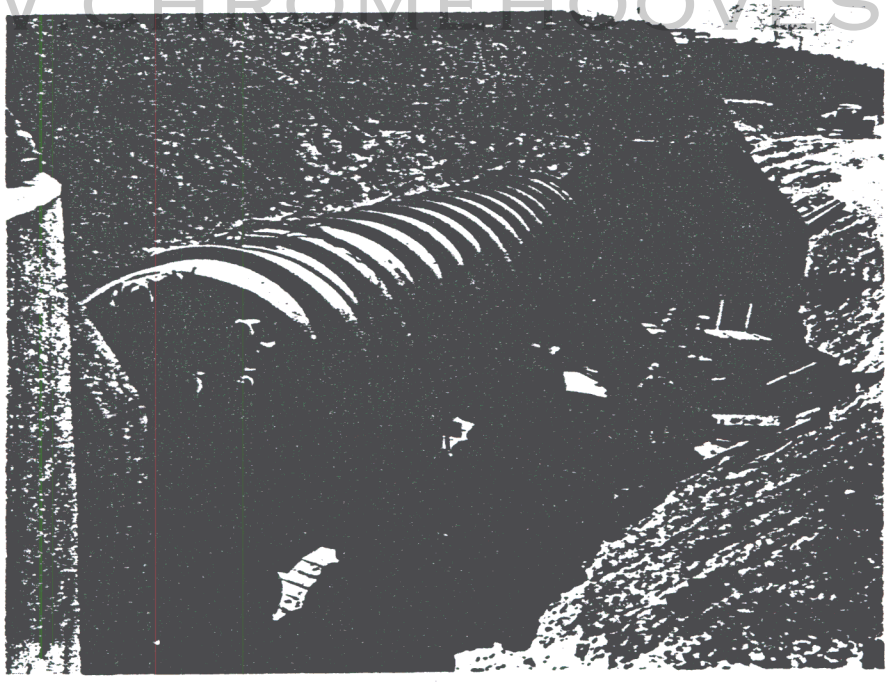
View of T-201 LOX tank unloading facilities at Buckley Field.



View of T-201 LOX tank being transported from Buckley Field to a launching site.

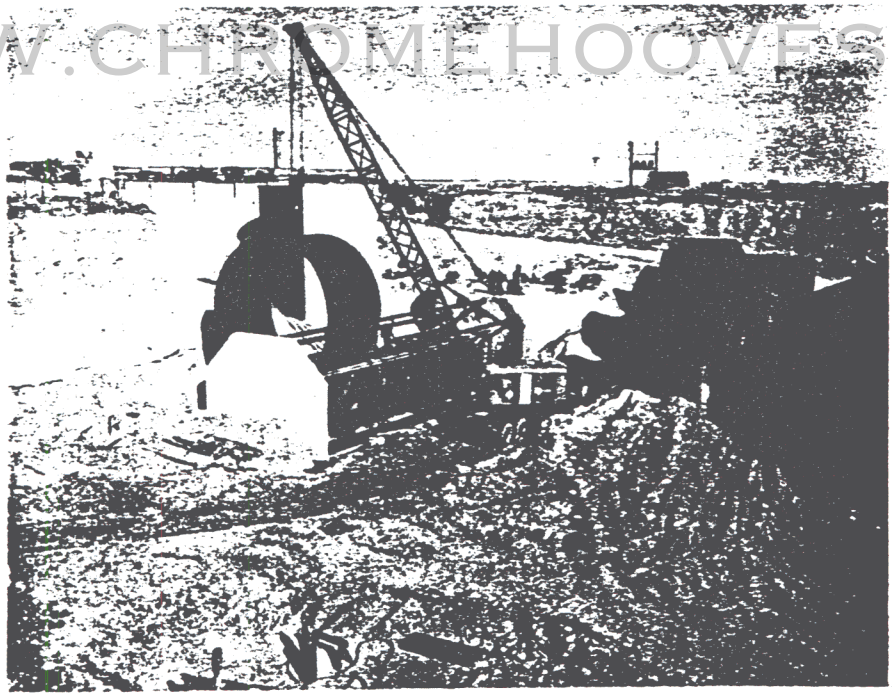


View of T-201 LOX tank being set into position at a launching site.



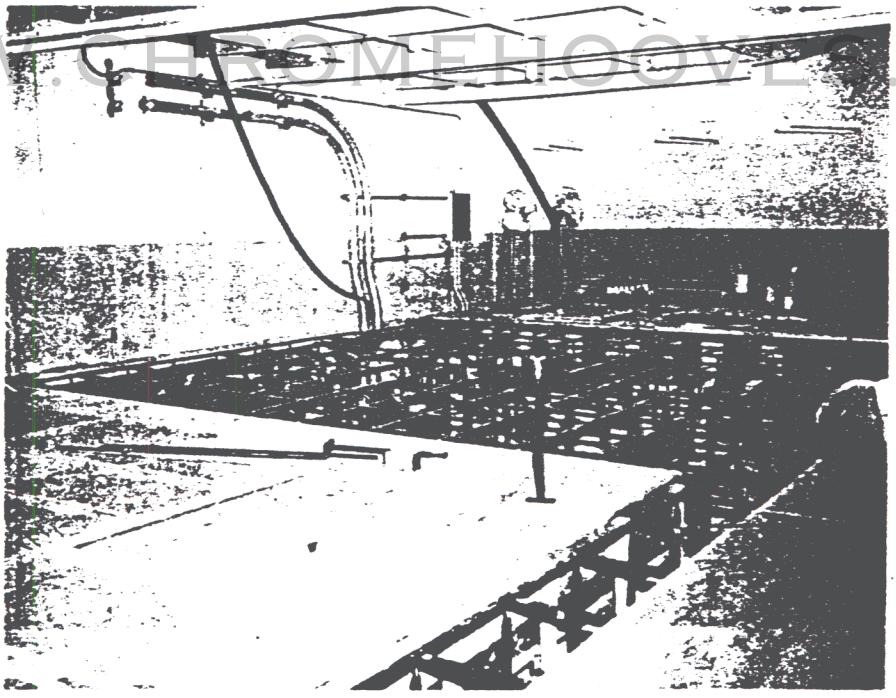
Another view showing T-201 LOX tank being set into position with the aid of a TD-24 crawler.

VIEW LOOKING EAST SHOWING NEARLY COMPLETED PORTAL SILO IN CENTER OF PICTURE WITH THE POWERHOUSE EXHAUST TUNNEL & DIESEL STORAGE TANKS SHOWN AT THE RIGHT



VIEW SHOWING PROTECTIVE TUNNEL SECTIONS BEING PLACED AROUND T-201 LOX TANK

TYPICAL VIEW OF ANTENNA SILO AREA WITH SILO DOORS OPEN



VIEW OF PAD FOR ATHENA COMPUTER LOCATED ON THE SECOND FLOOR IN THE CONTROL CENTER