TITLE I REPORT

BEAM SWITCHYARD

REPORT TO STANFORD LINEAR ACCELERATOR CENTER - ABA NO. 85

STANFORD UNIVERSITY SUBCONTRACT S-136

UNDER AEC CONTRACT AT(04-3)-400

Submitted by George Liik Approved by Roland L. Sharpe

AETRON-BLUME-ATKINSON
A Joint Venture
ARCHITECT-ENGINEER-MANAGER
Palo Alto, California

December 1963
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>BASIS FOR DESIGN</td>
<td>3</td>
</tr>
<tr>
<td>OUTLINE SPECIFICATIONS</td>
<td>13</td>
</tr>
<tr>
<td>BEAM SWITCHYARD SCHEDULE</td>
<td>23</td>
</tr>
<tr>
<td>COST ESTIMATE, PRELIMINARY</td>
<td>24</td>
</tr>
<tr>
<td>DRAWING LIST</td>
<td>28</td>
</tr>
</tbody>
</table>
INTRODUCTION

This report presents the Title I work performed in regard to the Beam Switchyard (BSY) and certain associated structures. It consists of information concerning original criteria used as a basis for this work, specific problems studied and resolved, a general description of the facility, outline specifications, schedule of work, a preliminary construction cost estimate, and preliminary drawings of site plan, structure plan and sections, and mechanical and electrical schematics.

The work described herein includes the following items:

1. Earthwork, including grading of Magnet Yard
2. BSY Housing, including Beam Dump
3. Access structures
4. Shielding
5. Drainage
6. Materials Handling System (MHS)
7. Data Assembly Building
8. Utilities, for "House" service only
9. Fire Protection

Several items in the above list are included for reference only, e.g., Data Assembly Building and Materials Handling System. These will be processed independently.

Specifically excluded from the ABA scope of BSY work are:

1. Communications
2. Radiation Monitoring
3. Controls and Instrumentation
4. AC Power to Power Supplies
5. AC and DC distribution to research equipment
6. LCW equipment and distribution
7. All research equipment, i.e. magnets, quadrupoles, collimators, etc.

The BSY terminates at the walls of the end stations area. The cost of the retaining walls between the end station buildings is budgeted in costs of the end stations, but for convenience of construction a major part of the walls will be included in the BSY Construction Contract.
BASIS FOR DESIGN

General

The preliminary design work described herein is based on previously established design criteria and on the results of various studies and investigations as follows:

6. Target Area scheduling studies, November 1963.
8. Criteria sketches, drawings and data from SLAC.

In addition, the appropriate chapters of the U. S. Atomic Energy Commission Manual, and the codes and standards listed therein, have been used as reference for the design work.

Features were incorporated into the design to accommodate the functional requirements, to obtain sufficient flexibility for possible future shielding requirements, and to maintain capability for limited future expansion.

BSY construction is closely related to the construction of the Accelerator Housing, End Station A and End Station B. The Accelerator Housing Contract currently includes 88 feet of the western end of the BSY and a major portion of the BSY's common excavation, which is used.
for Accelerator Housing shielding fill. Additional preliminary phases of the BSY construction are to be included in the Accelerator Housing Contract so that the work can be accomplished before the 1964-65 winter period.

At the east end of the BSY, the beam dump on the "A" beam will act to a degree as a control on the construction of End Station A. At End Station B, the BSY Contract will stop short of the target chamber. The closure portion of the "B" beam structure will be included in the End Station B Contract. Enough of the BSY structure to include room for installation of all beam components along this run is included. A major portion of the retaining wall between the two end station buildings will be included in the BSY Contract in order to permit early utilities installations in the backfills behind the walls.

Miscellaneous other work, under different contracts, which will affect BSY will consist of construction of the Data Assembly Building, installation of the Materials Handling System, and construction of Target Area Utilities.

Earthwork

Soils investigations for the BSY have been performed in three successive stages. During the site feasibility study, borings and site geological investigations were performed. Subsequently the Accelerator Housing soils investigations were extended through the BSY site and included soil borings to the approximate depth of the structure and surface trenching to determine suitability of the soils for use as a borrow area for Accelerator Housing construction and a preliminary investigation of foundation conditions for the BSY. During September and October, additional soil borings and soil sampling were conducted to provide data for foundation design and refined settlement predictions.
for the BSY.

Excavation sections for most of the BSY construction are similar to those used through sandstone areas for the Accelerator Housing construction. Temporary side slopes are 1/2 to 1 for the basic excavation. Interior trenches through the widened structure, and the lower half of the center-line beam tunnel beyond are considered as structural excavation and the Contractor will have the option of excavating to neat lines rather than forming the exterior surfaces.

All backfill up to the top of the structure is compacted to 95% of maximum density as determined by ASTM D 1557. The compaction requirements of the shielding fill above the structure are still under study. Zones adjacent to the retaining walls and the target area substation site receive 95% relative compaction. Compaction of shielding fill directly over the structure may be reduced in other areas so that vertical earth loads on top of the structure will not be increased. This zoning of the compaction tends to increase the lateral earth pressure against the sides of the structure however, and further study is required to determine the most satisfactory solution.

Side slopes of the shielding fill are 1 1/2 to 1 with benches at approximately 30-foot vertical intervals. Embankment slopes are topsoiled and seeded to aid in erosion control.

**Beam Switchyard Housing**

The BSY Housing is a sub-surface reinforced concrete structure designed to house beam runs, pulsed and bending magnets, quadrupoles, mechanical and magnetic slits, collimators, instrumentation and beam dumps. The BSY serves as the link between the Accelerator and physics research in the End Station area. Its function is to direct and transport the beam into the various research areas, to analyze and define it
for research purposes, and to absorb its energy as required by project operations. Beam Transport Geometry as shown on SK-505-103 was established by SLAC criteria.

The BSY is essentially a two story structure composed of an "upper chamber" and a "lower chamber." The structure extends from Station 100+00 (end of Accelerator Housing) to Station 109+35 plus additional lengths on certain beam lines.

**Cross-Sectional Shape**

To minimize space requirements, a concept has been developed in which the beam and its equipment will be located in a "lower chamber" with an "upper chamber" above for access of personnel, materials, and equipment. The two chambers will be separated by removable flooring which will vary from light structural elements suitable for walkways to shielding materials two feet thick, of concrete or steel, depending on radiation produced below. This concept has been compared to a conventional horizontally-oriented beam run and adjacent aisleways configuration. The vertically oriented structure has been selected because it permits a simplification of the access and service shafts and the material handling problem. Its costs are lower than those of the horizontal concept when comparable quantities of shielding materials near slits, collimator and dumps are included together with handling equipment space requirements near these shields.

**Support of Shielding Fill**

The required shielding thickness for the BSY has been determined by SLAC as thirty-two feet of concrete and earth from the top of the interior of the "upper chamber" to finish grade.

Vertical loading of the shielding fill is assumed at 1.4 times the
nominal weight of soil above the structure for the narrow sections and 1.0 for the side and transition sections. Horizontal pressure on the sides of the housing is assumed at one-half the vertical pressure. These coefficients are tentative and are subject to further study by our soils and seismic consultants. These studies are in progress. An accurate estimate of vertical load distribution for the transition sections is required so that differential foundation settlements can be controlled within acceptable limits.

**Type of Construction Material**

The Criteria Report concluded that reinforced concrete is the most desirable and economical material for construction.

The design of the structure will be based on conventional reinforced concrete design theory.

Because of required alignment tolerances for equipment in the BSY, concrete similar to that specified for the Accelerator Housing, i.e., concrete with low shrinkage and low coefficient of thermal expansion will be used.

Concrete columns founded on belled footings will be used in the open areas of the BSY.

**Earthquake Resistance**

The dynamic response of the structure to seismic forces has been studied on a preliminary basis. Final studies will be made after approval of the structure design and configuration as presented in this report.

**Dampproofing**

The system as proposed for the BSY will be similar to that used
for the Accelerator Housing, i.e. a polyvinyl chloride sheet set in mastic and protected by fiber sheets, except that the membrane will cover only the top and sides of the structure.

**Interior**

Treatment of concrete surfaces to reduce dusting will be required to minimize concentration of "hot" particles in the air. Radiation safety requires that inhalation of "hot" particles be prevented. Special finish requirements are now under study.

The drawings accompanying this report show plans and typical cross-sections of the BSY structure. The main elements of the structure, referred to Central Beam stations, are as follows:

1. **Section from Station 100+88 to 103+89** - containing a collimator, pulse magnets, steering magnet, initial bending magnets, and associated equipment in "lower chamber" and craneway in "upper chamber."

2. **Widened Section from Station 103+89 to Station 105+29** - where beam runs diverge into Beam A, Central Beam, and Beam B containing bending magnets, quadrupoles and associated equipment in "lower chamber," and the main entrance.

3. **Open Area from Station 105+29 to Station 107+75** - where beam runs further diverge into Beam A, Gamma Beam, Central Beam and Beam B. The "lower chambers" are trenchlike areas containing the beam runs. Each run will contain bending magnets, slits, quadrupoles, etc., as required. The "upper chamber" is a large open area varying in width from 27 feet to 132 feet with craneways over each beam run (excepting the Gamma Beam).
The roof is supported by concrete columns founded on belled footings.

4. *Four Separate Sections from Station 107+75 to End Stations and Experimental Areas* - the lengths of these runs were established to provide adequate lateral distance between the research areas beyond the beam switching area.

Beam A section extends to End Station A at Station 110+36 and contains additional bending magnets and structure for a future diverging A' beam, as well as a downward deflected beam dump.

Gamma Beam section extends through a combinations of pipe and trench sections to the yard area at Station 109+35.

Central Beam section extends to the yard area at Station 109+35.

Beam B section extends to the "target room" portion of End Station B at Station 109+05+.

The "lower chambers" contain the beam runs and the "upper chambers" contain craneways with the exception of the Gamma Beam run.

Succeeding sections in this report cover ancillary structures, appurtenances and utility requirements of the BSY.

**Access Structures**

Horizontal access structures include the main entrance structure, the cableway from the Data Assembly Building, the man accessway from the Data Assembly Building, duct banks from the Instrumentation and Control (I & C) cableway, and conduits from the collimator and slit sumps.

Vehicular access to the overhead crane system is provided by the
main entrance structure. Rails are provided in the floor to accommodate a future rail car system. As there are no large radiation sources in this area straight access is permissible. A movable concrete shielding door will be provided and the earth shielding thickness above the structure entrance can be increased if required.

The cableway and man accessway connect the Data Assembly Building and the BSY. Both tunnels follow maze patterns designed to minimize interruption of shielding between the BSY and the Data Assembly Building.

The duct banks between the I & C cableway and the BSY conform to SLAC criteria. The duct bank type of construction results in minimum interruption of shielding. Collimator slit and beam dump sump conduits are located in straight runs to permit replacement of piping if necessary.

Vertical penetrations consist of vacuum pipe shafts, synchrotron light shafts, and a materials access shaft. Capped sleeves for possible future penetrations will be provided. The vacuum pipe and sleeves for the future penetrations are similar to the accelerator service shafts. The synchrotron light pipe shafts are smaller diameter pipes and have a different detail through the structure roof.

A materials access shaft is included along the east wall of the open structure to provide a second entry for lighter loads during the construction and equipment installation period. A manway is not provided since the tunnel through the Data Assembly Building provides a second access for personnel.

**Shielding**

The earth fill and structural concrete will form the primary
shielding. The structure will permit stacking of interior shielding to double the normal two-foot thickness, thus enabling the opening of areas for maintenance and repair with a minimum hauling of shielding blocks.

In addition, above the slits, collimators, and radiators upstream from the A and Central Beam dumps, two to three feet of steel will be placed on top of the concrete structure.

Special steel and concrete shielding structures, integral with the BSY, will be provided for the beam dumps on the A line and at the eastern end of the Central Beam.

Drainage

Storm drainage for the BSY will be provided by downdrains on the embankment slopes and extensions of the culvert near Station 103. The storm drainage system is similar to that used for the Accelerator Housing and Klystron Gallery.

Subdrains of perforated pipe are used along the exterior walls of the BSY structure. Interior tunnels, the beam dump on "A" beam and the collimator sumps will not have foundation drains beneath them. The latter two will be designed under the assumption that the ground water table will be at the level of the subdrainage system serving the basic BSY structure.

Foundation subdrains will slope to the 42-inch storm drain running transversely under the BSY.

The roof and sides have a PVC membrane for moisture proofing similar to the Accelerator Housing. Ground water flows are anticipated to be less severe than along the accelerator; hence, a membrane is not provided for the floor of the structure.
Materials Handling System (MHS)

The MHS will be the major assembly, repair, and maintenance tool for the equipment contained within the limits of the BSY. A short description of the MHS is included herein for information only. Contractually, it will be a separate package.

The general functional requirements of the MHS are:

1. Capability of transporting, installing and removing all equipment in the BSY.

2. Capability of moving a 16-ton maximum load in three dimensions at all hoist speeds. Provision to lift and move 32 tons by the use of 2 cranes in tandem.

3. Capable of lift of 18 ft. 6 in. Coverage shall extend over the full length of beam paths served, to a minimum width of 5 ft. 6 in. In the area of diverging beams full coverage is required.

4. Speeds: Variable, 5 step control on bridge, trolley and hoist drives.
   Bridge: Range 20 - 150 ft/min.
   Trolley: Range 10 - 50 ft/min.
   Hoist: Range 3 - 15 ft/min.
   Maximum "inchling" for bridge, trolley, and hoist shall be 1\(\frac{1}{2}\) ft/min.

5. Provision of transfer of cranes to various beam paths.

6. Provision of optional operation by power from the 480 V wall receptacles.

7. Capability to carry illumination systems (possibly also TV cameras).

8. Provision of operational simplicity.


10. Require minimum maintenance.

11. Maintain a very high degree of reliability of operations.
Many different MHS's were investigated for possible use in the BSY. The System functional requirements were used as a base against which such factors as physical characteristics, reliability, availability, effect on BSY structure, overall costs, etc. were evaluated.

The MHS selected for use in the BSY is an underhung bridge crane operating on overhead rails. Minimum of three cranes will be required. The crane system will be so designed that any load may be placed on a load transfer car in the access area from any point served by the cranes without intermediate transfer form one crane to another.

Tentative MHS procurement procedure has been established and accepted by SLAC. The procedure is as follows:

1. ABA will prepare MHS performance specifications based on SLAC approved Design Criteria. SLAC review and approval.
2. ABA will prepare "Invitation to Proposals" to include performance specifications and requirements for cost and supplementary data. SLAC review and approvals.
3. ABA will issue "Invitation to Proposals" to selected manufacturers.
4. Proposals received to include complete information and costs for design, fabrication, installation and check-out of system.
5. Proposals evaluated by ABA-SLAC, manufacturers installations (and comparable systems installations) inspected. Supplier selected.
7. System Design by manufacturer.
8. Design evaluated and approved by ABA-SLAC.
9. System fabrication by manufacturer. ABA inspections and approvals.
10. System installation by manufacturer, ABA inspections and approvals.
11. System check-out by manufacturer, ABA, SLAC.
12. System acceptance, SLAC-ABA.

Data Assembly Building

Although the Data Assembly Building will be eventually an integral part of the BSY, the design and construction will be handled independently. A short description is included for reference only.

The building will be conventional, industrial-type one story structure of approximately 5,000 square feet. Three exterior walls will be of pressed metal siding and standard architectural sash between exposed structural steel columns. The fourth wall (north wall) will be of concrete. Pressed metal sight screens will be used to conceal equipment on roof. Roof overhangs will be provided to afford protection from sun and rain. Roof will consist of built-up roofing and insulation over metal deck. This building will contain the BSY Control Room, an office, laboratory, space for magnet power supplies, a cable vault, and washrooms. Floors will be concrete slab, except that the Control Room floor will be of steel plate; the slab in this area will be depressed to allow approximately 8 in., between slab and floor for cableways.

Electrical

Power for lighting, convenience receptacles, power outlets, cranes and exhaust fans will be supplied from unit substations located in a switchhouse near the Data Assembly Building. The Single-Line Diagram is shown on Drawing SK-505-601/701. The lighting installation for the BSY will be similar in design to system used in the Accelerator Housing.
Lighting and receptacles are provided for the "upper chamber" only. No conventional "house" wiring is provided in the "lower chamber." All conduit will be exposed, surface mounted.

The lighting fixtures and receptacles will be located along the walls. Lighting fixtures will be porcelain sockets with bare 100-watt incandescent lamps mounted on about 10-foot centers, and about 8 feet above the floor. A maximum of 8 lighting fixtures will be connected to a 20 amp circuit to permit the use of larger wattage bulbs in specific working areas. Emergency lights will be provided at about 100-foot intervals. The emergency power source will be located outside of the housing.

Wall-mounted convenience receptacle assemblies will be installed at about 40-foot centers. Each receptacle assembly will consist of a two-gang, duplex, 120 volt single-phase receptacle. Each duplex receptacle of the assembly will be supplied by a separate circuit. A maximum of six duplex receptacles will be connected to a 20-amp circuit. Power receptacles, rated 100 amps, 480 volts, 3-phase, 4-wire, will be provided at about 100-foot intervals along the walls, preferably in the vertical chases for cable runs.

Lighting transformers and panelboards will be located in the Data Assembly Building and along the I & C cableway. Lighting circuits will be separated from receptacle circuits. Lighting circuits will be arranged for remote control from the Data Assembly Building.

Wiring materials will be polyethylene insulated conductors, rigid conduit, and cast conduit-fittings. Transformers, panelboards, contactors and the like will be the weatherproof type for outdoor locations, general-purpose type for indoor locations.
Ventilation

The ventilation system proposed is the exhaust type, similar to the system used on the Accelerator Housing. The Flow Diagram and general plan for the ventilation system is shown on Drawing SK-505-601/701. The system will not be operated during beam-on time.

The fans will be two speed, sized and located to provide uniform purging of the entire housing. At the high-speed condition the fans will provide an air purge of six air changes per hour. The low-speed operation will provide a reduced air change rate for personnel for periods of installation and maintenance.

Air will enter the Housing through a filter bank at the main entrance. The calculated air flows and velocities are shown on Drawing SK-505-601/701. An air-tight barrier will be provided between the Accelerator Housing and the BSY to prevent infiltration of air from one area to the other. Similar barriers will ultimately be installed between the BSY and end stations. Air will be supplied to both levels of the BSY. Most of the exhaust air will be drawn from the "lower chamber" to keep that at a slight negative pressure relative to the "upper chamber."

The exhaust ducts will be located at the ends of the BSY and will be labyrinth type. They will not be installed in regions of high radiation output. An air-tight closure will be provided on top of the exhaust ducts. The closure will be interlocked with the fan. The exhaust fans will discharge vertically at a velocity of about 2,000 feet per minute when operated at the high speed. Provision will be made to monitor and filter the exhaust air.

No air heating or humidity control will be provided in the BSY.
Communications

No telephone or communications systems or facilities are included in this work, although they will ultimately be installed by others after conclusion of the construction contract.

Fire Protection

The fire protection facilities will be similar to that of the Accelerator Housing. Manual fire boxes will be provided along the walls and spaced at about 350-feet intervals. No fire detection or automatic fire protection systems are included in the housing. Any portable fire-fighting equipment will be provided by SLAC.

I & C Cableway

A cableway for installing instrumentation and control interconnects the Klystron Gallery, BSY, Data Assembly Building and the End Stations areas. The routing includes a corrugated metal tunnel from the Klystron Gallery which crosses under the roadway east of the Klystron Gallery; a roadway and stanchion supports along a bench to the Data Assembly Building; a 12 foot retaining wall, supporting cable trays, for 80 feet east of the Data Assembly Building; thence, corrugated metal tunnels to the Gamma Beam target area and to End Station A, and a narrow roadway and stanchions to the retaining wall south of End Station B.

Connections to the BSY interior consist of duct banks and a concrete tunnel between the Data Assembly Building and the BSY.
OUTLINE SPECIFICATIONS

The following outline specifications describe the materials to be used and the quality of construction.

A. CIVIL

1. Earthwork
   a. Stripping: The top 8" of all construction areas previously unexcavated will be stripped and the earth stockpiled for later use for erosion control planting or for use in areas where inferior material is suitable for embankment.
   b. Compaction: The compaction will be measured according to ASTM Method D-1557 (formerly the modified AASHO method) and the requirements will be as follows:
      (1) Embankment up to top of structure - 95%.
      (2) Shielding fill except for special areas directly above structure - 95%.
      (3) Special areas above structure may be placed in loose condition to equalize settlements.

2. Culverts
   a. Materials: Culverts will be corrugated metal pipe. All culverts in connection with the roads and yard areas will have tapered metal end sections.
   b. Construction Methods: Construction methods will generally conform to the California Division of Highway Standard Specifications.

3. Erosion Control
   a. General: All exposed slopes will be prepared for
planting by covering with 6" of topsoil impregnated with straw mulch.

b. Materials: Topsoil will be fertile and friable and obtained from the stripping operation. Straw material for mulching will be rice, wheat, oats, or barley as approved by the Manager. Seed for erosion control will be the same mixture used for the Accelerator Housing.

c. Construction Method: The existing slopes will be scarified and topsoil will be spread to a depth on 6" over the area. The straw will be spread over the topsoil at a rate of not less than four tons per acre. The area will then be rolled with a roller equipped with straight studs followed by seeding.

4. Aggregate Base Course

a. Material: Aggregate Base Course will consist of broken stone or crushed gravel of 2" maximum size, meeting the grading requirements of the Division of Highways Standard Specifications.

b. Construction Methods: The construction methods will conform to the Standard Specifications of the California Division of Highways.

5. Double Seal Coat

a. General: A double seal coat surfacing will be placed on first stage roads and on parking areas.

b. Materials: Prime coat will be SC-1. MC-3 bituminous binder or an emulsion will be used. Screening will be broken stone or crushed gravel and be hard, tough, dura-
ble and sound and at least 90% will have fractured faces.

c. Construction Methods: Construction methods will conform to the California Division of Highways Standard Specifications.

6. Asphaltic Concrete

a. General: Asphaltic concrete will be used on the magnet yard area.

b. Materials: Hot plant mix will be 1/2 inch maximum size, medium grading.

c. Construction Methods: Construction methods will conform to the California Division of Highways Standard Specifications.

7. Subdrain System

a. General: Ground water will be intercepted by a subdrainage system consisting of drainage fill and drain tile connected to concrete sumps or to a gravity discharge line.

b. Materials: Drainage filter will be pervious material such as crushed stone or gravel. Drain tile will be perforated asbestos-cement pipe.

c. Construction Methods: Pipe will have firm bedding in the drain fill and will be laid true to line and grade.

B. STRUCTURAL

1. Concrete

a. Concrete will conform to the requirements of the Uniform Building Code and the ACI Building Code for concrete.
b. Cement will be an approved brand of Portland cement conforming to ASTM Designation C-150, Type II, as modified for the Accelerator Housing Contract.

c. Minimum allowable ultimate compressive strength of 4,000 psi at 28 days will be used.

d. Reinforcement bars will be deformed intermediate grade, new billet steel conforming to ASTM Designation A-15 or A-305.

e. Aggregates will be from sources which will produce concrete with minimum shrinkage.

2. Steel

a. Steel for door frames, etc., will conform to ASTM Designation A-7 or A-36.

b. Tool car rail steel will conform to AREA Standards.

C. MECHANICAL

1. Fans

Fans will be two-speed belt driven, tube-axial propeller type. Fan capacities are shown on Drawing SK-505-601/701. Exhaust velocity will be about 2,000 feet per minute.

2. Controls

Fan controls will be designed for local control and for remote control from the Data Assembly Building. Fan controls will permit later interlocking with covers and doors.

D. ELECTRICAL

1. Lighting and Receptacles

Includes lighting and receptacles in "upper chamber"
only. No conventional "house" wiring provided in "lower chamber." Bare incandescent lamps, 110 volts, 100 watt, located on about 10-foot centers. Emergency lights located at 100-foot intervals. Convenience receptacles, 120 volt, single-phase, two-gang, duplex located at about 40-foot spacing. Power receptacles 480 volt, 3-phase, 100 amp located every 100 feet.

2. Materials

Rigid conduit, polyethylene insulated conductors, cast conduit fittings. Weatherproof equipment for outdoor installations, general purpose equipment for indoor locations.

E. FIRE PROTECTION

The alarm boxes are manual pull-lever type. No fire detection or automatic fire protection systems are included.
### BEAM SWITCHYARD SCHEDULE

<table>
<thead>
<tr>
<th>Document</th>
<th>Date</th>
<th>CPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABA/TITLE I DRAFT</td>
<td>22 November 1963</td>
<td>605</td>
</tr>
<tr>
<td>SLAC-AEC/REVIEW AND COMMENTS</td>
<td>9 December 1963</td>
<td>616</td>
</tr>
<tr>
<td>ABA/TITLE I REPORT</td>
<td>16 December 1963</td>
<td>621</td>
</tr>
<tr>
<td>SLAC-AEC/TITLE I APPROVAL</td>
<td>2 January 1964</td>
<td>632</td>
</tr>
<tr>
<td>ABA/TITLE II 50% SUBMITTAL</td>
<td>20 March 1964</td>
<td>687</td>
</tr>
<tr>
<td>SLAC-AEC/REVIEW AND COMMENTS</td>
<td>8 April 1964</td>
<td>700</td>
</tr>
<tr>
<td>ABA/TITLE II 90% SUBMITTAL</td>
<td>28 May 1964</td>
<td>736</td>
</tr>
<tr>
<td>SLAC-AEC/REVIEW AND COMMENTS</td>
<td>17 June 1964</td>
<td>749</td>
</tr>
<tr>
<td>ABA/REVISIONS</td>
<td>29 June 1964</td>
<td>757</td>
</tr>
<tr>
<td>ABA/100% REVIEW</td>
<td>1 July 1964</td>
<td>759</td>
</tr>
<tr>
<td>ABA/REPRODUCTION</td>
<td>9 July 1964</td>
<td>764</td>
</tr>
<tr>
<td>ABA/100% SUBMITTAL</td>
<td>10 July 1964</td>
<td>765</td>
</tr>
<tr>
<td>ABA/ISSUE BID DOCUMENTS</td>
<td>13 July 1964</td>
<td>766</td>
</tr>
<tr>
<td>ABA/BID OPENING</td>
<td>12 August 1964</td>
<td>788</td>
</tr>
<tr>
<td>ABA/REVIEW AND RECOMMENDATION</td>
<td>17 August 1964</td>
<td>791</td>
</tr>
<tr>
<td>SLAC-AEC/REVIEW AND APPROVAL</td>
<td>24 August 1964</td>
<td>796</td>
</tr>
<tr>
<td>ABA/AWARD CONTRACT</td>
<td>25 August 1964</td>
<td>797</td>
</tr>
<tr>
<td>CONTRACTOR/OBTAIN BONDS</td>
<td>3 September 1964</td>
<td>804</td>
</tr>
<tr>
<td>ABA/NOTICE TO PROCEED</td>
<td>4 September 1964</td>
<td>805</td>
</tr>
</tbody>
</table>
**BSY COST ESTIMATE, PRELIMINARY**

**SUMMARY**

<table>
<thead>
<tr>
<th>Description</th>
<th>Acct. No.</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Switchyard</td>
<td>5-050</td>
<td>$2,236,000</td>
<td></td>
</tr>
<tr>
<td>Storm Drainage</td>
<td>4-200</td>
<td>9,000</td>
<td></td>
</tr>
<tr>
<td>Paving</td>
<td>4-400</td>
<td>40,000</td>
<td></td>
</tr>
<tr>
<td>I &amp; C Cableways</td>
<td>6-020</td>
<td>109,000</td>
<td></td>
</tr>
<tr>
<td>Materials Handling System</td>
<td>7-936</td>
<td>215,000</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>$2,609,000</td>
</tr>
<tr>
<td>ACCOUNT NUMBER</td>
<td>DESCRIPTION</td>
<td>QUANTITY</td>
<td>UNIT COST</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>5-050</td>
<td>Earthwork</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Excavation</td>
<td>325,000 CY</td>
<td>$ 0.40</td>
</tr>
<tr>
<td></td>
<td>Compaction</td>
<td>325,000 CY</td>
<td>$ 0.20</td>
</tr>
<tr>
<td></td>
<td>Overhaul</td>
<td>1,500,000 Y</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Erosion Control</td>
<td>15,000 SY</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-050</td>
<td>Underground Structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structure Excavation</td>
<td>10,000 CY</td>
<td>$ 4.00</td>
</tr>
<tr>
<td></td>
<td>Structure Backfill</td>
<td>5,660 CY</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Graded Struct. Backfill</td>
<td>5,000 CY</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>Foundation Drainage</td>
<td>2,400 LF</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>Open Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>11,140 CY</td>
<td>$ 44.00</td>
</tr>
<tr>
<td></td>
<td>Reinforcing Steel</td>
<td>1,820,000 LB</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Misc. Steel</td>
<td>38,000 LB</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Two-Story Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>9,900 CY</td>
<td>$ 50.00</td>
</tr>
<tr>
<td></td>
<td>Reinforcing Steel</td>
<td>1,720,000 LB</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Misc. Steel</td>
<td>65,000 LB</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Central Beam End Struct.</td>
<td>485 CY</td>
<td>70.00</td>
</tr>
<tr>
<td></td>
<td>Grating, Catwalk</td>
<td>600 LF</td>
<td>20.00</td>
</tr>
<tr>
<td></td>
<td>Rails, Tool Car (4,000 LF)</td>
<td>60,000 LB</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>A-Line Beam Dump</td>
<td>(See Note #1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Service Shafts and Sleeves</td>
<td>(See Note #2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alignment Shafts, 30&quot;OD OD</td>
<td>2 EA</td>
<td>1,500.00</td>
</tr>
<tr>
<td></td>
<td>Access Shaft, Materials</td>
<td>6' x 12' - 1 EA</td>
<td>10,000.00</td>
</tr>
<tr>
<td></td>
<td>Main Access (Entrance)</td>
<td>12'x16'x105' - 1 EA</td>
<td>50,000.00</td>
</tr>
<tr>
<td></td>
<td>Shielding Door, Concr. &amp; Hdwe.</td>
<td>12'x16'x2' - 1 EA</td>
<td>10,000.00</td>
</tr>
</tbody>
</table>

Notes:
2. Service Shafts and Sleeves - includes 7-27" OD Vacuum and 8-8"OD Synchrotron Light shafts; and 13-27" OD and 6-8" OD sleeves.
<table>
<thead>
<tr>
<th>ACCOUNT NUMBER</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>ITEM COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-050</td>
<td>Underground Structures (cont.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steel Shielding</td>
<td>6,000 CF</td>
<td>$ 5.00</td>
<td>$ 30,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sumps and Conduits</td>
<td>(See Note #3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duct Bank Penetrations</td>
<td>5 EA</td>
<td>5,200.00</td>
<td>26,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interior Finish</td>
<td>140,000 SF</td>
<td>0.185</td>
<td>26,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,822,000</td>
</tr>
<tr>
<td>5-050</td>
<td>Mechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventilation, Fans, Filters, Controls</td>
<td>3 EA</td>
<td>L. S.</td>
<td>$ 22,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventilation Shafts and Ducts</td>
<td></td>
<td>L. S.</td>
<td>18,000</td>
<td>$ 40,000</td>
</tr>
<tr>
<td>5-050</td>
<td>Electrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lighting, including Emergency Lighting</td>
<td></td>
<td>L. S.</td>
<td>$ 32,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power, including Cranes, Fans, Receptacles</td>
<td></td>
<td>L. S.</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire Alarm</td>
<td></td>
<td>L. S.</td>
<td>5,000</td>
<td>$ 67,000</td>
</tr>
<tr>
<td>5-050</td>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misc. Shielding Structures</td>
<td></td>
<td>L. S.</td>
<td>$ 20,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Assembly Building</td>
<td>5,000 SF</td>
<td>16.00</td>
<td>80,000</td>
<td>$ 100,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$2,236,000</td>
</tr>
<tr>
<td>4-200</td>
<td>Storm Drainage</td>
<td></td>
<td>L. S.</td>
<td>$ 9,000</td>
<td>$ 9,000</td>
</tr>
<tr>
<td>4-400</td>
<td>Paving</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magnet Yard, Roads, Parking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8&quot; Base and 2&quot; AC</td>
<td>76,500 SF</td>
<td>$ 0.30</td>
<td>$ 23,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6&quot; Base and Seal Coat</td>
<td>85,000 SF</td>
<td>0.20</td>
<td>17,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ &lt; 40,000</td>
</tr>
<tr>
<td>6-020</td>
<td>I &amp; C. Cableways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tunnel from Klystron Gallery</td>
<td>185 LF</td>
<td>$ 140.00</td>
<td>$ 26,000</td>
<td></td>
</tr>
</tbody>
</table>

Note: 3. Sumps and Conduits - includes stainless steel lined sumps for slits and collimators, and CMP conduit for piping from sumps to outside.
<table>
<thead>
<tr>
<th>ACCOUNT NUMBER</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>ITEM COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-020</td>
<td>I &amp; C Cableways (cont.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roadway and Stanchions</td>
<td>435 LF</td>
<td>$ 23.00</td>
<td>$ 10,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8' x 8' Cableway Tunnel</td>
<td>70 LF</td>
<td>300.00</td>
<td>21,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12' Retaining Wall</td>
<td>80 LF</td>
<td>150.00</td>
<td>12,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8' Dia. Tunnel (Corrugated Metal)</td>
<td>224 LF</td>
<td>125.00</td>
<td>28,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7' Dia. Tunnel (Corrugated Metal)</td>
<td>70 LF</td>
<td>100.00</td>
<td>7,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Junction Structures</td>
<td></td>
<td>L. S.</td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$ 109,000</strong></td>
<td></td>
</tr>
<tr>
<td>7-936</td>
<td>Materials Handling System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cranes, including Track and Electrification and Controls</td>
<td></td>
<td>$ L. S.</td>
<td><strong>$ 215,000</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$ 215,000</strong></td>
<td></td>
</tr>
</tbody>
</table>
### DRAWING LIST

<table>
<thead>
<tr>
<th>Title</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Grading and Utility Plan</td>
<td>SK-505-001</td>
</tr>
<tr>
<td>2. Typical Sections</td>
<td>SK-505-002</td>
</tr>
<tr>
<td>3. Beam Transport Geometry</td>
<td>SK-505-003</td>
</tr>
<tr>
<td>4. Structural Plan, Sta. 100+88 to 103+84</td>
<td>SK-505-301</td>
</tr>
<tr>
<td>5. Structural Plan, Sta. 103+84 to 107+90</td>
<td>SK-505-302</td>
</tr>
<tr>
<td>6. Structural Plan, Sta. 107+90 to Ends</td>
<td>SK-505-303</td>
</tr>
<tr>
<td>7. Sections and Details</td>
<td>SK-505-304</td>
</tr>
<tr>
<td>8. Sections and Details</td>
<td>SK-505-305</td>
</tr>
<tr>
<td>9. Materials Handling System</td>
<td>SK-505-306</td>
</tr>
</tbody>
</table>