February 1988 SSC Monthly Report

SSC-165

PROJECT SUMMARY

CENTRAL DESIGN GROUP (CDG)

Magnets

The MSI Meeting February 16–17 was held at Fermilab.

A comprehensive plan that will coordinate all future magnet R&D, up to the testing of preproduction magnets in FY91, is being drafted.

A *Commerce Business Daily* annoucement that will begin the planned magnet industrialization program was prepared. Commercial establishments that have specific related experience will be invited to express their interest in receiving superconducting magnet technology from laboratories involved in SSC magnet fabrication.

Accelerator Physics

Participation in the aperture experiments at the Fermilab Tevatron (E778) was the highest priority effort of the Accelerator Physics Division. This work continued an experiment begun in May, 1987. Thirteen shifts were taken. The recent run was designed to address a few unresolved issues from the May run and to explore more details of the nonlinear dynamical effects of the beam in the presence of intentional sextupole nonlinearities.

One unresolved issue from last May was disagreement between theory and experimental results at high sextupole strength; the agreement had been excellent at moderate sextupole strength.

A complication that arose during the May run was caused by a collective synchrotron oscillation during the study of injection efficiency in the presence of intentional sextupoles. This time, the complication was avoided by turning off the rf.

The study of island structures in phase space, although not directly important for the SSC aperture choice, provides exciting details of the nonlinear dynamics effects, useful for later studies.

Additional work was done on the generation of differential algebra methods to analyze the SSC lattice, and on long-term tracking of the SSC, including both magnet errors and synchrotron oscillations.

Accelerator Systems

Phase II of the dynamic simulation of the SSC cryogenic system was reviewed February 24–25 in Allentown, Pennsylvania. Results are very encouraging. Air Products Corporation thermodynamics software is being tested with good initial results.

Accelerator Systems provided much of the software and some of the hardware for data collection in the E778 run on the Tevatron. The run was successful and data analysis is proceeding at the CDG.

The sample holder for the SRC (Wisconsin) photodesorption experiment is being redesigned at LBL. Modifications and fabrication will start soon. The major goal of the improved design is to decrease the temperature rise of the sample when it is struck by synchrotron light.

A draft of the Task Force Report on Radiation Levels in SSC Interaction Regions has been sent to Task Force members for final review.

Extensive effort was devoted to various magnet issues and tests. Preparations of hardware and software at FNAL for tests of magnets DD0010 and DD0012 were made. An outline of the test plan for DD0010 was written. Test data from D000X are being analyzed.

Conventional Facilities

Service area shafts were modified as required by the possible new low-energy booster.

The first draft of the Safety Review Document, which analyzes possible SSC hazards and mitigation measures in a non-site-specific manner, was sent to the Department of Energy for comment.

A specialist in rock mechanics and excavation engineering and a geologist who was formerly a particle physicist joined the division.

Project Planning and Management

Activity in the PP&M Division emphasized both support for computer software and hardware in the CDG and preparation of materials to support the presentation of the DOE Construction Plan to Congress.

Some technical improvements were made to the Open Plan-based R&D schedule and management plan, but effort was confined to maintenance of the existing data base and small schedule modifications.

Brookhaven National Laboratory (BNL)

Long model DD0014 was completed and shipped to Fermilab. This magnet resembles DD0012, shipped last month, except that its stainless steel collars incorporate tapered keys.

DD0011, an LBL dipole with aluminum collars and tapered keys, was collared and inserted into its iron yoke.

Coil assembly and collaring of DD0015 were successfully completed. This magnet uses stainless steel collars with tapered keys, and, like the Tevatron magnets, the collared coil assembly slides in the yoke.

The short magnet program focused on collaring and assembling DSS10. Good results were obtained in the initial tests of this magnet.

Fermi National Accelerator Laboratory (FNAL)

Final tests were performed of the wiring and electronics for the 800-channel increase in the data acquisition system, in preparation for tests of magnets DD0010 and DD0012. DD0010 was mounted and prepared for cooldown. A site-wide power reduction and the failure of a refrigeration compressor delayed the cooldown until the third week in March. Mounting and connecting of DD0012 proceeded smoothly.

Magnet DD0014 was received from BNL on February 10. This magnet will be equipped with the first of the second-generation cryostats. The cryostat is being equipped with extensive instrumentation to evaluate its mechanical and cryogenic performance.

Prototype collaring tooling being developed as part of pilot dipole production was successfully used to collar a set of 1-meter LBL coils. The coil is being sectioned to make cookies for analysis of conductor positioning.

The second run of accelerator experiment E778 followed the end of the fixed-target run. Results are being analyzed to understand their implications for SSC lattice design.

Lawrence Berkeley Laboratory (LBL)

Four cabling runs were completed: three production runs for the 17-m dipole and 1.8-m dipole coils, and one R&D experiment to evaluate a 24-strand option for the inner-layer cable.

Model D15A-5 was collared and will be inserted into the laminated yoke blocks from model D15A-4F. Magnet D15A-4F was retested after having been at room temperature for 21 days. One retraining quench occurred in the outer layer at 6905 A, a 200 A drop from the plateau value. There had been no retraining after the first thermal cycle, in which the magnet was at room temperature for three days.

At BNL, long dipole model DD0011 was inserted into its yoke, and new inner coils were wound for DD0013.

Two gauge packs, using the H-type inner gauges, were assembled and calibrated. Pack calibrations are linear and agree very well with block calibrations and with the ANSYS prediction. They will be tested in D15A-5.

A magnetic design procedure for bulged-end dipoles was developed. Prototype parts were molded for the internally supported straight end.

CDG REPORT

MAGNET PROGRAM

Magnet System Integration Meeting

The agenda for the MSI meeting at Fermilab on February 16-17 was as follows:

Introduction	CDG
Status of FNAL long magnet tooling	FNAL
Planned BNL tooling improvements	BNL
Further BNL tooling improvements	BNL
Insulation review	CDG
LBL perspective on insulation	LBL
BNL perspective on insulation	BNL
FNAL perspective on insulation	FNAL
DSS6 retest	BNL
Status of DD0010, 12, 14 and 15	BNL/FNAL
Cryostat effort at FNAL	FNAL
Upcoming coil motion measurements	FNAL
Objectives and schedules for further long magnets	CDG/BNL/FNAL
Performance of stand 5	FNAL
BNL strain gauges at FNAL	FNAL
Dipole tilt angle considerations	CDG
Results for D-15A-4F	LBL

The meeting began with a brief summary of magnet plans for the immediate future. The present focus is on understanding axial motions via ten 17-meter magnets: DD0010, 11, 12, 14, and 15 (all in various stages of construction or preparation for testing); DD0016, 17, and 18 (to be duplicates of DD0014); DD0021, 22 (basically DD0011 and 13 rebuilt with the first Fermilab coils). The next batch of long magnets, constructed at BNL and Fermilab, will address the issues of training and field quality.

The long magnet tooling program at Fermilab was discussed. The 6-foot-long mold and collaring press are both essentially operational. Preparations are being made for a 60-foot-long mold. The need to better understand the cable tolerance window was also discussed. Cold mass pilot production should start early next summer. Tooling improvements at BNL were discussed, both near-term for 1.8-m and 17-m tooling, and future plans (not yet funded). The latter will include further improvements of formblocks and a mandrel preparation station.

A discussion of the need to improve coil insulation was opened by the CDG. It was followed by a review of shorts that have occurred during assembly and operation of long magnets.

The views of the various labs on insulation were expressed. It was agreed that alternative schemes must be pursued as back-up (via short magnets); several schemes based on Kapton™ film with glass fibers attached or embedded will be investigated.

Two highly successful short magnet tests were reported: BNL's DSS6A (DSS6 reassembled with shims between collars and yoke), and LBL's D-15A-4F (the third model magnet with tapered keys in an aluminum collar). Both magnets exhibited excellent training performance. Long magnets DD0010, 12, and 14 were reported to be in various stages of preparation for testing at Fermilab. Preparations for experimental coil studies at Fermilab friction were reported to be going well.

In the additional discussion of objectives, schedules, and requirements for further long magnets, the possibility of a long test cryostat was raised, and the pros and cons of rebuilding DD0010 and 12, as well as DD0011 and 13, were aired. Forthcoming long magnets DD0016, 17, and 18 will be similar to DD0014 and will feature yoke-collar shims and tapered keys. These models will be constructed with improved tooling. Short magnets DSS10, 11, and 12 will replicate DSS6A. DSS13, 14, and 15 will test new features.

Thus far stand 5 has met all specifications and operates stably. D000X is installed on the stand as a test vehicle.

Good progress was reported on the program for utilizing BNL-type strain gauges at Fermilab.

Finally, a presentation was made on vertical plane measurements in long dipoles and on the current SSC criterion for this parameter.

R&D Plan

The magnet division is drafting a comprehensive R&D Plan for conducting all phases of future magnet research and development. The plan will extend up to the testing of preproduction magnets in FY91 and will encompass analysis and related activities, as well as magnet fabrication and testing. It is anticipated that the report will be completed at the end of March. A meeting was held on February 27 to discuss the impact of the R&D Plan on the activities of other CDG divisions, particularly on the scheduling of site preparation and test facilities.

Magnet Disassembly

As previously reported, a committee was appointed in November 1987 to oversee the disassembly of magnet DD000Z, to evaluate its performance, and to appraise the cause of its failure. The committee submitted its report to J. Peoples, the Magnet Division Head. Copies of the report were sent to the program managers at the participating laboratories. Comments received from the program managers will be included in the published version of the report.

Magnet DD0010, which is currently being prepared for testing, will be dismantled and inspected following the test program. A committee chaired by J. Tompkins of the CDG has been appointed to oversee this task. Committee members are C. Goodzeit, P. Wanderer (BNL), T. Nicol (FNAL), R. Coombes, A. Devred, J. Kaugerts, and K. Mirk (CDG). The committee held its first meeting at FNAL on February 15, to prepare an initial disassembly proposal. The proposal was presented at the Magnet Meeting held at FNAL the following day. Unlike magnet DD000Z, which was opened by cutting the skin weld, the committee proposal was to relieve the load on the end plate in a controlled way and to try to measure the spring constant of the end of the magnet before cutting the skin.

Industrialization

Preparations were made for the publication in the *Commerce Business Daily* of an announcement to initiate the first phase of the planned industrialization program. The intent of the first phase is to transfer to industry the technology that has been developed by laboratories participating in SSC magnet fabrication. Commercial enterprises with specific related experience will be requested to express their interest in participating in the technology transfer program. Meetings were held at FNAL and BNL to discuss program requirements. Magnet DD0014 was selected as the probable candidate magnet on which to center the program, as it features the latest tapered-key stainless steel collars and will be the first to use the full iteration-B cryostat.

Cryostat Development

On February 11 a coordination meeting was held at the CDG to bring together representatives from two companies that have contracted to do analysis and measurement work on the cryostat: EQE and Vibration Engineering Consultants. FNAL was also represented.

The purpose of the analysis program is to ascertain that loads applied to components within the cryostat during operation, quenches, earthquakes, transportation, and installation do not exceed allowable levels, and to study the impact of ambient ground motion during the operation of the collider. Calculations based on some assumptions for allowable stresses and stress combinations indicate that, following a few minor modifications affecting the upper magnet of a piggyback pair, the magnets would not be damaged under normal operational conditions nor by a standard earthquake. However, for the first pass, some simplified assumptions for transportation loading condition were used. It was found that under these conditions the stresses in the support posts attaching the cold mass to the cryostat exceed allowable levels. To refine the transportation loading input, data were obtained from two sources, from which acceleration spectra from measured transportation environments were extracted. One part of the current effort is to transform these data into a form suitable for input to the analysis program. In addition, materials properties are under study to determine allowable stresses and ways in which stresses should be combined.

To verify the analysis program and to provide damping values, tests will be performed by exciting oscillations in DD0014 and measuring its response. A planned extension to the program involves measuring the dynamic exposure of a piggyback pair of magnets and measuring the coupled response of a magnet mounted on a trailer.

Following site selection, the seismic and ground motion studies will be repeated with site-specific input data.

Magnet Behavior and Analysis

Finite element work is proceeding along two parallel paths. The NIKE2D model is being altered from C5 to C358A geometry, and material properties are being updated. Meanwhile, a detailed model of NC9 coil and collar has been prepared using ANSYS. Consideration is being given to a proper set of verification experiments for each model.

Recent magnets have a set of end displacement transducers mounted on the end bonnet. An ANSYS calculation has been performed to estimate the effect of bonnet deflection on the readings of these gauges. If the full Lorentz load were transferred to the magnet end plate, the bonnet deflection would add between 4 and 9 mils to the apparent gauge reading, depending upon the assumptions made for the interaction between the end plate and the shell. This is a large correction for a thick end plate, or when measuring the yokes, neither of which deform very much. A report has been prepared on this computation.

CDG Magnet Division personnel continue to be directly involved in the magnet test programs at the various laboratories. Help was provided to evaluate the hardware and software to be used for testing DD0010 at FNAL. Data from strain gauges and displacement transducers on the retest of long magnet D000X were analyzed, and a report was prepared. This experiment was conducted, at least in part, as a verification test of the displacement transducers, which appear to work smoothly and reliably. Data from the retest of short magnet DSS6, particularly for shell strain gauges, were analyzed and a report was prepared.

Magnet Measurement

At the magnet measurement workshop held at the CDG in November 1987, several methods were proposed for performing warm magnetic measurements in industry. The status of these proposals was reviewed. Search coils and, perhaps, Hall probes are the only concepts mature enough to be likely to work without a great deal of R&D. The next step will be to prepare an engineering design for a coil system of the type used at DESY. A detailed review will be conducted of the relation between existing warm and cold measurements.

Database Coordination

As part of an effort to compile and maintain a single, readily accessible database for all SSC superconducting material information, the magnet division has transferred copies of all the LBL superconductor databases and reports onto their IBM PC. These databases and reports have been copied to the CSA VAX cluster and are in the process of being copied to the FNAL and BNLDAG VAX clusters. The databases are in IBM PC dBASE III+ format and should be importable into other database systems. The reports are regular ASCII text files and are printable.

ACCELERATOR PHYSICS

E778 Status

Magnet Aperture. The aperture of the SSC magnet is one of the most important parameters of the SSC design. This experiment (E778) is an collaboration of the CDG, Fermilab, Cornell, CERN, and SLAC. The purpose is to confront theoretical studies with experiments and to study the aperture criteria used in the SSC conceptual design. The experimental data will be analyzed in the coming months. Results will have a direct impact on the choice of the SSC magnet aperture, and, consequently, on the magnet program. Preliminary results of data analysis will be reported as they become available in future monthly reports.

Data Acquisition. To obtain more experimental data than was possible during the 1987 experimental run, a million-turn beam position instrument (MIRABILE) was commissioned at the CDG and installed at Fermilab. The million-turn logging capability was intended for and successfully applied to the observation of beam capture into resonance islands. The evaluation capability was used for Fourier analysis of the beam and other online data monitoring.

Also tested were the diagnostic capabilities needed for the SSC. Using the Fermilab beam-position monitor signals, tune, chromaticity, and local coupling were measured. Special emphasis was placed on the chromaticity measurements, as the large radius of the SSC will make quick measurement of and feedback on this quantity desirable. For this measurement, the rf frequency was raised, then lowered, and finally returned to its initial value. The total cycle took about five seconds. The tune was measured at each value. Figure 1 shows the measured chromaticity plotted against the calculated chromaticity-correcting "knob" of the Tevatron.

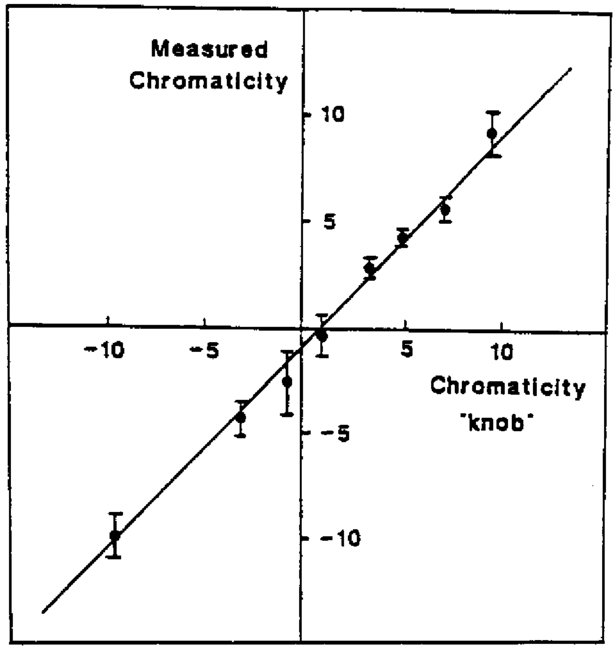


Fig. 1.

Resonance Islands. Four shifts of dedicated accelerator time were spent making resonance measurements during this run of E778. Most attention focused on the 2/5 resonance, although a cursory examination of the 3/8 resonance was made. Three distinct scans of physically significant variables were performed, taking tens of thousands of turns' worth of turn-by-turn information at each setting of the variables under consideration. First, data were taken in a closely spaced scan of base tunes at each of several initial kick amplitudes. This enabled the resonance width to be measured. Second, closely spaced base tunes were scanned for several values of a differential current put into the C sector and F sector experimental sextupoles, in order to observe how the sextupoles interact in constructing a higher-order resonance. Third, the tune modulation amplitude and frequency were scanned at three differential initial kick amplitudes. With the range of modulation parameters available to the experiment, this enabled the study of the transition between adiabatic resonance trapping and chaos. The analysis of the few hundred megabytes of information recorded has only just begun.

TPSA Status

M. Berz, E. Forest, and J. Irwin worked on differential algebra methods (also called truncated power series methods) to generate and analyze maps for the SSC full ring or lattice segments.

M. Berz had added features to this differential algebra package for calculation of Poisson brackets, partial inversions, and map compositions. Partial inversions are relevant to finding generating functions and fixed points for closed orbits.

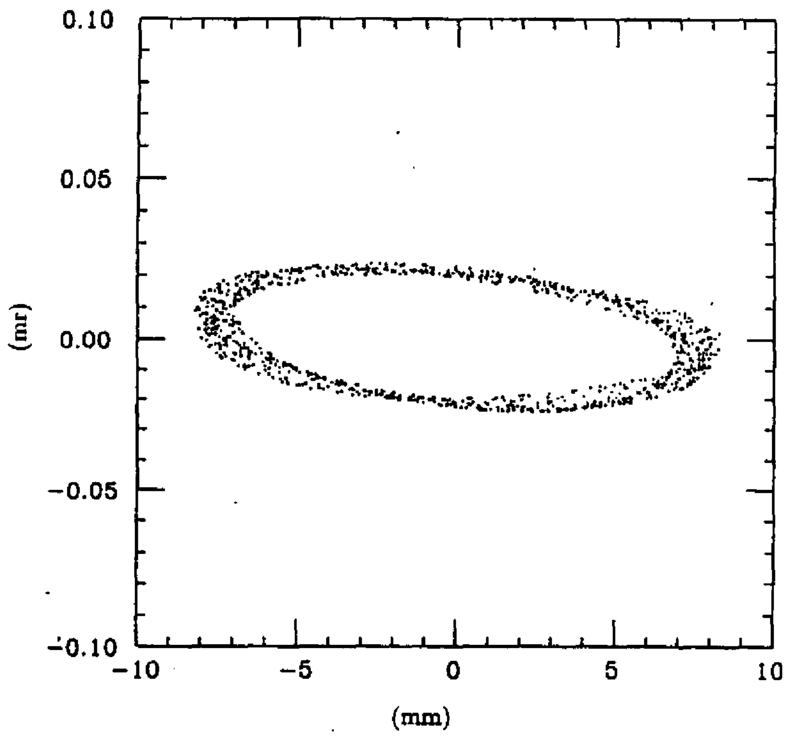
E. Forest has written a program using the differential algebra package to analyze maps using a normal mode analysis he has developed. An important outcome is the ability to find a pseudo-Hamiltonian that generates the given map. The program can generate a variety of proscribed "normal" forms to study mappings.

J. Irwin has begun modification of the THINTRAC program for generation of high order, multi-variable maps, minimizing the number of differential algebra multiplications in multipole calculations, and re-arranging the energy dependent operations. Formulas for the number of floating point operations required in the basic differential algebra operations were developed. Timing tests indicate that a full map of the SSC, including up to 9th order multipole errors in every dipole, can be carried out to 9th order in 5 variables with two hours of CRAY CPU time.

SSC Long-Term Lattice Tracking

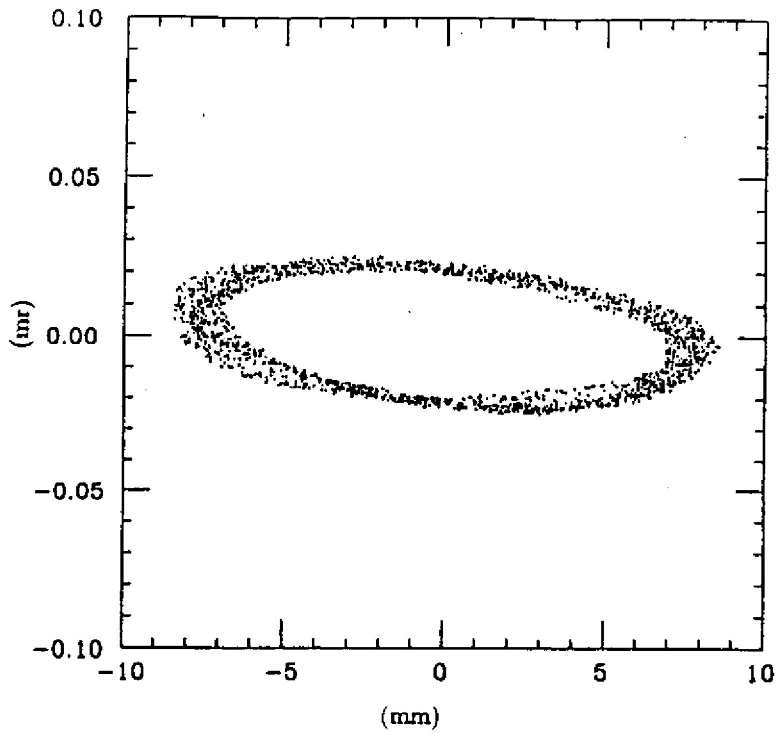
The full 90-degree SSC lattice with random errors in the dipoles was tracked, including synchrotron oscillations, using the program THINTRAC. Results from tracking particles for 40 to 100 synchrotron periods, at a synchrotron tune of 1/500, indicated that the particle orbits were still stable at 10 percent smear amplitudes, even when synchrotron motion was added.

Figures 2 and 3 show surface-of-section plots for chromaticities of 0 and 10 units, respectively.



X-PX PHASE PLOT

Fig. 2.



X–PX PHASE PLOT
X–PX 10 UNITS OF CHR

Fig. 3.

A one-turn map was found using THINTRAC. Multiple-turn tracking based on the map was compared with the straight tracking above. At first the tracking with the map behaved rather poorly and particles were lost in hundreds of turns. Working on the assumption that the tracking with map procedure, which involves finding the generating function and using a Newton search procedure on the end point, introduces spurious high orders, the Lie operator for the map is first multiplied by 1/N, with N equal to 10. Then a map and generating function are calculated from this Lie operator. Particles tracked from this generating function are now stable for 50,000 turns (corresponding to 50,000/N, or 5,000 "actual" turns). Results agree quite favorably with straightforward tracking.

Beampipe Stress

During a quench of the superconducting dipoles, the eddy current induced in the copper layer inside the beam pipe will produce a Lorentz pressure, flattening it at the vertical poles. The bigger the deformation, the easier it will be for the partially vaporized helium to crush the beam pipe. A computation was completed of the helium pressure p required to further distort the beam pipe beyond its elastic limit when a maximum equatorial Lorentz pressure P_m is applied. The result is shown in Fig. 4. The tensile yield stress for the pipe material Nitronic 40 is taken as $\sigma_{yp} = 115 \pm 25$ kpsi. As a safety factor, it is suggested that half of this value be used.

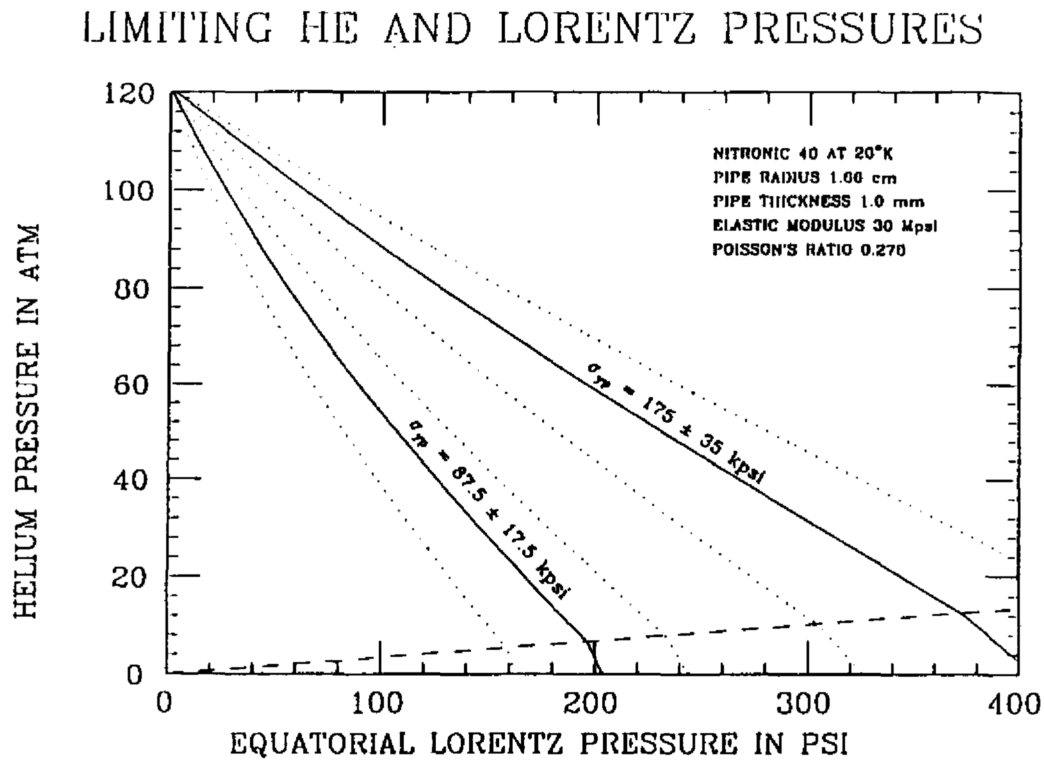


Fig. 4.

ACCELERATOR SYSTEMS

Cryogenics System Modeling Program

It has been reported previously that a contract with Air Products and Chemicals, Inc., for dynamic modeling of the SSC cryogenic system has been signed, and that work began in December 1987. This project has now reached its first milestone. After the definition phase, a set of helium thermodynamic properties computer routines are written that are optimized for use in the dynamic model. A considerable amount of the computing time is consumed by calls for thermodynamic properties. The usefulness of the cryogenic system computer model depends on its execution time; if the operation is too slow, both the size and the detail of the model are limited. So, having good and efficient properties routines of several levels of accuracy and speed is essential to the success of the modeling program.

This task was completed, and a meeting was held in Allentown February 25–26 to review the work and to receive the software. The thermodynamic properties package implements seven fluid state specifications in models of four levels of accuracy and completeness: first, the complete NBS model for helium including the superfluid state properties; second, the NBS model including only the normal state properties; third, a simplified NBS equation of state that is fully accurate for the saturation properties and approximate in the liquid region; and fourth, an equation of state cubic in the specific volume that is approximate, but a good approximation, throughout the region of interest in the system modeling problem. All equations of state are approximations, so "accurate" in this instance means that the measured properties of helium are represented to the extent of the measurement accuracy.

The speed for typical calls in each of these models was assessed, and an estimate by means of a simplified case was made of the CPU time needed to perform simulations of the SSC cryogenic system of useful scale and duration. There is a speed ratio of about a factor of two between each successive level of thermodynamic model. A full-scale simulation utilizing the fourth and fastest helium model can be expected to operate roughly in real time on the VAX 8700 processor. The accuracy of this approximate thermodynamic model appears to be adequate for many, if not most, of the problems of interest in the simulation. The prognosis thus is very good that the system model being developed under the contract will operate in a fully useful manner, even without extensive computing resources.

Work under this contract is expected to be complete in June, 1988.

Dipole and Cryostat Integrated Thermal Model

In 1987, work was completed under a contract between the CDG and General Dynamics Space Systems Division for the development of a computer thermal model of the dipole and cryostat. The final report of this work was delivered at the end of September.

Since that time a contract for additional work using this model has been signed. This work has now been completed, and a final review of the results was held at the CDG on February 26. The subjects of these thermal studies include determination from the model of the sensitivity of the various heat loads to the quality of the cryostat thermal insulating vacuum, and the effects of multi-layer insulation on the 4 K surfaces of the magnet cold mass; the variation of the heat loads with the temperature of the two shields in the cryostat; the variation of the peak heat flow into the helium in the bypass holes in the magnet yoke with the temperature distribution in the magnet winding after a quench; and the sensitivity of the temperature rise in the magnet coils, due to the synchrotron radiation heat load, to the value of the thermal conductivity of the Kapton™ ground insulation used between the coils and the collars.

Results of the calculations show the advantage in immunity to the effects of degraded cryostat vacuum provided by multi-layer insulation on the coldest parts of the magnet systems. These results focused attention on thermal conduction and convection processes of heat transport within the magnet. In addition, the shield temperature sensitivity studies provide the information needed for a final consideration of the optimum temperatures for the cryogenic refrigeration system.

These modeling studies, and others like them, are needed to support measurement programs, magnet and cryostat design and manufacturability studies, and cryostat cost optimization. Further work with the Integrated Thermal Model is being planned.

Systems Modeling and Engineering

During the week of February 8–12, R. Carcagno participated in the UCLA short course "Modeling and Simulation of Engineering Systems in the Supercomputer/Minisupercomputer Era." The latest progress in computational methods for modeling and simulation and best available techniques were discussed. Of direct interest to CDG activities was the general agreement that the Livermore solver LSODES is the best integrator available to solve large and stiff systems of ordinary differential equations, and that FORTRAN is preferred instead of simulation languages (for example, ACSL) when the execution speed is important and the process is complex. As an example of boundary value problems, a low-temperature helium heat exchanger analysis was presented as a particularly difficult problem due to its stiffness. Techniques such as the shooting method or finite difference method fail. The conclusion was that a fast and reliable technique for this problem is to apply first spline function approximations to the differential equations and then to determine the spline function coefficients.

Speakeasy was installed in the CSA3 machine.

The thermodynamics program provided by APCI as part of phase II of our contract was also installed on the LBL-VAX cluster. The thermodynamic code and the Speakeasy interface are running and, so far, give the same results as reported by Air Products. From the installation problems it is apparent that Speakeasy Fortran objects seem to be non-transportable, and that the Speakeasy procedure that generates them from the Fortran source code has a bug, which forces the user to specify certain attributes for the common blocks during the linking procedure.

E778 Experiment

A successful E778 run on the Tevatron took place. Accelerator Systems contributed a large part of the software and some of the hardware used to take data. The power and flexibility of workstations was demonstrated at FNAL.

An interesting sidelight resulted from taking a hard look at the beam position monitor front-end electronics. It is fine for closed orbit and works for limited turn-by-turn measurements, but generates noise. R. Talman's peak sensors were considerably cleaner (although non-linear at the intensities of the run) and provided lots of physics information. Data analysis is proceeding at the CDG. (For more information on this experiment, see the Accelerator Physics Division report.)

CONVENTIONAL FACILITIES

In studying a possible new low-energy booster design, reported in the January Monthly Report, the functional adequacy of the 30-foot service area shafts was examined. Modifications necessitated by equipment handling, safety, and radiation shielding requirements were made. Members of the Magnet Division, FNAL, and the Conventional Systems Division met to discuss tunnel clearances for the magnets. A study was begun to determine optimal means of access for welding and connecting the magnets.

The first draft of the Safety Review Document was sent to the Department of Energy for comment. The document analyzes in a non–site-specific way the possible hazards associated with the SSC, and it describes the measures taken to eliminate or mitigate them. T. Toohig will meet with DOE safety experts to discuss the document before receiving comments on the draft. Completion of the document is scheduled for June.

J. Sanford provided technical assistance to the DOE and attended the scoping meetings for sites on the list of best qualified sites.

The Conventional Systems team was joined by Dave Goss, on sabbatical from Nebraska Wesleyan University, and Chris Laughton, from CERN. Goss is a particle physicist turned geologist. Laughton is a specialist in rock mechanics and excavation engineering. He is on loan for two months from LEP, where he played a substantial role in the design and construction of the tunnel and underground facilities.

PROJECT PLANNING AND MANAGEMENT

A significant effort went into creation of the software structural elements for a relational database system to serve the personnel, salary, and travel related needs of the CDG Administrative Services Section. The Acius program "Fourth Dimension" is the commercial basis for this effort. This effort will consolidate and unify the data management needs of several functionally related groups in the CDG, and it will aid cost tracking and budget projections. It is expected to be largely complete and put into use in March.

Work continued at a moderate pace to support Open Plan tracking of magnet R&D at BNL, FNAL, and LBL. Because funding and production uncertainties continue to cause planning problems with the FY88 magnet R&D program, it has been impractical to pursue ordinary fixed-scope program planning approaches this year. It has, nevertheless, been possible to track ongoing work and to characterize (as well as these uncertainties permit) future magnet R&D work. The Open Plan tracking is primarily being pursued in a CDG context. A new effort to implement this approach in the laboratories will be made when the funding picture is clarified.

On the technical side, the new version 3.0 of Open Plan is being tested at CDG prior to its full implementation in the FY88 R&D Plan. This version is a significant upgrade from the 2.0

version currently being used. The goal is to fully test and validate version 3.0 before the new version is adopted. It is generally understood and appreciated that version 3.0 is significantly more powerful and flexible, and that the effort needed to effect its implementation will be justified by the resulting improvement. The time-scale for full R&D Plan adoption is March 1988.

Work progressed on an accurate historical record of recent progress in the SSC magnet R&D Program. The effort was undertaken in the Open Plan context and covered the period during which Open Plan was used to track the magnet R&D (FY87, 88).

The onset of the 1989 budget process in Washington, and the associated planning and presentations, introduced an intensified period of SSC Construction Project updates and revisions. Using the Open Plan characterization of the SSC Construction activities, CPN08 was refined and used to plan documents in support of the proposal for SSC Construction being submitted to Congress this year. The detailed nature of the Open Plan method provides appropriate documentation and technical backup for the high-level schedules actually presented to Congress. This work will continue and evolve over the year, to keep pace with the progress of associated legislation in Congress.

In addition to the specific activities outlined above, PP&M continued the usual maintenance, backup, and support activities to maintain the CDG's computer-associated activities in a state of high reliability. Software support, in the form of consultation, continues to be provided to all CDG divisions by PP&M experts.

BNL Report

Model Magnets

The cold mass of DD0014 was assembled and shipped to FNAL. At the present time, DD0010 awaits testing on a stand at FNAL. DD0012 is assembled into its cryostat, but is awaiting check-out of the new test stand (5) with D000X as the test vehicle. DD0014 is being prepared for insertion into a cryostat.

DD0015 was successfully collared with minimal springback (500 psi) and no electrical shorts. This success is attributable to a combination of tapered-key collars and attention to details, such as proper sizing of components. Unlike DD0010, 12, and 14, the collared coil of DD0015 is designed to slide within the yoke, resembling the FNAL Tevatron magnets.

DD0011 was successfully collared by LBL personnel and inserted into the yoke. By the end of the month the shell was being welded. DD0011 has aluminum collars with tapered keys and the NC-9 cross section. Preparation of coils for the next magnet in this series, DD0013, also progressed.

Short magnet DSS10 was collared, installed in the yoke, mounted to the "top hat," and tested in the vertical dewar. The magnet achieved short sample performance after 3 training quenches and behaved like earlier magnets in this series.

Photography has been completed of the cross section of DSS4. The plan is to enlarge these photographs and measure conductor positions, to help optimize coil design. Other research-and-development work included longitudinal thermal contraction measurements; end plate stiffness tests on DD0014; measurements of the longitudinal modulus of a collared coil; preparations for azimuthal coil modulus measurements; and contraction measurements, facilitated by fabricating extensometers for monitoring coil deflections.

Optimizing the coil design for the next series of magnets continued. It is crucial that each coil component fits accurately. The fit of the end saddles will be optimized to provide stability for the midplane lead. The end of the center post has been redesigned to facilitate using the same machining program to produce pole spacer parts. This will ensure an exact fit of these critical components. A die to compress the new asymmetric wedges is being designed that will eliminate the wedge-to-wedge tip buildup at the end transitions.

Orders for the next series of end spacers were placed. These components are 30 percent (by weight) molded glass fiber, one-thirty-second of an inch thick, to match the coil thermal contraction more closely. The asymmetric wedges, G10 end spacers, "pre-preg" material, and end saddle tubes were ordered. The radiation resistance of the G10 materials is being evaluated and alternatives are being examined.

Four inner coils based on the NC-9 cross section were wound and cured for LBL.

Discussions were held with FNAL concerning automatic shell welding tolerances. The set-up for this new welding system is critical, but the potential savings in time certainly warrants the expense. It is now apparent that BNL will have to assume responsibility for achieving these tolerances. With the results obtained by FNAL on twist for DD0010, 12, and 14, mechanical measurements are being re-evaluated over the fiducials and over the precision shells. The introduction of the new welding system should greatly improve the twist aspect. Alternative yoke designs are being investigated, including one-quarter-inch-thick laminations and other insulator/spacer combinations.

Improvements to magnet interconnections that can be implemented on the next group of magnets were discussed with FNAL. The power bus assembly has been reviewed to correct faults observed in DD000Z. Some changes were made but require further work.

Trim coils were received from Multiwire and testing begun. Trim coil material development is also making progress. Sheldahl has completed the first order of PK102 adhesive on a Kapton substrate. Samples of Multiwire polyimide and glass have been received; tests have shown that the pull strength of Sheldahl polyimide improves as the temperature decreases. Tooling development centered on obtaining hardened tooling for locating precision trim coil components and on completing bumper application tooling modifications.

Beam tube work focused on completion of a tube for magnet DD0013, issue of tube welding and operator qualification specifications, evaluation of flange-to-tube weld design, evaluation of Armco Steel Nitronic-40 TIG welds, and evaluation of microstructure and performance of room-temperature and liquid-helium-temperature tensile tests on Nitronic-40 seamless tubing.

A plating facility was set up at Silvex. Equipment requirements for plating evaluation and inspection during this fiscal year were assessed. Power supplies to be transferred to Silvex were located.

Industrialization activities concerned magnet collaring. Video tapes were made of this procedure.

TOOLING AND FACILITIES

Coils

With the completion of the four coils for LBL, coil production activities in Building 924 halted for the moment. Meanwhile, the new curing press is being installed. The hydraulic and oil heating unit from the old press were installed in the same room as the new equipment for the second press. The mechanical assembly of the winder for FNAL was largely completed. Remaining work involves wiring and connecting the automated controls. These are presently being installed.

Designs of 1.8-m outer winding and curing mandrels all were updated. Designs of 17-m inner and outer strongbacks were completed. These have been released to the shops. All parts have been received for the coil assembly tables. Assembly is expected to be completed by next month.

Collars

The present tapered-key collaring press was reworked to eliminate the hydraulic leaks and to make improvements to the removable spacer bars. All flexible hoses were replaced and seals repaired. Shut-off valves were ordered and will be added at the next opportunity. The mounting frame for the horizontal cylinders was deflected and needs attention.

Good progress was made on the preproduction collaring press. The press frame was moved to the designated location and nearly all parts have been attached. Leveling and alignment of the wear plates was started. Several sections of roller conveyors were installed. Work progressed on the upper and lower cylinder mounting plates.

A test fixture was set to evaluate the shell welding fixture.

Field Measurements

The improved suspension was set up, and the electrical leads for the vertical test dewar were reworked. These improvements were successfully tried out when DSS10 was tested.

Design work was completed on the Mole connector. Similar work was started on the gas bypass, and design of the Mole injection system was completed.

SUPERCONDUCTOR

Cable Procurement

Additional inner-coil cable arrived from LBL and is being inspected. This cable is planned for magnets DSS13, 14, 15, and 16.

Miscellaneous

During February the SSC and DSS Flow Charts were updated and released. This completes the SSC Project Data Base update for this quarter.

Stack tests comparing woven glass to Brookhaven's standard slit glass continued and will be completed in mid-March. The delay was caused by the addition of new tests, and by manpower shortages due to higher priority work.

The retest of DSS6 was completed. (DSS6, after a successful initial test, was rebuilt by placing shims between the yoke and collared coil.) New quench data this month show that no retraining was necessary after a thermal cycle for fields up to about 8 T (3.0 K).

The initial test of DSS10 took place. At 4.5 K, the magnet reached a quench plateau after three training quenches. No retraining was required after a thermal cycle, although the quench origin switched coil halves.

FNAL Report

Dipole Cryostat

Insulation blankets for long magnet models DD0012 and DD0014 were fabricated. The facility performed well. Sewing as a method of controlling blanket register and density appears to be effective. More than one blanket can be wound simultaneously. Blankets will be produced for subsequent model magnets on a demand basis.

Work continued on the instrumentation of long magnet model DD0014. Support posts and anchor tie bars were instrumented and proof tested. The cold mass was received and is being cryostated. The balance of the cryostat instrumentation, i.e., the temperature sensors for the heat intercept cables and shields, will be installed during magnet assembly. Accelerometers will be mounted on the cold mass for modal analysis measurements.

Discussions took place with the contractors studying the dynamic structural response of the SSC dipole magnet. It was agreed to perform a model analysis on a next-generation cryostat. It is planned to use long magnet model DD0014, after its magnetic testing. Accelerometers will be mounted on the cold mass to monitor the accelerations of the cold mass resulting from external excitation. The magnet model will be excited in three different configurations: mounted rigidly to the floor, mounted to the excited BNL air ride trailer, and mounted on a lower magnet assembly. The lower magnet assembly for the latter test will be just the vacuum vessel of the next-generation cryostat, since the internal components only minimally affect the dynamic response. The accelerometers will be mounted during the construction of DD0014. Modal analysis is tentatively planned for May.

Instrumentation for cold mass axial motion measurements is being prepared. Magnets DD0010 and DD0012 have been instrumented with strain gauges, to further the understanding of axial motions and load distributions within the cold mass.

The mechanical properties of cold-mass components and assemblies continue to be studied. Apparatus is being assembled for the study of the relative motion between the collared coil assembly and yoke assembly. The test components for the current long magnet model design and a magnet model design having 'improved' sliding between the collared coil and the yoke assembly (as in DD0015) have been received from BNL. The components have been inspected prior to assembly. The initial collared-coil-to-yoke motion study will evaluate the cross section to be employed for long magnet model DD0015. Another possible configuration for evaluation is the low-friction assembly used in the HERA magnets at DESY.

Apparatus was constructed to measure the mechanical stiffness of a yoke pack. The apparatus will first be evaluated for structural integrity and deflection characteristics at room temperature. It will then be operated at liquid nitrogen temperature with yoke packs provided by BNL.

The first phase of test stand 5 commissioning was completed when magnet D000X was successfully powered and quenched six times. Quench currents ranged from a low of 5326 A on the second quench to a high of 5797 A on the third quench. The training behavior on the second thermal cycle was poorer than on the first thermal cycle, during which a current of 6099 A was reached on the sixth quench. Two runs were taken recording strain-gauge data as a function of magnet current. In the first, data were recorded on a ramp to quench; in the second, data were recorded on two complete cycles to 5460 A without quenching. End motion sensors showed movement of the end plates and of the collars on the order of 5 mils at maximum current; the yoke showed at most a few tenths of a mil motion. The noise level of the data suggest that the minimum detectable motion is a few tenths of a mil. Software for the dynamic reading of strain gauges during quenching was not in place, so no data were recorded. To measure the noise level, three strain gauge channels were monitored with an oscilloscope during the powering of the magnet to 3000 A: one inner-coil collar pack gauge, one end-force gauge, and one end motion gauge. The noise on all channels was independent of magnet current and of whether the magnet power supply was on or off; it corresponded to less than 10 microstrain.

Installation of magnet DD0010 on test stand 4 was completed, and essentially all of the instrumentation electronics and readout equipment was installed and fully tested. Cooldown of the magnet was delayed by the failure of the second stage compressor in the MTF refrigerator, following a site-wide power failure on February 26. The compressor was replaced and the gas system is being cleaned up. The only major adjustment to be made is in the system to allow dynamic readout of the BNL-style strain gauges. The two stage amplifiers built by LBL, which take the analog difference between the voltages across active and compensating gauges, have noise levels corresponding to about 20 microstrain. This, however, is about an order of magnitude smaller than the line-cycle noise that is currently present at the input to the amplifiers. The source of this noise is being investigated, but the test program will not be delayed if it is not found. (The static measuring system uses an integrating DVM which suppresses line-cycle noise by 80 dB.)

Magnet D000X has been removed from stand 5; installation of DD0012 is under way. The beam tube feed-throughs were installed, and the low voltage instrumentation wires were soldered to terminal boards in the interconnect region. Connectors to mate these leads with the magnet are being attached by short cables to the same boards. All external cabling required for this highly instrumented magnet was installed at the same time the corresponding cables were installed on stand 4; much of the front-end and readout electronics exists, although not all of it is yet installed. The voltage tap data will be read out through the same isolation amplifiers and data loggers as used for DD0010.

DD0012

The assembly was completed on February 10; it was shipped to MTF on February 29.

DD0014

The cold mass arrived from BNL on February 10. This is the first magnet to incorporate the B-style cryostat. Assembly of the cold mass and support posts was completed, and the vertical plane was measured and set. Instrumentation will be completed by March 7. New spot welding equipment is being installed for shield assembly. This equipment should be on line for trial by March 10. The two-footed vacuum vessel was completed and straightness and twist were measured. The measurement data have not yet been analyzed. This assembly is scheduled to be completed March 31.

Cold Mass Tooling

Collaring. The prototype tooling was used to collar magnet F1. The tooling performed as expected, and the entire collaring operation went smoothly. (Details will be presented in a separate report.) The collared assembly was epoxy potted and is being machined into cookies. The first cookies should be ready for measuring by March 11. Coils for F1 are being measured in preparation for collaring. Collaring should be completed by March 28. Strain gauge packs are the critical-path item in this assembly.

Coil Winding and Curing. The inner winding mandrel and curing molds were completed. The outer mold is being assembled. The outer mandrel laminations await die rework to correct a feature position. Proof samples are due about March 10. If approved, laminations will arrive around 3/17/88. Winding of the inner coils will start March 11.

Accelerator

E778. Experiment E778 took data for the second time. Thirteen Tevatron shifts were set aside for this experiment within the two-week accelerator development period at the end of the fixed-target run. New experimental techniques included operation at low-emittance in both multi-bunch and single-bunch modes, and extensive use of the new diagnostic equipment (noted in last month's report). Measurements were made in all aspects of the E778 program. Preliminary indications are that the anomalous decoherence behavior observed in the May 1987 run is not present in the low-emittance beam, and that the slow beam loss at high-nonlinearity strength is associated in large part with longitudinal motion.

Theory. Most of the computer runs associated with the energy deposition survey study are completed. A draft of the document was started. A VAX version of CASIM, capable of studying energy deposition in the TeV regime, is being prepared in response to the CDG's request.

LBL REPORT

SUPERCONDUCTOR AND CABLE

Four cabling runs were completed: three production runs for the 17-m dipole and 1.8-m dipole coils, and one R&D experiment to evaluate a 24-strand option for the inner-layer cable. Two lengths of inner-layer cable (SC375, 3430 ft and SC376, 1790 ft) were completed and shipped to BNL for use in the inner coils of magnets DSS13, 14, 15, and 16. One length of outer-layer cable (SC378A, 4570 ft) was sent to BNL for DD0016 outer coils; the remainder (SC378B, 320 ft) was kept at LBL for a 1-m dipole.

From the cable manufacturing standpoint, a 24-strand cable offers one important advantage over 23-strand cable: the payoff spools are balanced for a 24-strand cable and the cabling machine can therefore be operated at higher speeds. Also, the 24-strand cable made with a 0.0312-inch diameter wire will be somewhat more flexible than the 23-strand cable made with a 0.0318-inch diameter wire. The 24-strand cable was made with the same overall dimensions as the standard SSC inner-layer cable, and samples have been sent to BNL for critical current measurements. If the results are satisfactory, this design may be proposed as an alternative to the 23-strand cable.

MAGNET MODELS

Dipole Models

Model D15A-5 will be inserted into the laminated yoke blocks from model D15A-4F. This model contains both old style and new style (Hotel Type) inner-coil pressure gauges.

D15A-4F Dipole Retest

Magnet D15A-4F was retested after 21 days at room temperature. One retraining quench occurred in the outer layer at 6905 A, a 200 A drop from the plateau value. (There had been no retraining after the first thermal cycle, in which the magnet was at room temperature for three days.) If memory loss is associated with creep at room temperature, long-term experiments may have to be added to the SSC research program.

Long Magnets

Magnet DD0011 was assembled, collared, and inserted into its yoke at BNL. Four new inner coils were wound at BNL, one by BNL technicians. These new coils have redesigned end insulation and are free of shorts. Two will be used in DD0013.

Instrumentation

Two gauge packs, using the H-type inner gauges, have been assembled and calibrated. Pack calibrations are linear; they agree well with block calibrations and with the ANSYS prediction.

End Design

The following programs are now available for "bulged-end" dipole design:

1. Winder - A wire frame generator for conductor placement.
2. Mafcoprep - A pre-processor that interfaces Winder with Mafco.
3. Mafco - A field computational program.
4. Harmo - Performs integration and harmonic analysis and generates a field quality table for the magnet end.
5. AutoCad - An existing CAD system that plots the three-dimensional wire frame geometry.

Sample parts for the internally supported straight end (Royet end) were designed, fabricated, and used as patterns for injection molded parts. Lexan will be used for initial tests. Numerically machined parts are now being made of G-10.

PROJECT COST DATA

INDEX

TABLE C-1

CENTRAL DESIGN GROUP - SUPERCOLLIDER

FEBRUARY 1988 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	105.4	95.2	140.5	341.1	1194.1	3818.3
1.2	PROGRAM PLANNING & MANAGEMENT	28.9	3.0	13.8	45.7	222.5	686.8
1.3	ACCELERATOR R & D	197.2	81.1	89.8	368.2	1707.0	5644.7
1.4	CONVENTIONAL SYSTEMS DEVELOP.	24.1	-0.8	0.8	24.2	195.9	726.3
	PROGRAM COSTS	355.7	178.5	245.0	779.1	3319.5	10876.0
1.41	RTK COSTS	0.0	2.7	0.0	2.7	13.8	175.0
	CDG/RTK COSTS	355.7	181.2	245.0	781.8	3333.3	11051.0
	COMMITMENTS					408.3	
	CHANGE IN COMMITMENTS (Delta)					213.1	
	EQUIPMENT COSTS					0.0	229.0

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY - SUPERCOLLIDER

FEBRUARY 1988 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	LONG MAGNET FABRICATION	121.2	81.8	79.5	282.5	1615.0	2980.0
2.2	TOOLING & FIXTURES	30.3	160.7	74.8	265.8	1308.0	2594.0
2.3	SHORT MODEL MAGNETS	18.9	0.0	7.4	26.4	152.0	616.0
2.4	INDUSTRIALIZATION	7.6	2.8	4.1	14.4	81.0	250.0
2.5	ACC. LIFE TEST (CRYO)	30.3	50.8	31.8	112.9	345.0	1560.0
	PROGRAM COSTS	208.3	296.1	197.6	702.0	3501.0	8000.0
	COMMITMENTS					1569.0	
	CHANGE IN COMMITMENTS (Delta)					-186.0	
	EQUIPMENT COSTS	0.0	11.4	0.0	11.4	11.4	500.0
	EQUIPMENT OPEN COMMITMENTS					68.4	

TABLE C-3

FERMI NATIONAL ACCELERATOR LABORATORY - SUPERCOLLIDER

FEBRUARY 1988 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	0.0	7.3	2.6	9.9	36.3	195.0
3.2	LONG MAGNET FABRICATION	79.1	38.9	41.2	159.2	644.9	834.0
3.3	MAGNETIC MEASUREMENTS	123.3	216.0	118.4	457.7	1251.3	1206.0
3.4	COLD MASS FABRICATION	10.1	54.6	22.6	87.3	488.9	3083.0
3.5	INDUSTRIALIZATION	4.5	0.0	1.6	6.1	6.1	190.0
3.6	CELL TESTS	0.0	0.0	0.0	0.0	0.0	222.0
	PROGRAM COSTS	217.0	316.8	186.4	720.2	2427.5	5730.0
	COMMITMENTS					368.3	
	CHANGE IN COMMITMENTS (Delta)					2.3	
	EQUIPMENT COSTS	0.0	27.5	0.0	27.5	53.5	271.0
	EQUIPMENT OPEN COMMITMENTS					4.3	

TABLE C-4

LAWRENCE BERKELEY LABORATORY - SUPERCOLLIDER

FEBRUARY 1988 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET*
4.1	GENERAL	7.3	0.1	3.6	11.0	41.8	190.0
4.2	SUPERCONDUCTOR	4.6	16.2	3.0	23.8	126.8	1170.0
4.3	QUADRUPOLE DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	300.0
4.4	COMP. DEVELOP. & TESTS	60.0	15.6	36.3	111.9	654.2	975.0
4.5	INDUSTRIALIZATION	0.0	0.0	0.0	0.0	0.0	50.0
	MAGNET R & D TOTALS	71.9	31.9	42.9	146.7	822.8	2685.0
4.6	ACCELERATOR PHYSICS R & D	25.0	1.4	12.7	39.1	183.8	410.0
	LBL/THEORY COSTS	96.9	33.3	55.6	185.8	1006.6	3095.0
	COMMITMENTS					294.0	
	CHANGE IN COMMITMENTS (Delta)					-50.0	

TABLE C-5

PROGRAM SUMMARY - SUPERCOLLIDER

FEBRUARY 1988 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDG PROGRAM	355.7	178.5	245.0	779.1	3319.5	10876.0
1.41	RTK PROGRAM	0.0	2.7	0.0	2.7	13.8	175.0
2.	BNL SSC PROGRAM	208.3	296.1	197.6	702.0	3501.0	8000.0
3.	FNAL SSC PROGRAM	217.0	316.8	186.4	720.2	2427.5	5730.0
4.	LBL SSC PROGRAM	96.9	33.3	55.6	185.8	1006.6	3095.0
	TOTAL SSC PROGRAM COSTS	877.9	827.3	684.6	2389.8	10268.4	27876.0
	COMMITMENTS					2639.6	
	CHANGE IN COMMITMENTS (Delta)					-20.6	
	EQUIPMENT COSTS					64.9	1000.0
	EQUIPMENT OPEN COMMITMENTS					72.7	

TABLE C-6

MONTHLY AND CUMULATIVE SUMMARY OF PLANNED AND ACTUAL COSTS AND COMMITTMENTS

1.0 CENTRAL DESIGN GROUP - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	920.9	920.9	33.4	33.4	496.4	496.4	463.0	463.0
NOV	920.9	1841.8	747.4	780.8	572.4	1068.8	288.0	-175.0
DEC	920.9	2762.8	1221.6	2002.4	1199.6	2268.4	266.0	-22.0
JAN	920.9	3683.7	549.0	2551.4	478.2	2746.6	195.2	-70.8
FEB	920.9	4604.6	781.8	3333.2	995.0	3741.6	408.3	213.1
MAR	920.9	5525.5						
APR	920.9	6446.4						
MAY	920.9	7367.3						
JUN	920.9	8288.3						
JUL	920.9	9209.2						
AUG	920.9	10130.1						
SEP	920.9	11051.0						

2.0 BROOKHAVEN NAT'L LAB - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	666.7	666.7	498.0	498.0	2095.0	2095.0	1597.0	1597.0
NOV	666.7	1333.3	643.0	1141.0	995.0	3090.0	1949.0	352.0
DEC	666.7	2000.0	763.6	1904.6	632.6	3722.6	1818.0	-131.0
JAN	666.7	2666.7	894.9	2799.5	831.9	4554.5	1755.0	-63.0
FEB	666.7	3333.3	702.0	3501.5	516.0	5070.5	1569.0	-186.0
MAR	666.7	4000.0						
APR	666.7	4666.7						
MAY	666.7	5333.3						
JUN	666.7	6000.0						
JUL	666.7	6666.7						
AUG	666.7	7333.3						
SEP	666.7	8000.0						

3.0 FERMI NAT'L ACCEL LAB - SUPERCOLLIDER

DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	477.5	477.5	314.7	314.7	792.5	792.5	477.8	477.8
NOV	477.5	955.0	390.6	705.3	353.1	1145.6	440.3	-37.5
DEC	477.5	1432.5	694.7	1400.0	462.4	1608.0	208.0	-232.3
JAN	477.5	1910.0	307.3	1707.3	465.3	2073.3	366.0	158.0
FEB	477.5	2387.5	720.2	2427.5	722.5	2795.8	368.3	2.3
MAR	477.5	2865.0						
APR	477.5	3342.5						
MAY	477.5	3820.0						
JUN	477.5	4297.5						
JUL	477.5	4775.0						
AUG	477.5	5252.5						
SEP	477.5	5730.0						

4.0 LAWRENCE BERKELEY LAB - SUPERCOLLIDER

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DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	257.9	257.9	230.5	230.5	662.5	662.5	432.0	432.0
NOV	257.9	515.8	191.1	421.6	191.1	853.6	432.0	0.0
DEC	257.9	773.8	135.9	557.5	135.9	989.5	432.0	0.0
JAN	257.9	1031.7	263.3	820.8	175.3	1164.8	344.0	-88.0
FEB	257.9	1289.6	185.8	1006.6	135.8	1300.6	294.0	-50.0
MAR	257.9	1547.5						
APR	257.9	1805.4						
MAY	257.9	2063.3						
JUN	257.9	2321.3						
JUL	257.9	2579.2						
AUG	257.9	2837.1						
SEP	257.9	3095.0						

0.0 PROGRAM SUMMARY - SUPERCOLLIDER

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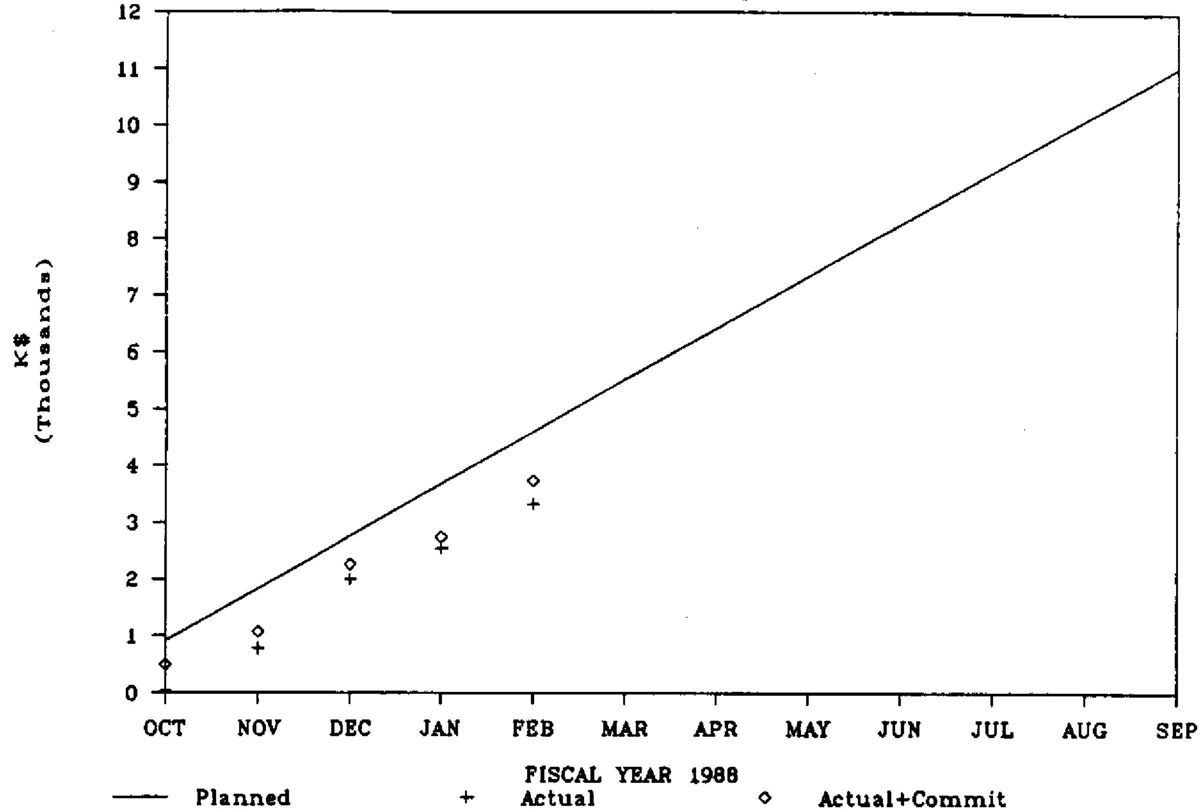
DATE	MONTHLY PLANNED COSTS	FY PLANNED CUMULAT	MONTHLY ACTUAL COSTS	FY ACTUALS CUMULAT	MO ACT+ DELTA COMMITS	CUM ACT + COMMITS	CURRENT COMMITS	DELTA COMMITS
OCT	2323.0	2323.0	1076.6	1076.6	4046.4	4046.4	2969.8	2969.8
NOV	2323.0	4646.0	1972.1	3048.7	2111.6	6158.0	3109.3	139.5
DEC	2323.0	6969.0	2815.8	5864.5	2430.5	8588.5	2724.0	-385.3
JAN	2323.0	9292.0	2014.5	7879.0	1950.7	10539.2	2660.2	-63.8
FEB	2323.0	11615.0	2389.8	10268.8	2369.3	12908.5	2639.6	-20.6
MAR	2323.0	13938.0						
APR	2323.0	16261.0						
MAY	2323.0	18584.0						
JUN	2323.0	20907.0						
JUL	2323.0	23230.0						
AUG	2323.0	25553.0						
SEP	2323.0	27876.0						

1.0 CENTRAL DESIGN GROUP

Cumulatives in K$



1.0 CENTRAL DESIGN GROUP

Monthly Costs in K$

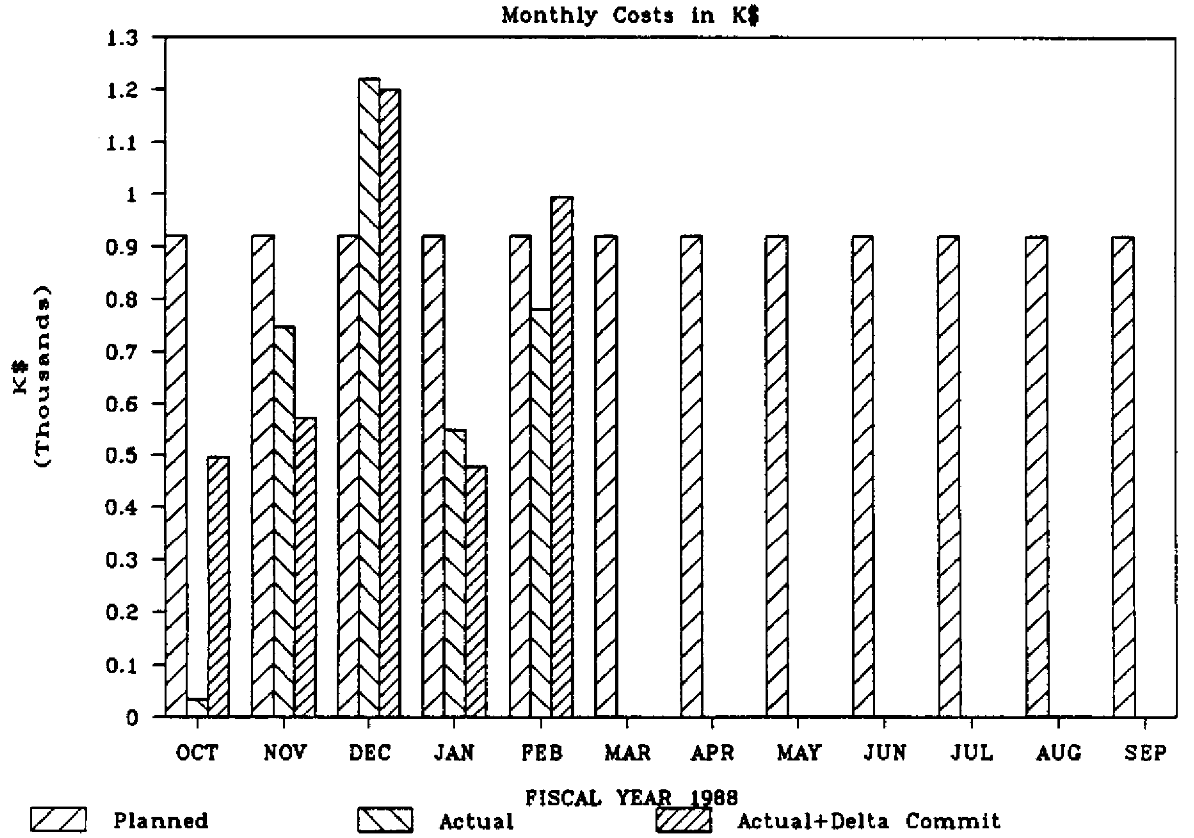
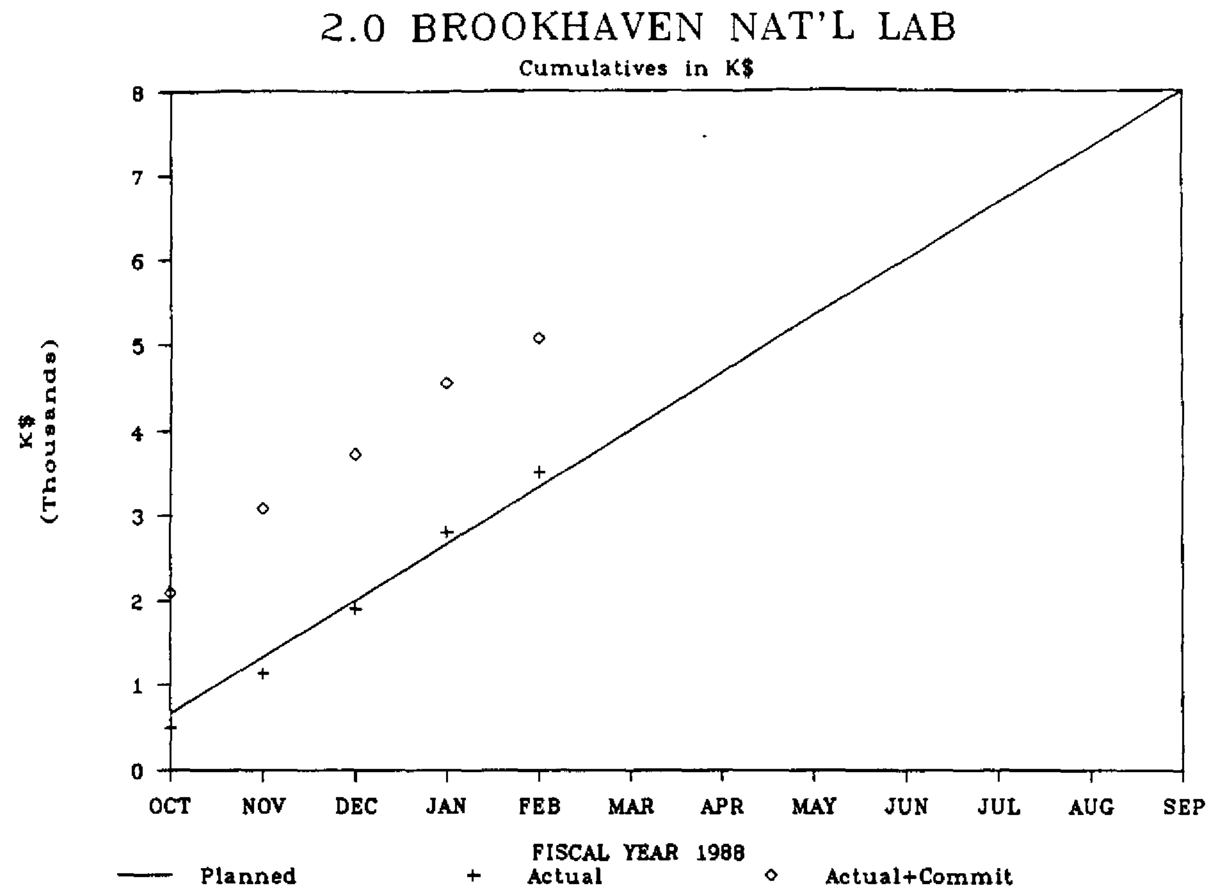


Figure 1


2.0 BROOKHAVEN NAT'L LAB
Cumulatives in K$
K$ (Thousands)
0
1
2
3
4
5
6
7
8
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit

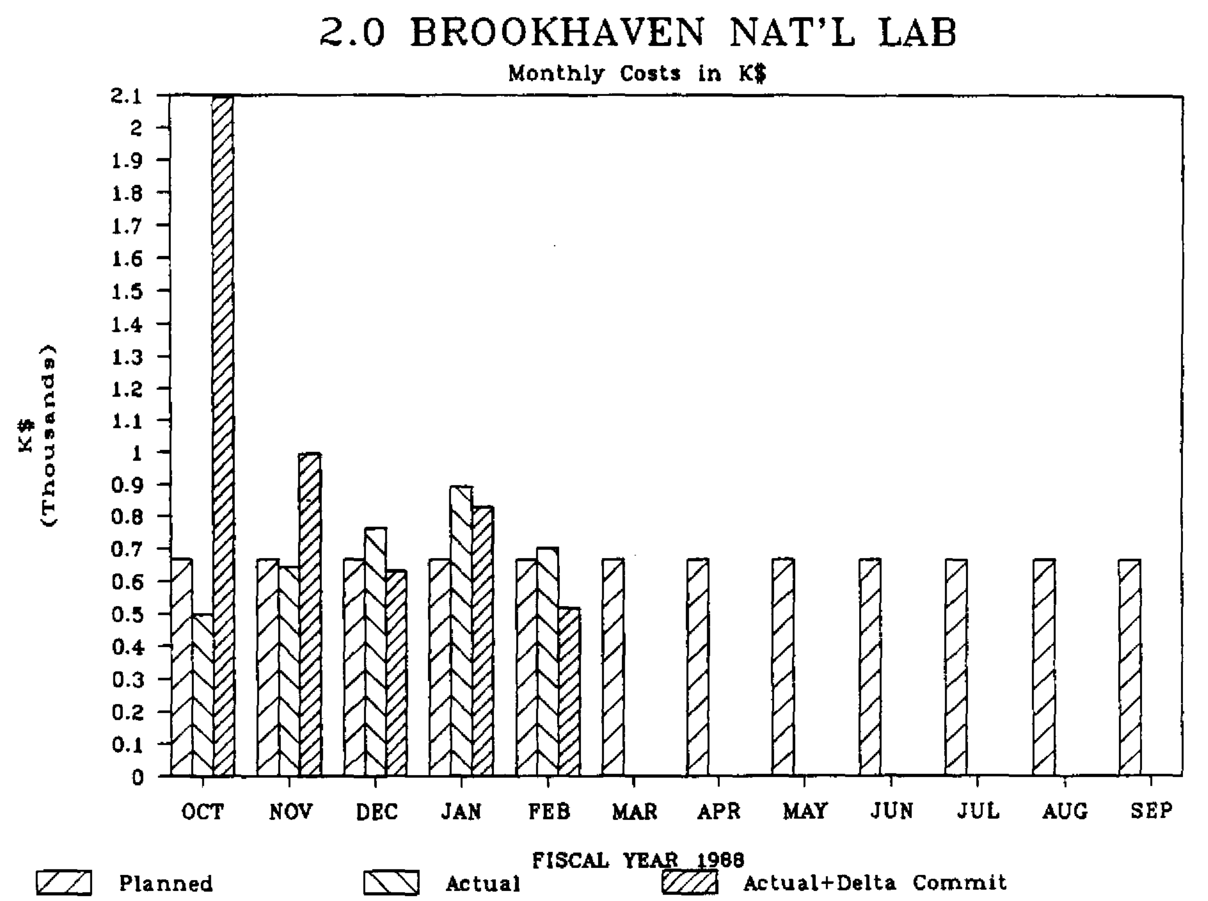
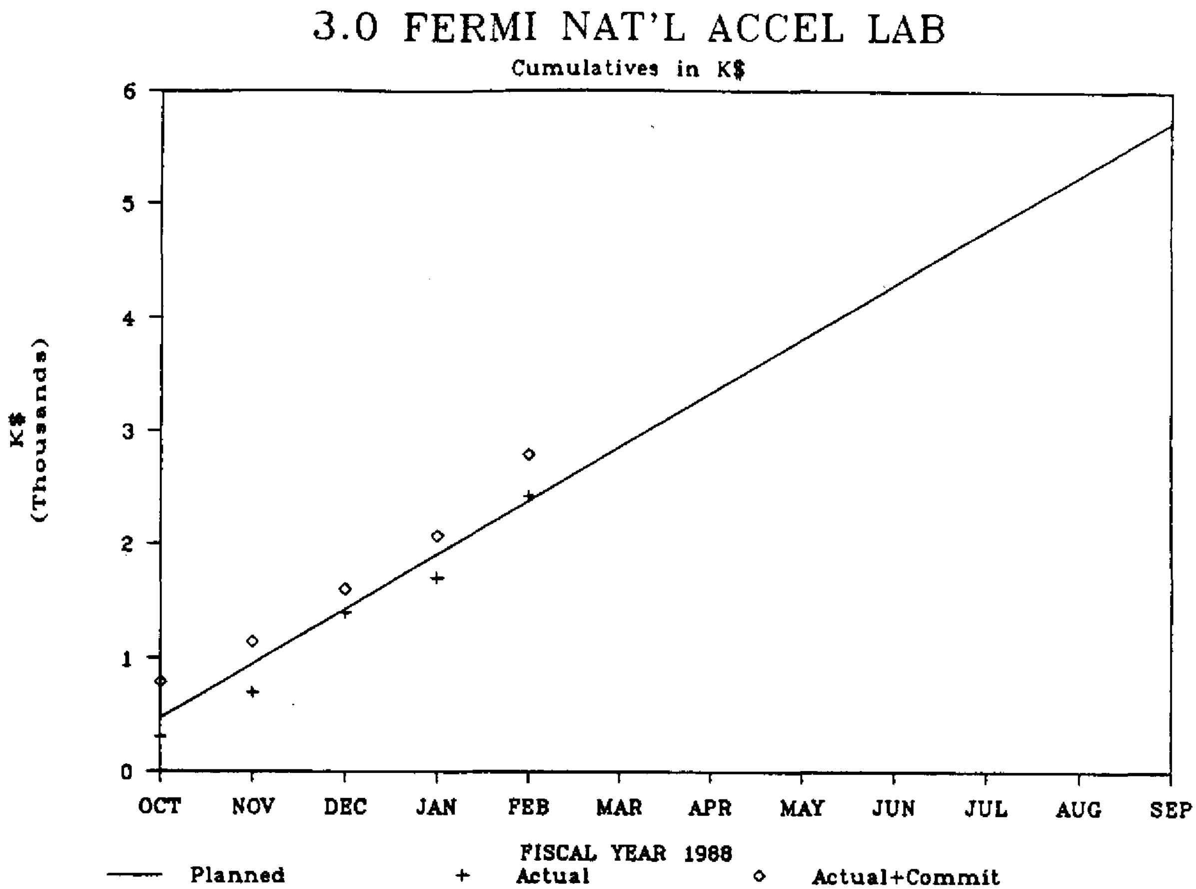

2.0 BROOKHAVEN NAT'L LAB
Monthly Costs in K$
K$ (Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 2


3.0 FERMI NAT'L ACCEL LAB
Cumulatives in K$
K$ (Thousands)
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit

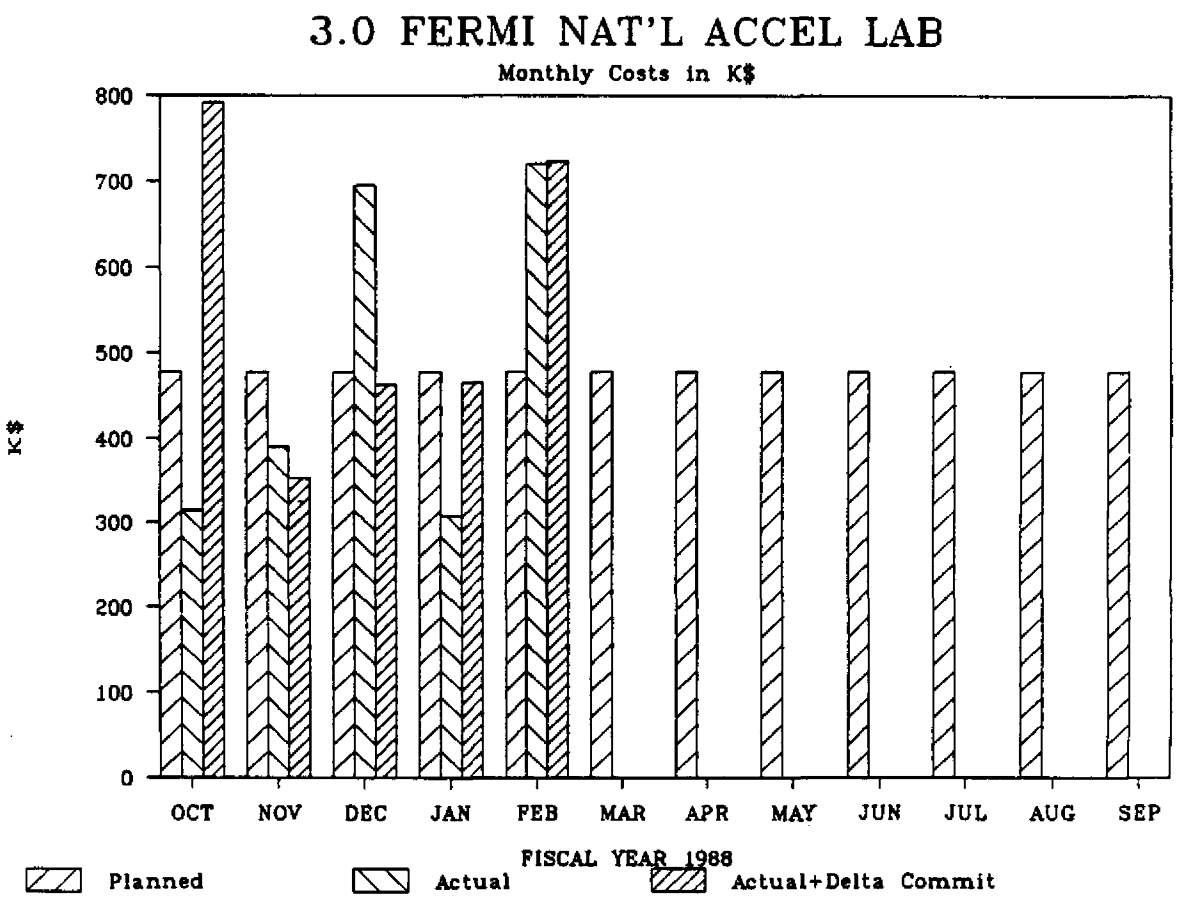
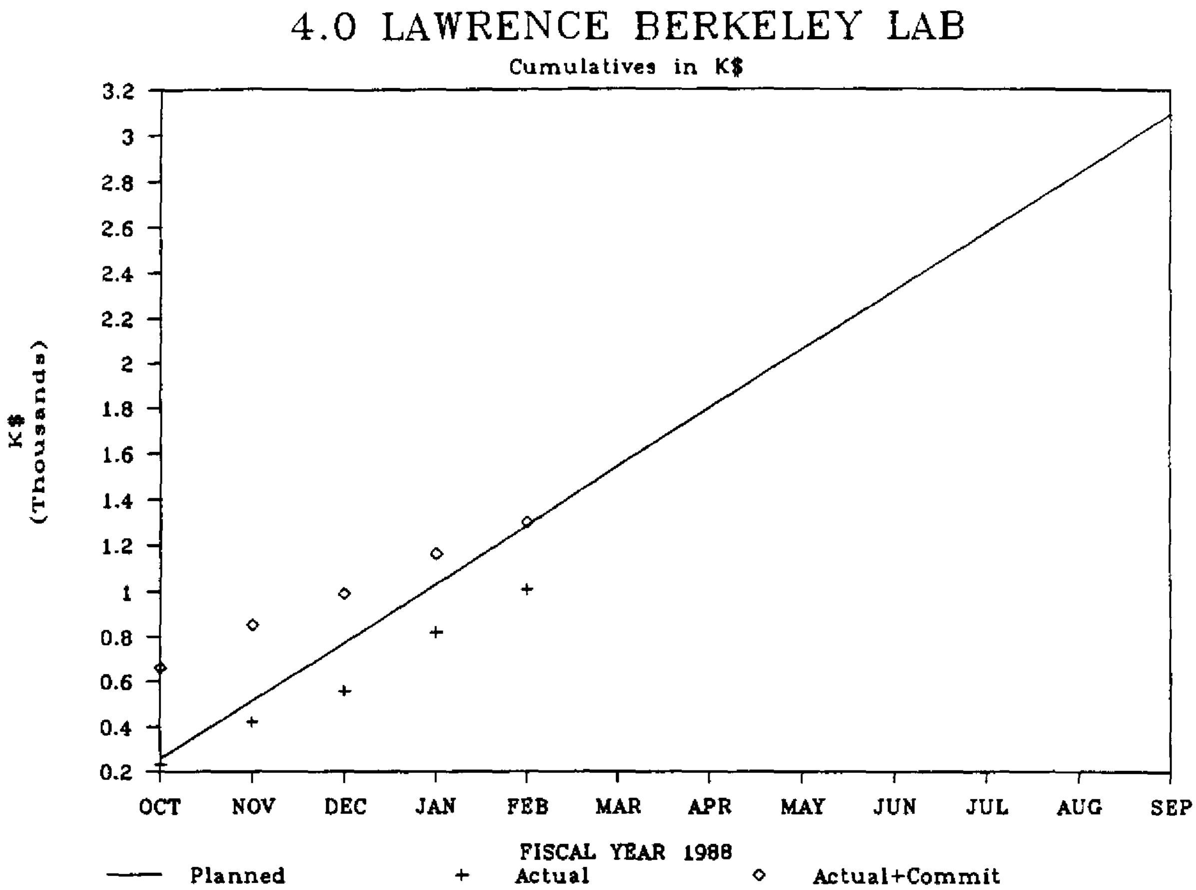

3.0 FERMI NAT'L ACCEL LAB
Monthly Costs in K$
K$
800
700
600
500
400
300
200
100
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 3


4.0 LAWRENCE BERKELEY LAB
Cumulatives in K$
K$ (Thousands)
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Commit

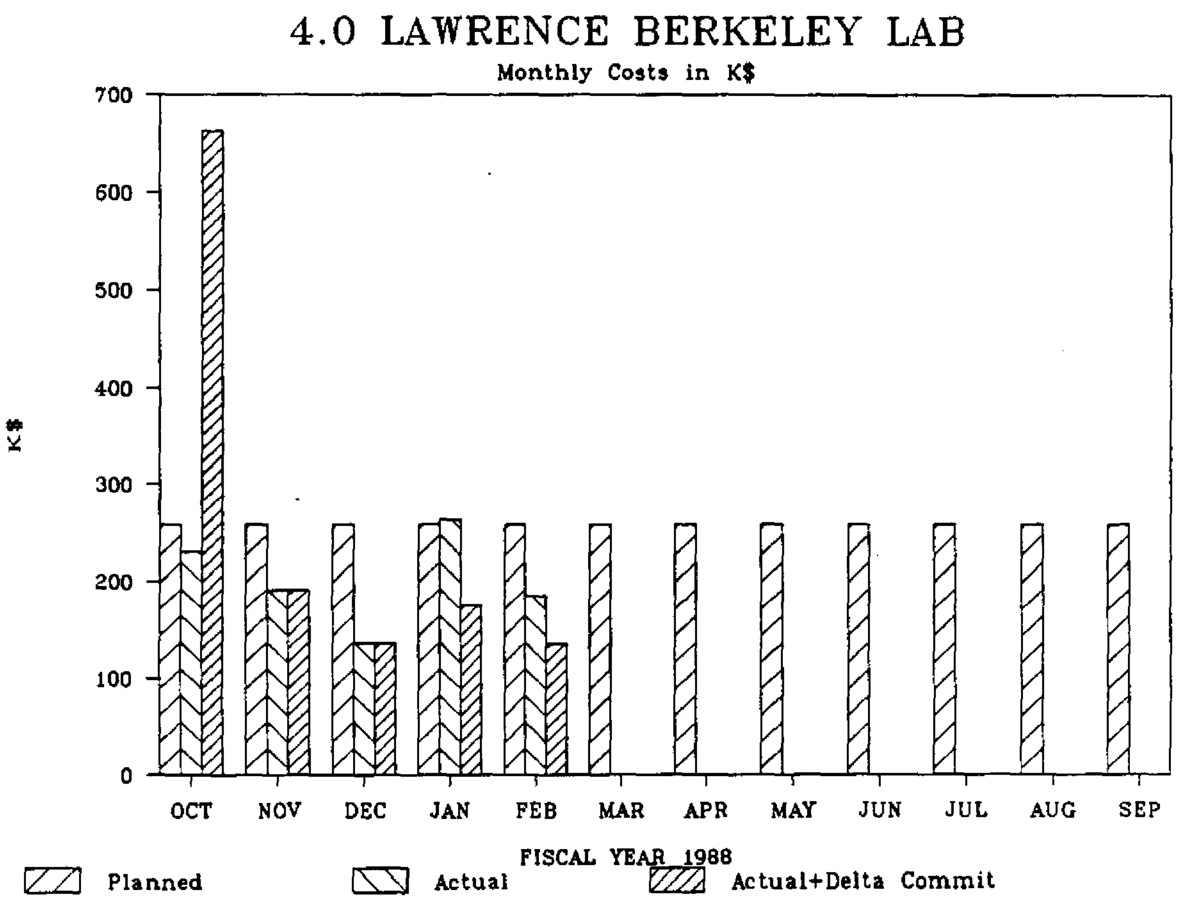
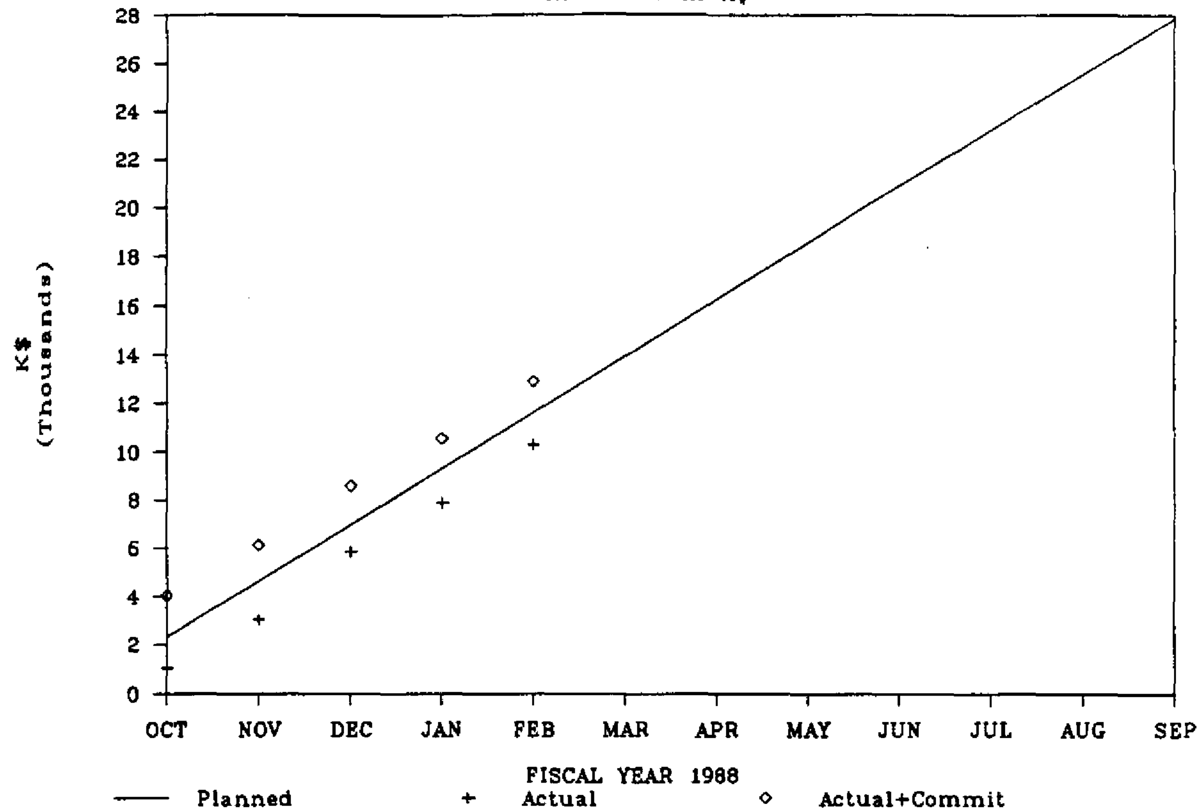

4.0 LAWRENCE BERKELEY LAB
Monthly Costs in K$
K$
700
600
500
400
300
200
100
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FISCAL YEAR 1988
Planned
Actual
Actual+Delta Commit

Figure 4

0.0 PROGRAM SUMMARY – SUPERCOLLIDER

Cumulatives in K$



0.0 PROGRAM SUMMARY – SUPERCOLLIDER

Monthly Costs in K$

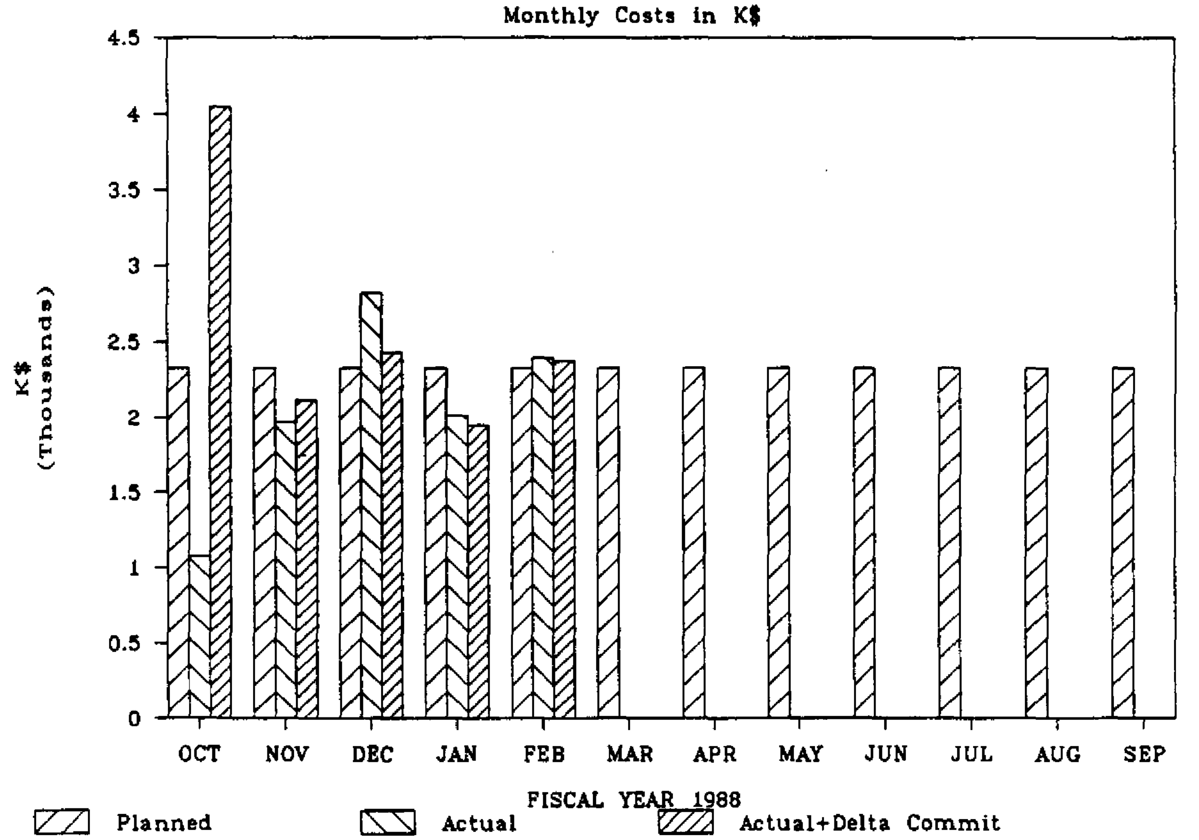


Figure 5