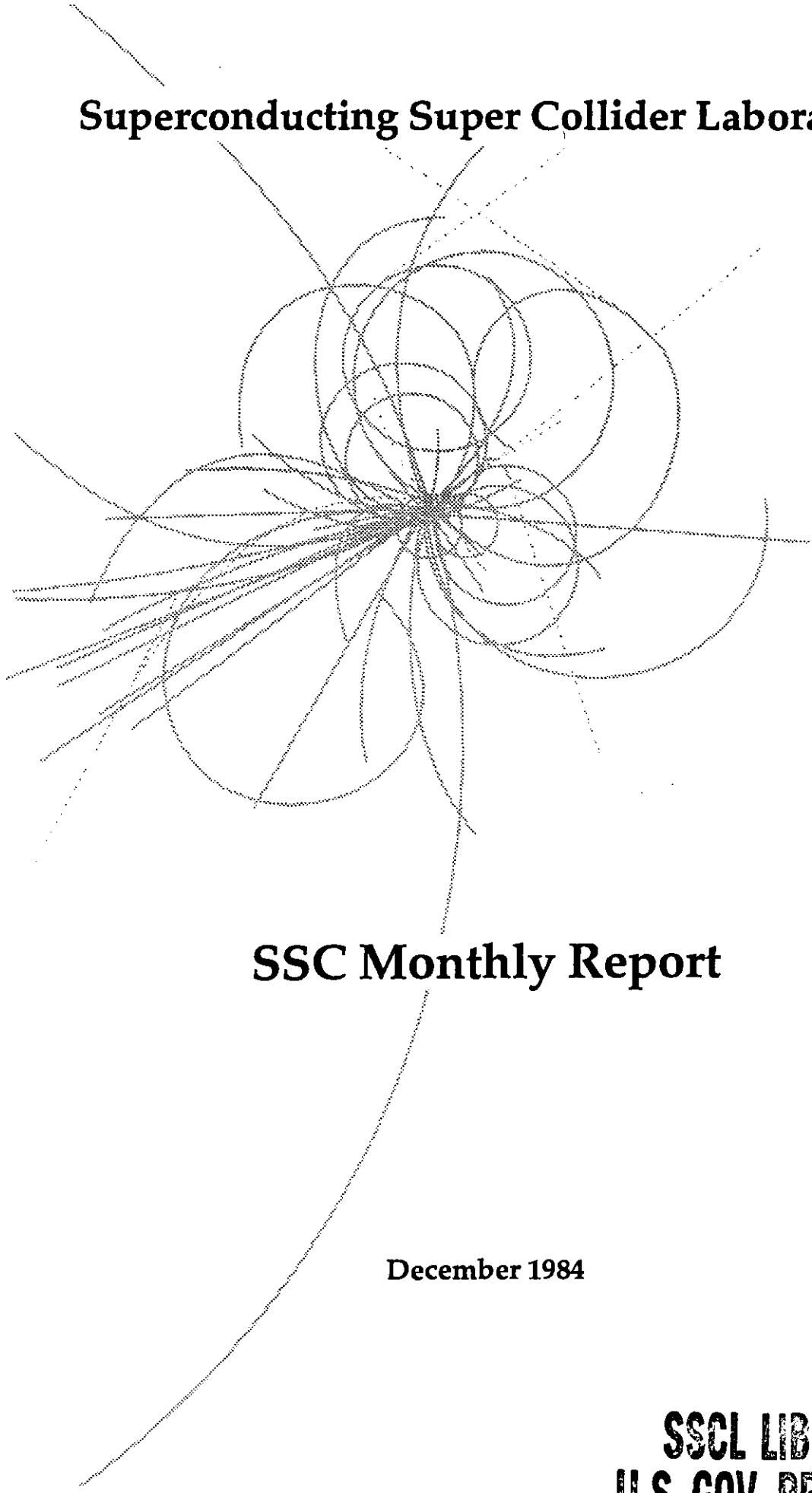
SSC-4

Superconducting Super Collider Laboratory

SSC-4



SSC Monthly Report

December 1984

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Superconducting Super Collider
Universities Research Association
c/o Lawrence Berkeley Laboratory, University of California
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Berkeley, California 94720
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January 23, 1985

Mr. Jay Hunze
U.S. Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

Dear Jay,

The SSC Monthly Report for December is enclosed.

We look forward to seeing you next week at the SSC review.

Regards,

Tom

Tom Elioff

cc R. Fricken (DOE)
J Matheson (URA)
B. McDaniel (Cornell)
W. A. Wallenmeyer (DOE)

TE/as
(0291S)

SSC MONTHLY REPORT

DECEMBER 1984

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SSC MONTHLY REPORT
DECEMBER 1984

A. PROJECT SUMMARY

1. Highlights of the December activities include the following:

   - CDG Agreements with BNL, FNAL, LBL, and TAC respectively were completed. The agreements define the R&D efforts and associated funding levels for FY85 programs.

   - An agreement was negotiated with LBL, BNL, and FNAL for a coordinated effort toward a new Magnet Design "D". Design D reflects the best feature of previous designs A and B.

   - Results of the SSC Aperture Workshop were completed (SSC-TR-2001). A report on the subsequent Aperture Task Force activities (SSC-TR-2002) has been prepared.

   - Reports from the Magnet Technical Review Panel and the Management and Fiscal Review Panel have been completed.

   - A panel on Commissioning and Operations of the SSC was established. Planning for a January workshop on this subject was initiated.

   - Plans were finalized for conducting experiments on photodesorption from cryogenic beam tubes at NSLS.

   - The CER Corporation with Parsons Brinkerhoff will assist the CDG in developing the Site Parameters Document.

   - The selection process for A/E services to the CDG over the next two years was initiated by DOE-CH.

   - The SSC Site Selection program was announced by DOE.

2. Magnet Programs

A major development was the joint BNL/FNAL/LBL agreement to proceed with a single magnet design designated Reference Design D, devised by merging Reference Designs A and B: 4.0 cm aperture, 6.0-6.5 T, collared coils, 1-in-1 cold iron yoke. As noted in last month's report, preliminary design calculations on such an alternative to the BNL/LBL 2-in-1 design had already been started. The provisional design retains the collared coils of the previous 2-in-1 design and will have a minimum impact on the short range magnet program. Work will continue at LBL and BNL on optimizing wire and cable, coil cross section, (non-flared) ends, collaring, and yoke design for the longer range program.

At LBL work is proceeding well on the units of the 4.0 cm bore 6.5T models using collars. The first model uses aluminimum collars and will be finished in early February. The second, to be completed in March, uses Nitronic 40 stainless steel collars. In both cases, collars are machined rather than stamped because of the long lead time required to procure dies. Magnet D12B2 was retested with a realigned sextupole corrector and sextupole error fields could be reduced by a factor of 30.

Although development activity on the FNAL no iron design (Design B) continued during December, planning effort was concentrated on shifting to Design D which has resulted from the collaboration agreement. Many of the results of the Fermilab programs to develop coils and cryostats for Design B will be directly applicable to Design D. In the next few months Fermilab will concentrate on dry winding (no-epoxy) techniques for coil fabrication and on cryostat design for Design D.

At TAC the first two (1 m) models have been hooked in series for additional tests. Some problems have been encountered in the assembly of the first 25 foot model. Appropriate corrections have been made and tests of the 25 foot model are expected to begin in February.

3. Reporting Format

The initial WBS structure for the SSC Phase I program that was presented in last month's report has been revised to reflect more accurately the budget categories for the SSC program and those of ongoing laboratory programs that are related to the SSC. The SSC related programs are indicated by an asterisk in the following Table 1. These programs are reported here because of their importance and relevance to the SSC effort.

TABLE I

WBS Structure (SSC Phase I)

1.0 Central Design Group

- 1.1 Administration
  - 1.1.1 Director's Office
  - 1.1.2 Administrative Support
- 1.2 Program Planning and Management
- 1.3 Accelerator Research and Development
  - 1.3.1 General
  - 1.3.2 Theory and Computation
  - 1.3.3 Accelerator Systems
  - 1.3.4 Superconducting Magnets
  - 1.3.5 Injection Systems
- 1.4 Conventional Systems
  - 1.4.1 Planning and Coordination
  - 1.4.2 Site Parameters
  - 1.4.3 Conceptual Design
  - 1.4.4 Tunnel Concepts

2.0 Brookhaven National Laboratory

- 2.1 General
- 2.2 Magnet Models
- 2.3 Tooling
- 2.4 Magnet Measurements
- 2.5 Power Supplies and Quench Protection
- *2.6 Superconductor Development
- *2.7 Cryogenic System

3.0 Fermi National Accelerator Laboratory

- 3.1 General
- 3.2 Magnet Models
- 3.3 Facility Development and Operation
- *3.4 Superconductor Development
- *3.5 Cryostat Development
- *3.6 Accelerator Physics

4.0 Lawrence Berkeley Laboratory

- 4.1 General
- 4.2 Magnet Models
- 4.3 Calculations and Analysis
- 4.4 Instrumentation and Measurements
- *4.5 Accelerator Theory
- *4.6 Superconductor Development

5.0 Texas Accelerator Center

- 5.1 General
- 5.2 Short Magnet Models
- 5.3 Long Magnet Models
- 5.4 Tooling Development
- 5.5 Theoretical/Analysis
- 5.6 Facility Development

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*Ongoing Laboratory Accelerator R&D activities that are relevant to the SSC program.

B. PROJECT REPORT

1.0 Central Design Group

1.1 and 1.2 Administration, Project Planning and Management

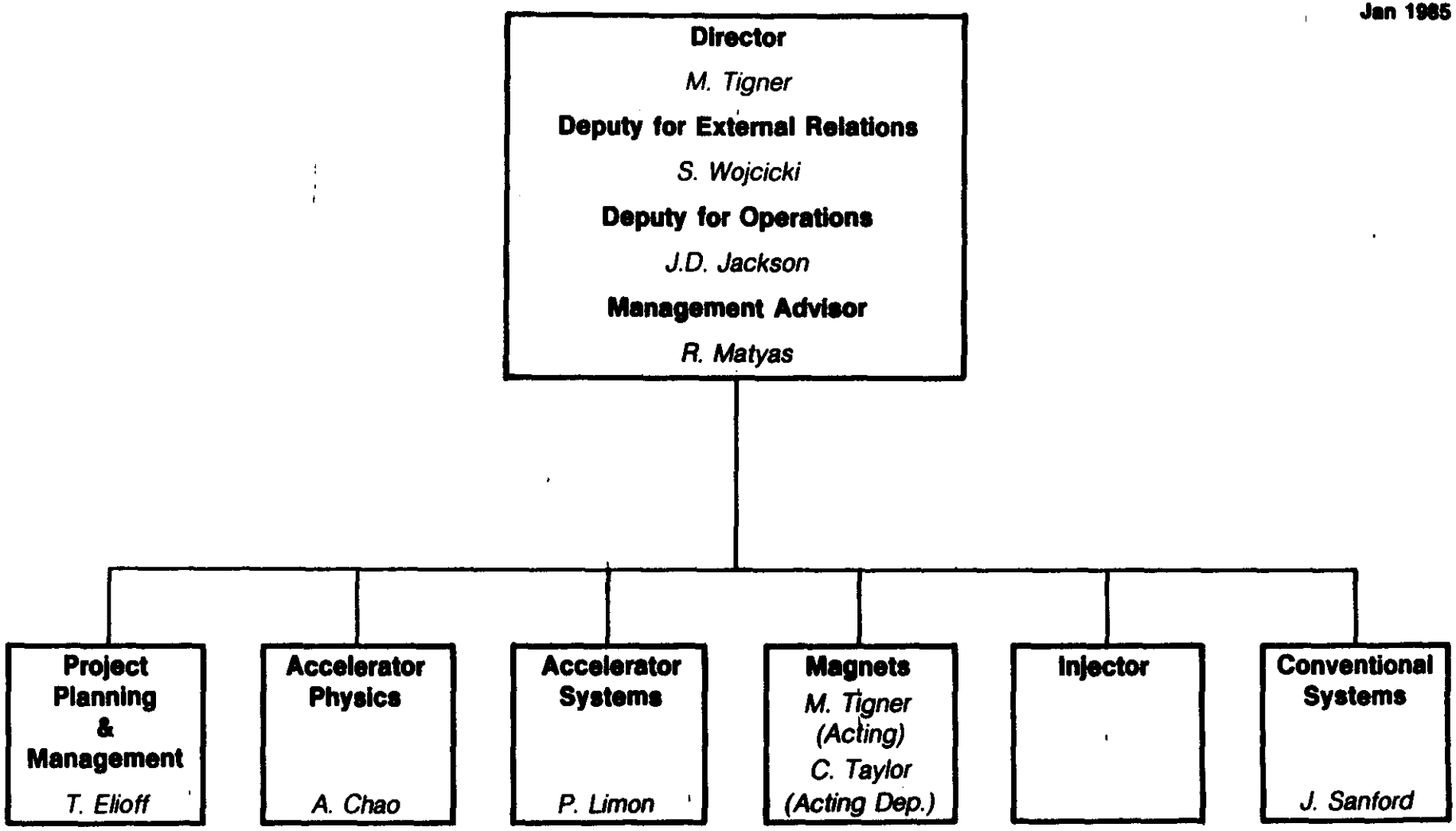
The CDG has continued to evolve in its operations, staff, and facilities. Offices are being modified for additional staff in Bldg. 90 and plans are being developed for improved conference room facilities.

The CDG organizational chart as of Jan. 1, 1985 is shown in Fig. B-1. The Magnet Division will be led on an interim basis by M. Tigner and Clyde Taylor. Their immediate task is to plan and complete the basic Magnet type selection process and make the selection during the last quarter of FY85.

Detailed performance agreements between CDG and the four institutions participating in the superconducting magnet programs were drafted and reviewed. These documents provide the signed agreements defining the specific scope of work and budget recommendations for the FY1985 R&D program. Each individual laboratory will bear the responsibility to coordinate and direct the work of its employees and collaborators in carrying out the agreed upon activities. In addition each laboratory will identify a specific person for coordination and liaison between the laboratory and the CDG. Two of these agreements were completed and signed in December; the remaining two are undergoing final review with signatures expected in early January.

The format for the agreements describes the specific activities that are required in support of the overall CDG efforts; for example, a description of the particular model magnets to be assembled, various test procedures and records to be submitted, detail design packages

Jan 1985


Director
M. Tigner
Deputy for External Relations
S. Wojcicki
Deputy for Operations
J.D. Jackson
Management Advisor
R. Matyas
Project Planning & Management
T. Elioff
Accelerator Physics
A. Chao
Accelerator Systems
P. Limon
Magnets
M. Tigner (Acting)
C. Taylor (Acting Dep.)
Injector
Conventional Systems
J. Sanford

Jan 1985

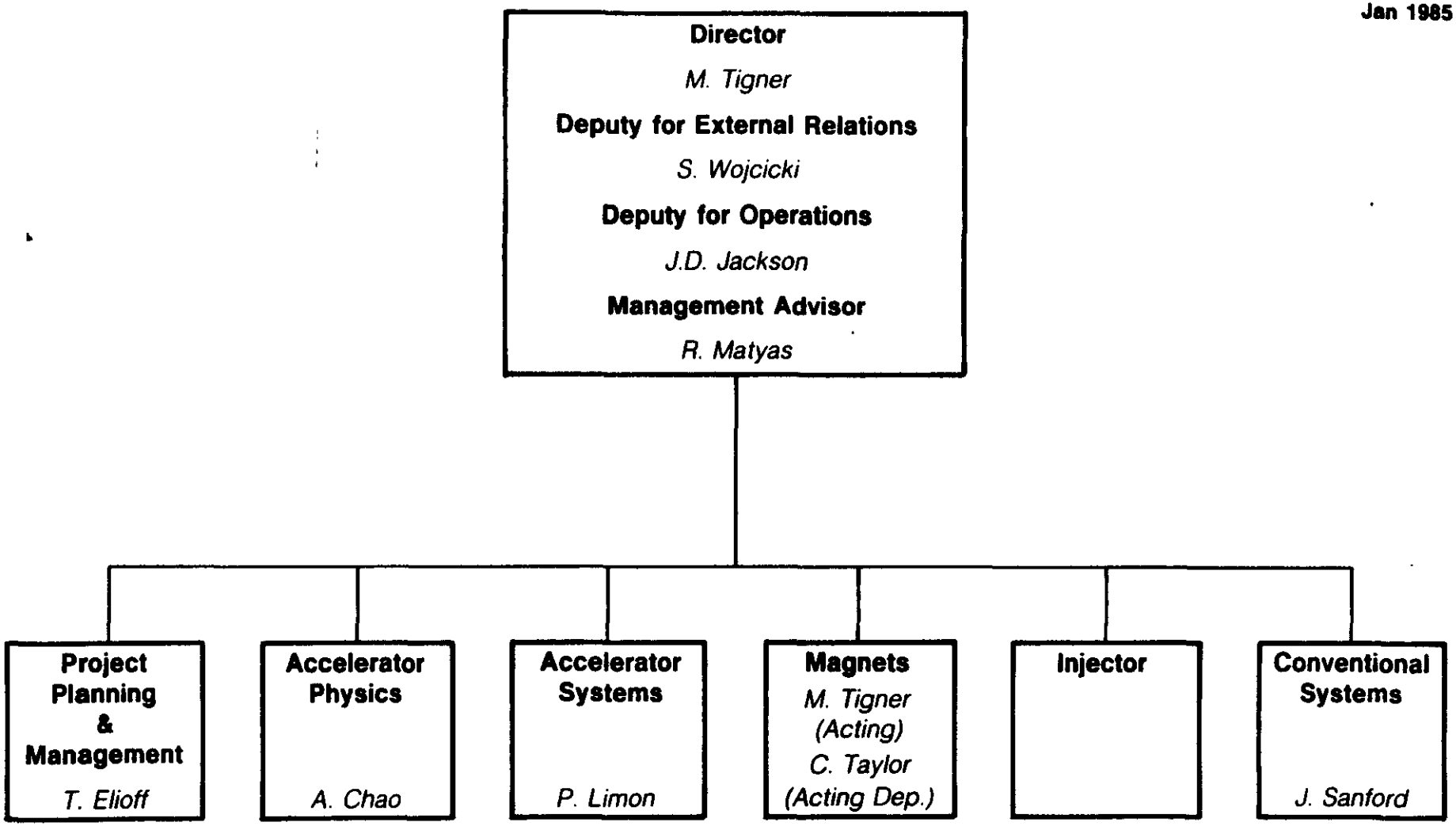


FIGURE B-1

expected, and the periodic (monthly) reporting requirements and structure to be used. The key laboratory participants are also identified. The specific budget recommendations are detailed for each laboratory group, and the schedule requirements are defined.

1.3 Accelerator Research and Development

1.3.2 Accelerator Theory and Computation. Activities of the CDG Accelerator Physics Division and the LBL-SSC Theory group in December were a continuation of previously reported work. The central focus is provided by the problems posed by the aperture question, particularly the consequences of magnetic field imperfections on single particle motion and collective effects.

Since the November Workshop, the Aperture Task Force has coordinated continuing work by the workshop participants according to the action plan. For example, a database is set up at the Central Design Group; various tracking and lattice programs are being improved; analytic techniques for aperture evaluation are being reviewed; aperture related operational features as well as possible experiments on existing accelerators are being studied. During this time, two group meetings took place, one at BNL on 12/3-5 by the Test Lattice group, and one at LBL on 12/3-5 by the Magnet Errors group.

To review overall progress and to focus on future needs, an Aperture Task Force meeting was called on 12/17 at LBL. The main outcome of the meeting was a renewed action plan for the coming few months in order to insure the completion of the Task Force objectives. The results are summarized in report SSC-TR-2002.

In the area of tracking codes work continued on both long term code improvement and preparation of codes and test cases for the generation of early numerical results. A selection of the codes on which the group will focus has been made. These are: PATRICIA, as a "kick code"; DIMAT, as a higher order, simplectified, tracking code; and MARYLIE (the only obtainable Lie algebraic code) will be further developed and used. Progress was made towards coding analytical calculations to be performed and towards implementing new Lie algebraic formulations obtained in the past months.

1.3.3 Accelerator Systems. Activities were centered mainly in three areas:

- Planning for a Workshop on Commissioning and Operations of the SSC, to be held in January at UC Berkeley.

- Finalizing plans for conducting an experiment on photo desorption from cryogenic beam tubes to be done at BNL.

- Contributions to CDG agreements with associated R&D centers for work to be performed in FY85.

The Workshop on Commissioning and Operations of the SSC. It became clear during the meetings of the Technical Magnet Design Taskforce that the operational characteristics of the SSC will be an important input to the deliberations on which type of magnet is best suited for the SSC. Consequently, a task group has been formed to consider the various operational and commissioning problems of the SSC as they are influenced by magnet type. The taskforce consists of Peter Limon (CDG-Chairman), William Fowler (FNAL), Donald Hartill (Cornell University), Christoph Leemann (LBL), J.R. Orr (FNAL), Paul Reardon (BNL), F.R. Huson (TAC), and Donald Groom (University

of Utah--ex officio). The purpose of the task group will be to write a report on the operational characteristics of the SSC as they are influenced by the various magnet types. The completed report is expected by the end of April, 1985.

The above activity will be initiated by a week long workshop at UC Berkeley, January 14-18, 1985. Experts on various aspects of accelerator operation have been invited and approximately 35 people are expected to attend. The list of attendees, as it is known at this time, a preliminary agenda, and some of the questions that should be addressed are included as adenda to this report. The purpose of the Workshop is to identify the most important operational considerations and to assign specific people to work in these areas. The Workshop has been divided into four groups, each with its own coordinator--Cryogenics, Design, Operations, and Systems. It is expected that there will be an informal Workshop Report circulated before the final report of the taskforce is completed.

Photo Desorption Experiment. During the month of December, considerable progress was made in planning the photon desorption experiment. This experiment, the results of which are necessary for magnet design work to proceed to the detailed level, is a collaboration of BNL, Fermilab, and CDG. It will be performed, starting in February, 1985, at the VUV ring of the NSLS at BNL. The synchrotron light from the VUV ring has characteristics that are very similar to the light emitted by the 20 TeV proton beams of the SSC. The manpower arranged to do this experiment are Hans Jöstlein (spokesman-FNAL), Dejon Trbojevic (FNAL), Henry Halama (BNL), and Carl Christianson (BNL). Negotiations are proceeding to add other members to the group.

The beam line has been designed, with the assistance and cooperation of the NSLS staff, and a safety review is scheduled for January 14, 1985. In addition, the necessary tasks have been assigned. BNL staff will be responsible for the beam line construction. For this purpose, the assistance of two technicians from the BNL magnet division will be available. The procurement and assembly of stands and collimators began in December. Fermilab will be responsible for the design and fabrication of the cryostat and for a warm beam tube that will be used for a preliminary test. Two quadrupole mass spectrometers were ordered in December, and will be assembled into the apparatus and tested at Fermilab. There has been excellent cooperation from both BNL and FNAL in arranging for this experiment, and initiating the work plan.

Discussion with the KEK (Japanese) vacuum people have taken place. These discussions centered on their past work and possible future work on photon desorption experiments, and on developments of all-aluminum vacuum systems.

CDG Agreements. A few aspects of the agreements negotiated with the R&D Centers impact the Accelerator Systems Division. The following particulars were included in the agreements:

- Fermilab and BNL were assigned responsibility for executing the photon desorption experiment, and investigating the properties of beam tubes.

- Fermilab, BNL, LBL, and TAC are charged with investigating various aspects of the magnets that will effect the system design. These include, but are not limited to, quench propagation, cryostat design, heat leak measurements, multipole measurements, and cold diode assemblies.

- o BNL and Fermilab are responsible for the short and long string tests as defined in SSC-SR-1001. The Agreements presently state that BNL will be responsible for the final long string test, used for systems tests. Fermilab is charged with building a preliminary string, of ten to twenty magnets for the purpose of cryogenic measurements, and systems development.

1.3.4 Magnet Program

A search is still under way for a permanent head of the Magnet Division. In the interim M. Tigner will be acting head of this division with C. Taylor as acting Deputy.

A major accomplishment in December was an agreement to merge the efforts of the BNL, FNAL, and LBL groups into a collaborative effort noted as magnet "Design D." The tentative magnet specifications call for a 4 cm aperture with 6.0 T field (6.5 T goal). This design will be a "1-in-1" design with collared coils and cold iron.

The purpose of this collaboration is to utilize the best technical advantages of previous designs A and B, to reduce R&D costs and to more effectively utilize existing resources at each laboratory.

The immediate program calls for LBL to continue development of improved wire and cable, to develop appropriate end-shapes for the coils, and to confirm design approaches with 1 meter models.

FNAL will develop the dry-wound coil insulation system and test with appropriate models and concentrate on the design and development of cryostats. FNAL will also continue as the central liaison to wire manufacturers.

BNL will continue with the development of bore tubes and magnetic measurement hardware. This effort will include the fabrication of 5 long magnets ($\sim$4 m) as well as the development of long term plans for manufacturing and production scheduling.

While the above summary describes the immediate effort in FY85, joint collaboration on the design and fabrication of full length magnets and associated system tests is prescribed for FY86 and beyond.

1.4 Conventional Systems

The major activity this month involved exploring means of acquiring professional engineering help for the siting studies, especially in the preparation of a Site Parameters Document that describes in general terms the planned facility and its requirements. To acquire the needed help, DOE Chicago recommended using a firm already under contract, namely the CER Corp. Discussions were held with Ron Ryan of CER which in turn lead to a sub-contract being placed with Parsons Brinckerhoff (PB). PB personnel had performed the work on the conventional facilities for the Reference Designs, and are well suited to assist the CDG in the area of the siting requirements.

Dr. Trivelpiece, Head of DOE's Office of Energy Research, described in a letter to URA the Department's plans for the site selection process. Although no decision has been made with respect to building the SSC, the Department recognized the importance of outlining the site selection procedures that the Department intends to follow. The announced procedures follow very closely those proposed last month by the CDG. It is hoped that the announcement will help to foster an orderly process for the siting studies.

Longer term plans have been laid for a two-year program of A/E work leading up to the preparation of a Conceptual Design Report. The Chicago Office of the DOE set up an A/E selection process with input from the CDG. An announcement seeking A/E services appeared in the December 6th issue of the Commerce Business Daily with responses due in early January. It is thought that this will lead to the adoption of a major industrial partner for the conventional facilities conceptual design.

At the request of DOE, a panel of academic and industrial experts was assembled to advise on matters of tunneling and underground technology as applied to a proposal from the Texas A&M Research Foundation to DOE. The proposal is titled "Continuous Unitized Tunneling System" (CUTS). The seven member panel was chaired by David Hammond (Vice President of DMJM). The presentations on December 9 and 10 were attended by CDG and DOE observers. The report of the panel has been submitted to DOE.

2.0 Brookhaven National Laboratory Program

2.1 General. Analytical studies were conducted for the coil used in the initial three 3.2 cm aperture model dipoles. The design was recomputed with an outer to inner coil current ratio of 1.43 instead of 1.35 to determine peak fields and whether a higher central field could be obtained (for better agreement with measured field values). An analytical form for new critical current data for the high homogeneity NbTi was developed for use in conjuction with peak field calculations to determine critical magnet currents. No significant central field enhancement was found with the revised current ratio at 4.5K; at 2.5K an enhancement in B_0 of 0.08T was obtained.

A series of 1-in-1 dipole magnet computer models with varying coil-to-iron spacing was constructed; the various iron saturation effects were determined. Adequate control of saturation effects was obtained with a 15.6 mm gap (15 mm collar). With this gap, a superconductor current density of 1940 A/mm^2 (4.2K.5 T) in the outer coil is required to reach B_0 = 6.0 T at 4.5 K. The same current density would result in B_0 = 6.3 T with a gap of 0.6 mm (i.e., no collar), but also cause a swing in the sextupole harmonics of about 10×10^{-4}.

2.2 Model Magnets. Work continued on problems uncovered in connection with curing Nb_3Sn coils. A procedure was developed for coil curing which is capable of maintaining the mandrel length longer than the fixture at all times. This precludes placing undue strain in the cable.

Significant progress was made on numerous components for the 4.0 cm aperture x 4.5 m long magnets, primarily in the following areas:

- Stress analysis of yoke-containment shell due to underlying cut-outs in yoke for electrical bus, with appropriate adjustments to minimize stress.

- o Redesign of the yoke for a 1-in-1 configuration and adjustment of the vendor contract for dies and laminations.

- o Redesign of, and collar laminations for, the 1-in-1 configuration.

- o Redesign of G-10 end collar spacer to accommodate the quench protection strip heaters.

- o Release of drawings to Central Shops for collar spacer, coil end supports, and material for the pole piece extension.

- o Placing of orders for trim coil Kapton for the Multiwire process. The first multiwire prototype samples being prepared for testing.

- o A series of tests performed on dipole SBN003 to investigate quench propagation characteristics (described under Tests and Measurements).

- o Progress on ongoing tests on coil collar assembly to substantiate the design. Calibration of strain gauges and completion of fixturing. Tests should be completed in early January 1985.

2.3 Tooling and Facilities

a) Coil Fabrication Tooling

- o Modified 3.2 cm aperture inner curing fixture steam system to permit controlled heating of the fixture.

- o Released to Central Shops and Staff Shops all parts drawings pertaining to tooling for winding and curing 4 cm aperture inner and outer coils. Similarly, released

assembly drawings pertaining to assembly of the curing press in Building 924 including form-block and mandrel assembly fixtures.

- All tooling and fabrication associated with the full-length coil winder and curing press has been stopped.

b) Coil and Yoke Assembly Tooling

- The module bonding fixture for the 10.5 inch O.D. (Outer Diameter) 1-in-1 yoke has been redesigned.

- Work continued on the magnet assembly tooling to accommodate the conversion to a smaller diameter 1-in-1 yoke.

- Significant progress was made on the yoke press modification for the collar tooling, the key insertion system and the coil handling system.

- Substantial progress was also made on the coil transport equipment, including the modification of both coil stands and the transport boxes that are used during the coil pack assembly.

c) Bore Tube and Trim Coil Tooling

- Work continued on the trim coil to bore tube assembly tooling. Significant progress was also made on the bore tube wrapping equipment, and on the trim coil multiwire transporter.

d) Magnet Test Facilities

- Work continued on the design of the horizontal test facility even though all fabrication and procurements have been terminated. Material that had been ordered previously has been collected and stored. Since the magnet design has changed from a 2-in-1 to a 1-in-1 configuration, a corresponding alteration in the design of the test facility may be necessary.

- Testing of the precision control system for the "mole" field measuring coil is well under way. Gravity sensors are not affected by fields less than 2 Tesla. Coil period can be controlled to better than 3 milliseconds. A precision pressure control system has been selected.

- A new vertical dewar system for 1-in-1 magnets is being designed. In addition, all existing suspension systems for the vertical dewars are being analyzed to determine a limiting load, and a detailed stress analysis is being documented.

2.4 Tests and Measurements. Quench propagation studies were conducted using the third 4.5 m model dipole, wound with high homogeneity NbTi (initially tested in October, and described in the Report for that month). A number of heaters bracketed by voltage taps were used to initiate quenches of the magnet. From measurements of voltages and currents during the quenches, quench velocities and temperatures as a function of $\int I^2 dt$ may be obtained. Preliminary results indicated that the magnet conductor survived a temperature of about 900°K at $\int I^2 dt = 8.71 \times 10^5 \text{amp}^2\text{-sec}$ but suffered failure at $\int I^2 dt = 9.00 \times 10^5 \text{amp}^2\text{-sec}$ with the temperature greater than 1200°K. Data is being analyzed to determine quench velocities.

2.5 Power Supplies, Quench Protection, Electrical Systems. The design of a quench protection heater system made considerable progress. The system incorporates a heater located in each coil quandrant on the outer coil circumference and extending the length of the coil. Clearance is provided by adjusting the inside diameter of the collar. Ground insulation is by means of Kapton.

2.6 Superconductor Development. A contract was awarded to IGC for an R&D study of the development of a Nb_3Sn wire made by reacting tin internally in niobium tubes. The main objective of this study is to determine if fine filaments (3 μm) can be obtained by this method.

During the first and third weeks in December BNL representatives visited New England Electric Wire Corp. (NEEW) for the purpose of setting up their production tooling to produce both 23 strand and 30 strand conductor for the LBL cable design. Numerous runs were made with wire supplied from both BNL and LBL, to produce cable to the desired dimensional specifications. The final run of both cables produced cable that met specifications for the keystone angle and mean thickness, but fell just outside of specifications on width. Following adjustments of NEEW tooling, a production run is planned for the end of January at which time all parameters are expected to lie within specifications.

2.7 Cryogenic Systems. Engineering studies have begun to estimate the heat load of a 1-in-1 magnet system for SSC. If the Magnet/Cryogenic System of Reference Design A were used without modification, a 40 to 50% increase in load would result. In order to reduce this load, the inclusion of a second, lower temperature (10 to 20K) heat shield, similar to the shields proposed in Reference Designs B and C, is being studied. The operational temperature and the method of producing the refrigeration for this shield will be studied.

3.0 Fermi National Accelerator Laboratory

3.2 Magnet Models. Procurement of parts for the first 5 cm aperture SSC Design B style coil is nearly complete. This will be the second in the series of drywound (epoxy free) one meter models. The model will use production type collars, formed around wrap end saddles and keys. The wedges used to space out the turns in the coil will be made from stacks of stamped copper laminations. This novel method for making wedges is relatively inexpensive, quick to fabricate and gives a dimensionally precise shape.

The data from the second test of the scheme to compensate low field persistent current sextupoles with passive superconductor have been analyzed. The level of sextupole cancellation measured agreed with calculations.

Tooling is being designed for dry winding 4 cm aperture models as part of the Design D effort. Until tooling and coil parts become available for 4 cm aperture models, the coil development program will continue on the 5 cm aperture models.

3.3 Facility Development. The data acquisition system for the magnetic model continues. The system has two modes. The fast mode uses circular buffers for fast data acquisition during a quench. These data are coil voltages, temperatures, and mechanical displacements of the coil and cryostat components. The slow model measures temperatures and mechanical motion of cryostat components during warm up and cool down.

3.4 Superconductor Development. The first 0.030 inch strand from the Fermilab R&D conductor procurement has been produced. The procurement involves four twelve inch diameter billets using 1.8 to 1 copper to superconductor high homogenity alloy. The vendor-performed tests indicate a current density of more than 2600A/mm^2. Strand from the first billet is being sent to New England Electric

Corporation for cabling. This cable will be used in the Fermilab 5 cm model program. The material from remaining billets will be held pending a decision on the cable needs for the BNL/FNAL/LBL "Design D" program.

3.5 Cryostat Development. Assembly of the magnetic model continued. A trial assembly of the single phase was completed with the suspension system into the vacuum vessel shell. The off-axis motion adjustment mechanism was tested and the accuracy of the translation sensors was verified.

Work continued on test procedures, apparatus schematics and safety documentation. Instrumentation hardware preparation was completed. The "fast" data acquisition system for data taking during quenches is essentially complete. Work continues on the "slow" data acquisition system for data taking during cooldown and warmup. Test facility preparation focused on a shakedown run utilizing an Energy Saver Quadrupole.

3.6 Accelerator Physics and Systems Study

Aperture Task Force Commitments include:

- Example lattice design.
- Design of experiments using the Tevatron.

General Efforts include:

- Extension of relevant electromagnetic processes to 20 Tev.
- Calculations in support of magnet design.
- Non-linear dynamics development.
- Magnet design computer code development.
- Emittance reduction calculations.
- Survey requirements.
- Computer support system software development.

4.0 Lawrence Berkeley Laboratory Program

4.1 General. This category includes all administrative activities, purchasing, planning, and travel expenses.

4.2 Magnet Models. Fabrication and assembly work continued on the two 1 m long "one-in-one" dipole magnets, (D12C1 & D12C2), described in last month's Report.

D12C1 Status

During December the following tasks were completed:

a) Fabrication of pre-formed Kapton coil insulation.
b) Fabrication of strain-gage load cell sub-assemblies.
c) Moulding of coil end wedges.
d) Coil winding and curing.
e) Assembling collar hard-packs.
f) Installation of load cell sub-assemblies into collar hard-packs.

The coil assembly was started toward the end of this reporting period and is on schedule. Completion of magnet D12C1 assembly is scheduled for February 7th and this still appears achievable.

D12C2 Status

During December the following tasks were completed:

a) All 1200 stainless steel collars were N.C. laser cut and tumbled. E.D.M. cutting of the keyways was started, and the collar fabrication is expected to be completed in early January.

b) Fabrication of load cell sub-assemblies.

c) Design of end plates, splice plates, collar position and shape indicator.

e) The manufacture of both the 23 and 30 strand superconducting cable required for the inner and outer coil layers.

Fabrication of the magnet yokes was started and delivery is scheduled for the end of February. The design and fabrication of D12C2 appears to be on schedule.

4.3 Calculations and Analysis. The measured sextupole component of an iron-core magnet was compared with that predicted using the POISSON program for field values ranging from zero to the maximum.

The writing of a report covering the most recent modifications to the POISSON program continued. This covers the elliptical outer boundary condition that correctly simulates an air region extending to infinity.

The preliminary design of iron having an elliptical outer boundary for a 1-in-1 SSC dipole was accomplished.

The practicability of the use of R. Fernow's (BNL) magnet design program by LBL was investigated briefly. The program incorporates the MINUIT optimization program, and runs on BNL's CDC-7600. The options include: (1) LBL running on BNL's computer, (2) adapting the program to run on LBL's CDC-7600, and (3) adapting the program to run on another LBL machine such as our own HP-1000. Option 1 would be practical only for the short term. Option 2 would be practical only if a small effort is required since the CDC-7600 will go out of service soon. Option 3 appears to be the best long-term solution. The investigation will continue.

The effort on the prediction of random field errors for the SSC dipole magnets continued. A workshop on the topic was held at LBL (E. Fisk, chairman) early in December. A report on LBL's work, to be included in the workshop report, was prepared. A more extensive report will be prepared for the Particle Accelerator Conference, and work on the topic will continue at a low level.

4.4 Instrumentation and Measurements. In December 1984, dipole D12B2 was retested with sextupole correction coil #2 that had been aligned at room temperature for maximum sextupole cancellation. The magnet itself retained no memory of its previous training. The correction coil experiment was quite successful, with sextupole error field reductions of up to 30 being achieved.

4.5 Accelerator Theory and Design

The activities for this section are described under section 1.3.2.

4.6 Superconductor. The fabrication of 450 lbs. of Inner Layer and 450 lbs. of Outer Layer conductor was completed at Intermagnetics General Corp. This material will be cabled in February for use in 4.5 m long SSC model dipoles. Preliminary measurements indicate that the material meets specification, with exception of J_c at 5T. The values are 2200 A/mm^2 for the Inner Layer material and 2300 A/mm^2. In reviewing the fabrication records, IGC discovered that the billets were interchanged upon return from the extruder; this meant that the intermediate heat treatment and drawing schedules were also interchanged. This mistake can account for the low J_c values. Intermagnetics General Corp. have revised their quality control plan to prevent this mistake from recurring. The material is satisfactory for use in the first SSC models and will be cabled in February as planned.

A cabling experiment was performed at New England Electric Wire during the week of December 17-21. The goals were (1) to establish the processing parameters necessary to achieve the specified cable dimensions, and (2) manufacture long lengths in order to identify any potential problems. These problems can then be corrected before the new strand material is cabled in February. Approximately 3000 ft. of Inner Layer cable and 2500 ft. of Outer Layer cable were produced for evaluation. Preliminary measurements indicate that the dimensions, including keystone angle, are within specification, but near the lower limit with respect to keystone angle. Further measurements, including magnet sectors, will be made in order to complete the characterization.

Both cables were made without problems of flashing; however, some strand crossovers occurred. The cause of the crossovers in the 30 strand cable is loss of strand tension, and the cabler is being rebuilt to correct this problem. The cause of crossovers in the 23 strand cable is still under investigation. The probable cause is a worn Turkshead mount and this is being corrected. All the necessary modifications will be complete before the next run in February.

5.0 The Texas Accelerator Center Program

5.2 Short Magnets. The first two (1 m) magnets have been mounted together and hooked in series for more tests. A 2-in-1 one meter model is nearly complete and ready for test. When difficulties were encountered concerning the assembly of the 25 foot model, a decision was made to assemble a 2-in-1 one meter model.

The assembly of the first 25 foot magnet uncovered some problems. The goal of this assembly was to gain confidence that all tooling and assembly procedures will produce a successful magnet. Every aspect of the assembly was correct except that a 5 mil gap remained between the half cores after assembly. It was possible to close this gap but it took more force than was predicted. The magnet was disassembled to investigate the problem and it was found that on average the conductor was larger by a few mils than the specifications, due to additional overlap of the Kapton insulation. The pin used as a key between the half cores was also a fraction of a mil too large.

The 5 mil gap will be removed by putting in 7.5 mil shims around the conductor rather than 10 mils. The key pins will be ground slightly smaller. In the future better quality control is required on all pieces going into the magnet. The key situation will be fixed by making the half holes in the cores slightly more than a half circle (a standard procedure).

5.3 Long Magnets. Mike Kimmy of General Dynamics was at TAC in December, at the time of the first assembly of the 25 foot magnet. It was mutually agreed that it is reasonable to proceed with a contract and acquisition of the tooling for winding longer coils now, as both parties are confident the coil winding and assembly procedures will work. A set of papers and drawings describing General Dynamics work thus far and a copy of the General Dynamics proposal has been sent to CDG.

5.4 Tooling. The tooling that has been completed for the 25 foot model works satisfactory.

5.5 Analysis. Design work continues on poleface shapes and coil positions to optimize the magnetic field.

5.6 Facility Development. The 200 watt helium refrigerator has been set-up and is ready for commissioning.

C. PROGRAM COSTS

The December costs for the SSC program are provided in Tables C-1 through C-6 as follows:

Table	SSC Group
C-1	CDG
C-2	BNL
C-3	FNAL
C-4	LBL
C-5	TAC
C-6	SSC Program Summary
C-7	Related Program Summary

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TABLE C-1

CENTRAL DESIGN GROUP

DECEMBER 1984 COST REPORT (K$)

	Program Element	Labor	Mat'l & Services	G&A	Month Total	Year To Date	Annual Budget
1.1	Administration	44	64	47	155	235	1500
1.2	Program Planning & Management	12	0	6	18	120	450
1.3	Accelerator R & D	21	12	8	41	89	1825
1.4	Conventional Systems Develop.	6	62	1	69	79	1075
	CDG TOTAL	83	138	62	283	523	4850

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY

DECEMBER 1984 COST REPORT (K$)

	Program Element	Labor	Mat'l & Services	G&A	Month Total	Year To Date	Annual Budget
2.1	General	27	14	15	56	197	840
2.2	Magnet Models	50	14	24	88	294	2540
2.3	Tooling	55	70	47	172	443	810
2.4	Magnet Measurement & Devel.	32	10	16	58	175	780
2.5	Power Supplies & Quench Prot.	20	1	8	29	89	360
	BNL SSC PROGRAM	184	109	110	403	1198	5330
2.6	Superconductor Development	21	13	13	47	158	670
2.7	Cryogenic Systems Development	53	12	21	86	267	1000
	BNL ACCELERATOR RELATED PROG.	74	25	34	133	425	1670
	BNL TOTAL	258	134	144	536	1623	7000
	Additional Commitments		477				

TABLE C-3

FERMILAB

DECEMBER 1984 COST REPORT (K$)

	Program Element	Labor	Mat'l & Services	G&A	Month Total	Year To Date	Annual Budget
3.1	General	1.5	7	3.1	11.6	30.7	340
3.2	Magnet Models	81.3	39.5	43.5	164.3	717.2	3350
3.3	Facility Development	9.6	6	5.6	21.2	84.2	340
	FNAL SSC PROGRAM	92.4	52.5	52.2	197.1	832.1	4030
3.4	Superconductor Development	0	33.8	12.2	46	69.1	400
3.5	Cryostat Development	84.5	24.8	39.4	148.7	520.7	890
3.6	Accelerator Physics	35.1	2.7	13.6	51.4	178.2	830
	FNAL ACCELERATOR RELATED PROG	119.6	61.3	65.2	246.1	768	2120
	FNAL TOTAL	212	113.8	117.4	443.2	1600.1	6150
	Additional Commitments		569.6				

TABLE C-4

LAWRENCE BERKELEY LABORATORY

DECEMBER 1984 COST REPORT (K$)

	Program Element	Labor	Mat'l & Services	G&A	Month Total	Year To Date	Annual Budget
4.1	General	6	6	7	19	39	115
4.2	Magnet Models	18	4	11	33	94	395
4.3	Analysis	8	1	4	13	35	125
4.4	Instrumentation/Measurements	4	2	3	9	38	155
	LBL SSC PROGRAM	36	13	25	74	206	790
4.5	Accelerator Theory	9	7	8	24	209	800
4.6	Superconductor Development	3	3	3	9	28	410
	LBL ACCELERATOR RELATED PROG.	12	10	11	33	237	1210
	LBL PROGRAM TOTAL	48	23	36	107	443	2000
	Additional Committments		111				

TABLE C-5

TEXAS ACCELERATOR CENTER

DECEMBER 1984 COST REPORT (K$)

	Program Element	Labor	Mat'l & Services	G&A	Equip.	Month Total	Year To Date	Annual Budget
5.1	General		21.6	10		31.6	117.6	825
5.2	Short Magnet Models	28.9	11	5		44.9	362.9	1150
5.3	Long Magnet Models	10.1				10.1	50.1	1660
5.4	Tooling					0	0	630
5.5	Theoretical Analysis	1.5				1.5	7.5	130
5.6	Facility Development				6.3	6.3	34.3	605
	TAC SSC PROGRAM	40.5	32.6	15	6.3	94.4	572.4	5000

TABLE C-6

SSC PROGRAM SUMMARY

DECEMBER 1984 COST REPORT (K$)

		Labor	Mat'l & Services	G&A	(Equip)	Month Total	Year To Date	Annual Budget
1	CDG TOTAL	83	138	62		283	525	4850
2	BNL SSC PROGRAM	184	109	110		403	1198	5330
3	FNAL SSC PROGRAM	92.4	52.5	52.2		197.1	832.1	4030
4	LBL SSC PROGRAM	36	13	25		74	206	790
5	TAC SSC PROGRAM	40.5	32.6	15	6.3	94.4	572.4	5000
	TOTAL SSC PROGRAM	435.9	345.1	264.2	6.3	1051.5	3333.5	20000

TABLE C-7

ACCELERATOR RELATED R&D PROGRAM SUMMARY

DECEMBER 1984 COST REPORT (K$)

		Labor	Mat'l & Services	G&A	(Equip)	Month Total	Year To Date	Annual Budget
1	CDG TOTAL	0	0	0		0	0	0
2	BNL PROGRAM	74	25	34		133	425	1670
3	FNAL PROGRAM	119.6	61.3	65.2		246.1	768	2120
4	LBL PROGRAM	12	10	11		33	237	1210
5	TAC PROGRAM	0	0	0		0	0	0
	TOTAL ACCEL RELATED R&D PROG	205.6	96.3	110.2	0	412.1	1430	5000

D. Appendix I

Information for the Workshop on SSC Commissioning and Operations (Jan 14-18, 1985)

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o	Expected Participants	37
o	Daily Schedule	38
o	Cyogenic Questions	39
o	Design Questions	40
o	Operations Questions	41
o	Systems Questions	42

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Workshop on SSC Commissioning and Operations

January 14 - 18, 1985

Participants

Workshop Coordination

Don Groom	University of Utah
Peter Limon	Central Design Group
Karen Larsen	Lawrence Berkeley Laboratory

Cryogenics Group

William Fowler, Coordinator	Fermi National Accelerator Laboratory
Donald Brown	Brookhaven National Laboratory
Claus Rode	Fermi National Accelerator Laboratory
Peter VanderArend	Cryogenics Consultants, Inc.
John Van Sloan	Air Products & Chemicals, Inc.
Richard Wolgast	Lawrence Berkeley Laboratory

Design Group

Christoph Leemann, Coordinator	Lawrence Berkeley Laboratory
Alex Chao	Central Design Group-SSC
Ernest Courant	Brookhaven National Laboratory
Don Edwards	Fermi National Accelerator Laboratory
Eugene Fisk	Fermi Natoinal Accelerator Laboratory
Albert Hoffman	Stanford Linear Accelerator Center
Steve Peggs	Central Design Group-SSC
Jack Peterson	Lawrence Berkeley Laboratory

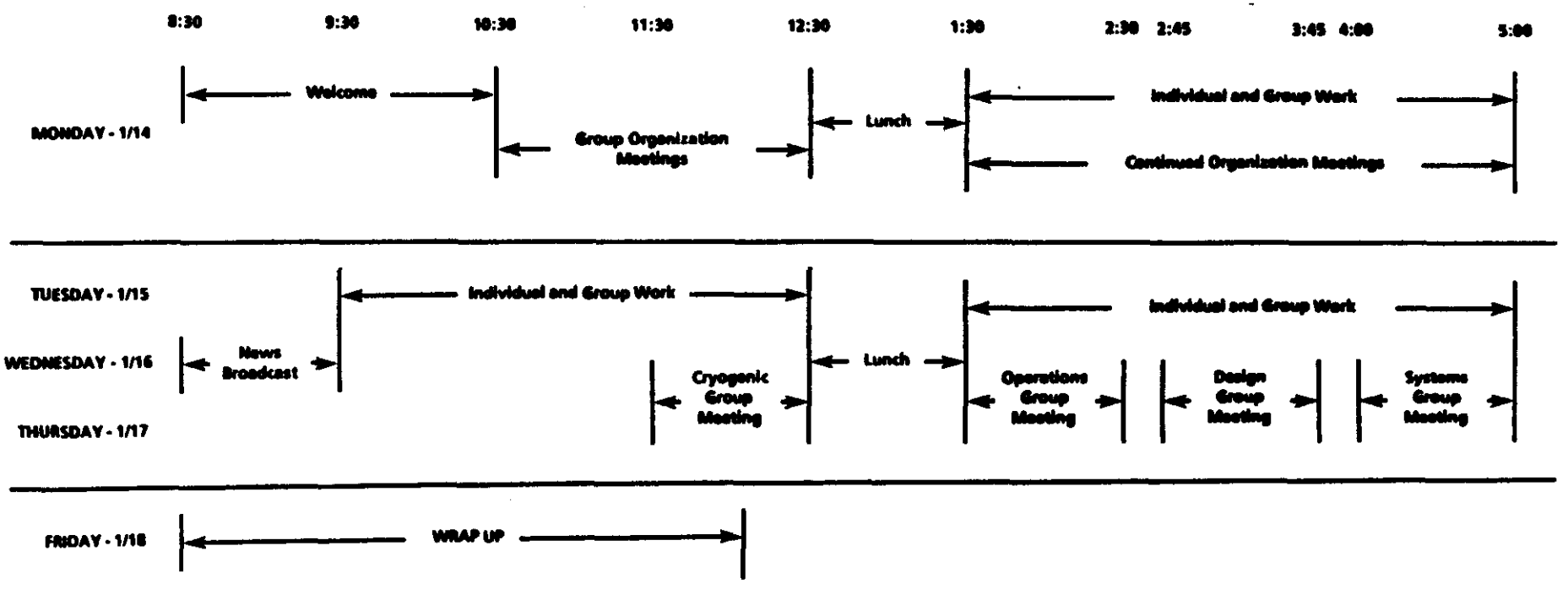
Operations Group

Paul Reardon, Coordinator	Brookhaven National Laboratory
Phil Bryant	CERN
Lyn Evans	CERN
Mike Harrison	Fermi National Accelerator Laboratory
Russ Huson	Texas Accelerator Center
Andrew Hutton	Stanford Linear Accelerator Center
Derek Lowenstein	Brookhaven National Laboratory
Robert Mau	Fermi National Accelerator Laboratory
Rich Orr	Fermi National Accelerator Laboratory
John Poole	CERN
Luc Vos	CERN
Peter Wanderer	Brookhaven National Laboratory

Systems Group

Donald Hartill, Coordinator	Cornell University
Dixon Bogert	Fermi National Accelerator Laboratory
Richard Cassel	Stanford Linear Accelerator Center
Karl Koepke	Fermi National Accelerator Laboratory
Gerry Tool	Fermi National Accelerator Laboratory
John Zeigler	Texas Accelerator Center

WORKSHOP ON COMMISSIONING AND OPERATIONS OF THE SSC
Daily Schedule



Cryogenic Questions

- Large Scale Cooldowns
  Time, cost, how often?

- Magnet Replacement
  Time required, beam valves, how is it done, how often?

- Steady State Operation
  Removing heat from synchrotron radiation and ramping.

- Two Phase Flow
  Is it stable?

- One Phase Flow
  What do the recoolers look like?

- Quench Recovery
  Two-in-one implications.

- Separate Cryogenics
  Should one-in-one magnets have separate cryostats?

Design Questions

- Magnet Selection

  Is it desirable? What are the two-in-one implications?

- Fractional Testing

  During commissioning, how many magnets will have to be changed?

- Field Level

  What is the difference between very large and ultra large rings?

- Optics Restrictions

  How do they depend on magnet type? How important are they?

- Beam Crossing

  Problems related to magnet type.

- Correction Elements

  Problems related to magnet type. What level of redundancy?

Operations Questions

- Installation

  Questions related to magnet type.

- Ramp Cycle Time

  Is a slow ramp okay? What about eddy currents?

- Beam Injection and Abort

  Questions related to magnet type, and side-by-side/over-under configurations.

- Quenches

  How often might we expect them? Are they at injection or high field?

- Beam Conditioning

  How long does it take to fill, accelerate, condition, collide, etc.?

- Partial Acceleration

  Is it possible to accelerate one beam while injecting the other? Is it useful?

- Overall Complexity of Machine Operation

  Related to magnet type.

Systems Questions

- Quench Detection and Protection
  Different methods for different magnet types.

- Power Supply Configurations
  Related to magnet type.

- Regulation Requirements
  Electromagnetic coupling. Transmission line effects.

- Vacuum System, Control System
  Differences related to magnet type.