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Superconducting Super Collider Laboratory

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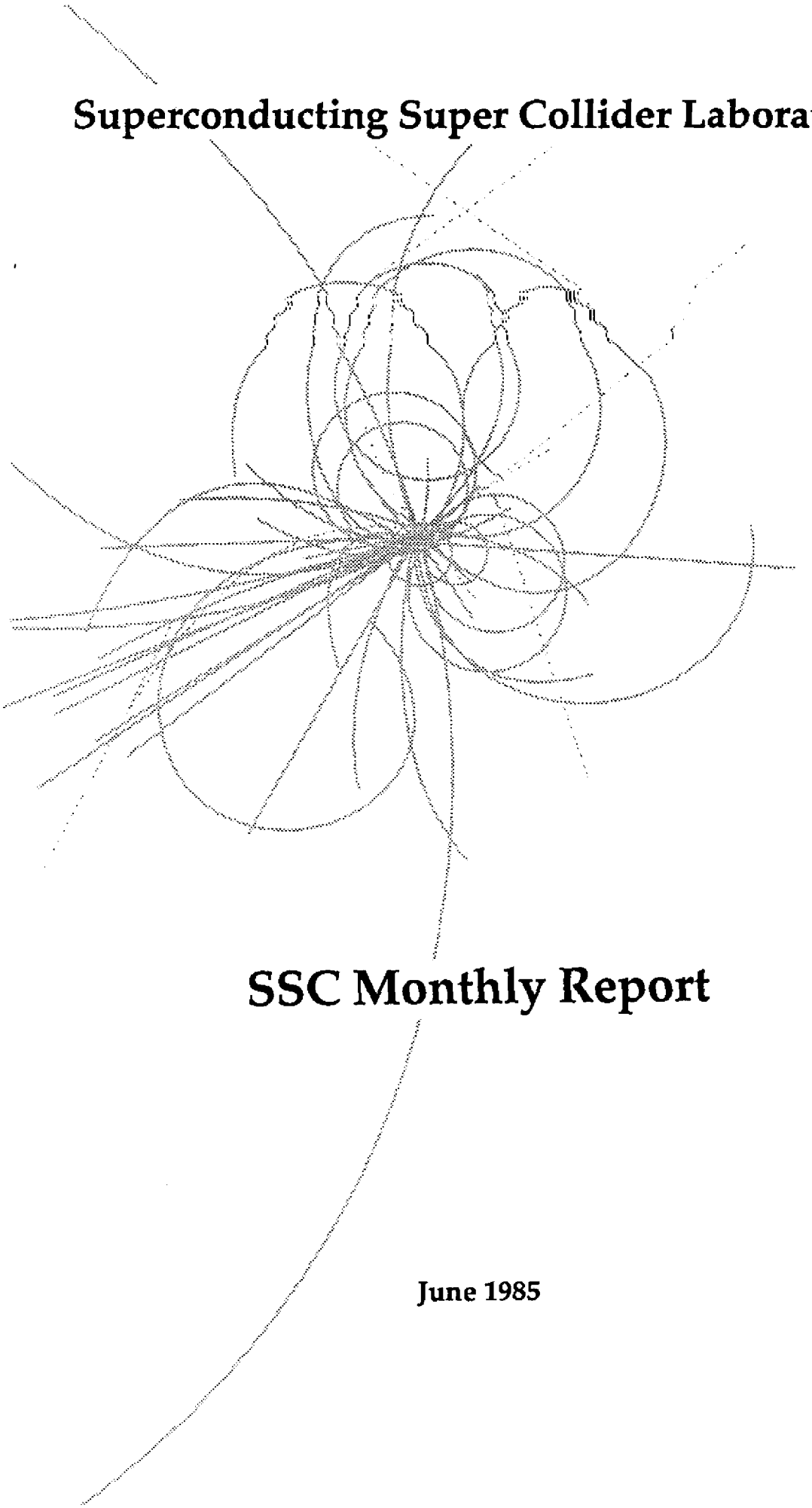

SSC Monthly Report

June 1985

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SSC MONTHLY REPORT

JUNE 1985

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SSC MONTHLY REPORT

JUNE 1985

A. Project Summary

- The SSC CDG Annual Review was held on June 19, 20, and 21. The DOE Washington Program Office was in charge, with the Chicago and San Francisco Operations Offices represented. The DOE officials were aided in their deliberations by three consultants: Tom Fields, ANL; Ewan Paterson, SLAC; and Bjorn Wiik, DESY/U. of Hamburg. The review went very smoothly, and the cooperation among the laboratories (BNL, Fermilab, LBL, and TAC) was highly praised. The reviewers also stated that "impressive progress has been made since the Reference Designs Study (May 1984)." In particular, superconductor strand development was cited as "outstanding."

- In preparation for the Annual Review, an SSC Interim Report was written. This involved many hours of work for all Division heads. A final report is presently being compiled.

- The major activity of the Magnet Division this month was in assemblying the cost data on various magnets and in reviewing the mechanical, electrical, and cryogenic features of the models that have been built.

- Contract negotiations between the A/E firm, RTK, who will be providing design services to the SSC for the next two years, and the Chicago Operations Office were completed on June 24.

- The SSC Siting Parameters Document was released June 15, 1985, with DOE's approval. By the end of the month, more than 200 copies were mailed to interested individuals.

- The Clustered IR Study Group held its second meeting on June 6 at the CDG. Results from the meeting and work carried out shortly afterwards included:
  - Creation of two test lattices based on different IR design principles;
  - Study of chromatic effects on the two test lattices;
  - Optimization of chromatic effects on one of the test lattices;

  The group will hold a third meeting sometime in August to summarize the results and to prepare a report.

- A University of Michigan-sponsored workshop on SSC polarization was held at Ann Arbor, June 10-15. Issues discussed were spin physics at the SSC, acceleration and storage of polarized beams, Siberian snakes, polarimeters, and the possibility of a demonstration snake. A workshop report is being prepared.

- An impedance workshop was held June 27 and 27 at the CDG with about 16 participants. More studies, both calculational and engineering, are needed to improve the accuracy of impedance estimates, but results so far indicate that the SSC will most likely not have serious instability problems if the necessary precautions are taken.

- Presentations were made by R. Matyas and T. Toohig at the meeting of the American Underground-Space Association at their annual meeting in New York City on June 17.

- BNL. The highlight of the Magnet Division activities in June was the very successful initial test results for the first 4.5 m long dipole for Reference Design D. The magnet reached short sample performance, about 6.5 T at 4.5K, and subsequently trained to approximately 8 T in subcooled liquid. Preliminary field quality data appear quite satisfactory, as does the performance of the built-in sextupole trim coil. Detailed measurements are expected to continue into July; meanwhile, assembly of a second magnet is well within schedule.

- Fermilab. Effort during the month of June emphasized the analysis of the results of a number of tests carried out during May. Analysis was completed for the tests of the two cryostat models and the magnetic measurements of one recent model magnet.

  Design work on the style D cryostat progressed toward the goal of producing cryostats for full-length magnets by February of 1986.

  One meter models being built to perfect the dry winding technique both for 4 and 5 cm bore continue to be built and analyzed.

  Calculations relating to accelerator physics aspects of the SCC continued. Fermilab also continued support of the photodesorption experiment at the NSLS at BNL.

  The results of magnet R&D work have been summarized for a series of reviews held over the past several weeks.

- LBL. Model D12C-3, with aluminum collars, was tested and exhibited excellent training behavior; the initial quench was at 6.0 Tesla with the fourth quench at 6.4 Tesla. Model D12C-4, with BNL-Nitronic 40 collars, was completed and under test at the end of June, and model D12C-5 and D12C-6 were under construction.

  Delivery of cable to BNL for the 4.5 m models was completed. To date, 12,000 ft have been produced at LBL and 9,000 at New England Electric Wire (NEEW). Work has started on two-level cables and on investigation of the influence of cable parameters on degradation.

  Improvement in calculation methods predicts magnetization effects that agree very closely with measured results in the 1-m models.

- TAC. Most of the progress during June was on assembly of the long magnets at General Dynamics. Since this is the first magnet, it is being assembled extremely carefully and with some modifications as it is being assembled. Thus far, no great problems have been found.

B. Project Report

I. Central Design Group

Magnet Program. The major activity of the Magnet Division this month was in assemblying the cost data on various magnets and in reviewing the mechanical, electrical, and cryogenic features of the models that have been built.

Conventional Systems. Division personnel provided additional analytical support during the month to the Chicago Operations office of DOE as they completed contract negotiations with the A/E firm, RTK, who will be providing design services to the SSC for the next two years. RTK, a joint venture of Raymond Kaiser Engineers, Tudor Engineering Company, and Keller & Gannon - Knight, is based in Oakland, California. The effective date of the new contract was June 24, 1985. The first meeting on technical matters between CDG and RTK personnel was held on June 27. In addition to acquainting RTK personnel with the scope of the project, selected technical studies were initiated. Frequent meetings will be held as the A/E effort is mobilized.

At the CDG, tunnel cross-section drawings have been prepared to study the configuration of equipment within the collider enclosure. Examples of magnets used include the one-in-one, type D magnet, and the two-in-one, type C magnet. When allowance is made for space to guide the transportation vehicles, and a personnel aisleway in addition to the technical equipment, an inside diameter of nine to ten feet is indicated. Studies are continuing on the placement of electrical and mechanical systems within a typical cross section.

As reported previously, the SSC siting studies resulted in the preparation of a Siting Parameters Document. DOE agreed to the release of this manuscript, and a final version dated June 15 was prepared. By the end of the month more than two hundred copies were mailed to interested individuals.

Numerous questions are being directed to CDG staff members, and answered, as appropriate. The contract with the CER Corp., and Parsons Brinckerhoff came to a conclusion at the end of the month. Personnel from these firms, led by A. Gursoy, completed their contributions to the Siting Document and parted with the thanks and best wishes of the CDG staff.

The Annual Review provided a good opportunity to review the progress made during the past year. Highlights from this period are:

Development of the Program Plan
Preparation of a Scope of Work for the Siting Studies
Acquisition of Engineering Assistance from Industry
Initiation of Technical Discussions/Work within the CDG.

Presentations were made R. Matyas and T. Toohig at the meeting of the American Underground-Space Association at their annual meeting in New York City on June 17. Interested attendees filled the room and asked numerous questions, particularly after a panel discussion. There is considerable industrial interest in the SSC, its purpose, and the technology employed. It is anticipated that more such meetings will be held during the coming year.

Accelerator Theory and Computation. Aperture studies this month have concentrated on providing information for the cost estimating on both the cosine theta and the superferric magnet designs. In particular, an algorithm was developed to find the optimum magnet aperture and the lattice cell length which minimizes the cost of the SSC arcs. More technical information is due by the end of July so that as much data as possible will be available for the Magnet Selection Advisory Panel.

A University of Michigan-sponsored workshop on SSC polarization was held at Ann Arbor, June 10-15. Issues discussed were spin physics at the SSC, acceleration and storage of polarized beams, Siberian snakes, polarimeters, and the possibility of a demonstration snake. A workshop report is being prepared.

An impedance workshop was held June 27 and 27 at the CDG with about 16 participants. Various contributions to the impedance were reviewed. The main sources of impedance are identified as bellows, kickers, and pick-up electrodes. Calculation of instability effects caused by impedance and the possibility of impedance measurements were also discussed. More studies, both calculational and engineering, are needed to improve the accuracy of impedance estimates, but results so far indicate that the SSC will most likely not have serious instability problems if the necessary precautions are taken.

II. Laboratory Programs

A. BNL.

1. General

Analytical Studies. A coil configuration termed "D1" with 5 cm i.d. was designed, in cooperation with LBL, using the same cabled conductors as are used in the present 4 cm i.d. "C5" configuration (Reference Design D). Like C5, D1 is partially keystoned. All harmonics (b_i) are less than 0.1×10^{-4} at 1 cm radius. At 2/3 coil radius (1.67 cm), the harmonics are 0.15, -0.38, 0.76, -0.74, -1.40, and -0.21 for b2 through b12, respectively. The infinite permeability transfer function is 10.75 G/A compared to 10.33 for C5, and the number of turns is 23 in the inner layer and 22 in the outer layer.

Using analytical expressions for finite permeability iron, existing coil and iron configurations were scaled to several different apertures and fields to obtain the amount of iron and superconductor; this information is to be used in a study of the effect of different magnet parameters in SSC cost estimates.

Overall criteria were developed for the regular arc quadrupoles. These include a single layer coil, NbTi conductor, inner diameter 60 mm (the same as for the outer coil of the dipole), and four quadrant coils. Based on these criteria, a magnetic design was generated with the following characteristics:

Number of turns	= 14
Magnetic length	= 6.64 m
Maximum gradient	= 139 T/m
Systematic harmonics	= less than 0.1 b_n,

Mechanically the magnet will consist of four quadrant coils which will be assembled in pairs inside the two-piece yoke. To support the bore tube inside the 60 mm bore, a "spider" will be necessary. The yoke halves will be assembled in a press, and the interlocking laminations keyed together to retain the pre-stress. For the insertions, maximum performance quadrupoles

will be required. A preliminary design for these magnets uses the same structure as the regular arc quadrupoles, with the addition of an inner coil. These magnets are designed for a maximum gradient of 300 T/m.

Field computations with the code POISSON for a 4.0 cm aperture 2-in-1 SSC magnet were studied: a) the effect of iron saturation on the harmonics up to a central field of 6.75 T; POISSON does not show any change in harmonics up to the 4 T field level. b) In the unbalanced case, the difference in harmonics in the two legs at the injection field (0.325 T), with the current in the other leg being 3 times and 5 times higher.

2. Model Magnets

a. <u>4.0 cm Aperture x 4.5 m Long Magnets</u>.

- Assembly of the first dipole, SLN-008, was completed. At the end of the month vertical liquid helium tests of this magnet, started on June 17, were continuing.

- Assembly of the second magnet, SLN-009, is progressing, with winding and curing inner and outer coils for additional magnets in this series continuing. A total of 12 inner and outer coils, respectively, have been completed.

- The feasibility of winding SSC coils with straight (non-flared) ends was investigated. A model coil was wound, utilizing laminated end spacers and green putty wedge extensions, and appears quite feasible. Tests are continuing.

- The quench protection resistor design was modified to reduce the quantity of resistive elements.

- The on-going coil modulus tests were completed, with analysis of the results continuing.

- Certain dimensions of the yoke support shell, and their tolerances, were revised as a result of experience in the assembly of SLN-008.

- A particular +/- 0.020 in. coil-to-yoke shimming method, to minimize quadrupole harmonics at assembly, was investigated.

b. <u>4.0 cm Aperture x 16.6 m Long Magnets:</u>

- Considerable effort was expended on technical reports reviewing engineering aspects of the magnet design for the Technical Magnet Review Panel--namely collar and yoke design, single phase system, coil design and fabrication, magnet alignment, support and interconnections.

- The yoke support shell length was revised, based on collaring experience to date.

- A surveying procedure for locating the helium containment assembly within the vacuum tank, applicable to the strap-type support system, was developed and analyzed.

- The yoke laminations were revised to permit greater collar deflections, by enlarging the yoke aperture; they were revised with regard to several other details as well. The revisions were forwarded to H&J Tool and Die Co.

c. Bore Tubes and Trim Coils.

- On the basis of experience gained in the assembly of SLN-008, the following modifications were initiated: bumpers and keys were modified to minimize deformation of the bore tube, and tooling modified accordingly; tooling was relocated to the RHIC tunnel to facilitate fabrication of full-length bore tubes and trim coils.

- As noted under Tests and Measurements, tests were satisfactorily conducted on the first trim coil in SLN-008.

- The first 4.5 m long trim coil produced by the Multiwire process has been wound, degaussed, and overcoated with Kapton.

- The trim coil for SLN-009 was completed and assembled in the magnet.

3. Tooling and Facilities

a. Coil Fabrication Tooling.

- Design has begun on the coil handling and assembly equipment for the 16.6 m magnet.

- The coil assembly handler has been modified to allow pinning the inner and outer coils together.

- Assembly of the long winder has begun. Support stands were surveyed and grouted in place, and the pedestal assembly is now in progress.

- Preparations are being made to modify tooling for producing short coils of 4.0 cm aperture with non-flared ends.

- Design of various remaining parts for the long coil tooling, as well as final assembly drawings, is nearing completion.

b. Coil and Yoke Assembly Tooling.

- Design continues in the following areas for the full-length magnet: lifting tongs for cradle and collared coils; modifications to the incremental collaring press; modifications to the single module press to determine shim site; assembly for rotating the collared coil; long lifting beam; factory-based coil transportation fixtures.

c. Magnet Test Facilities.

- Work continues on the horizontal test facility. A model fixture is under construction for testing an inflatable vacuum seal.

- The performance of the 4 cm aperture vertical rotating coil and its dewar support, in the testing of SLN-008, was satisfactory.

- Layouts were completed in the following areas: lead pot assembly, gas-cooled leads, flexible bus, and junction boxes; gas supply end, vacuum enclosures, and piping as required.

- Drawings for the Morgan coil were released to the Shops. Wire locations were determined and forwarded to Multiwire for a flat coil pattern produced by their process.

3. Superconductor

a. Cable Procurement. A contract has been awarded to Oxford Superconductivity Technology for delivery of completed cable for one SSC 16.6 m long model magnet. This order is for conductor with 5 micron filaments with guaranteed current density performance of 2400 A/mm2, but allowing for cabling degradation. Delivery of the material is expected by January of 1986. After the problem developed with the re-rolling of outer cable XT-015-3012HH described in the May Monthly Report, there was concern over fabrication of cable with a single rolling operation; however, this concern was eliminated with the successful production by LBL of XT-019-3012HH and XT-020-2317HH. These cable reels, of approximately 3000 ft lengths, were for the continuation of outer and inner coil fabrication, respectively, for model magnets. The mechanical and electrical characteristics were found to meet all of the specifications. LBL has now fabricated a length of cable to replace XT-015-3012HH.

b. Tooling. One of three lump detectors has been assembled, except for a part which awaits some minor machining. The hand-held cable measuring device (Keystone Measuring Gauge) has been released to the Shops. A device to measure cable width both on and off the cabling machine awaits detailed design. A second cable-stack measuring device for measuring mean cable

thickness has also been released to the Shops. Modifications to the Kapton Wrapping Machine await completion in the Shops, due to be completed in July.

4. Tests and Measurements. Testing of the first Reference Design D dipole, SLN-008, began June 17 and continued through the end of the month. The performance of this magnet was excellent in all respects. At 4.5K it reached the short-sample unit of the conductor within five training quenches. With subsequent testing at lower temperatures, fields close to 8 T were reached. The allowed multipoles were close to the predicted values, and the unallowed multipoles were small. The hand-wound trim coil operated successfully at seven times the required current without training. Testing was continuing at the end of the month.

5. Electrical Systems. A pulse power source has been designed, built, and tested to power the new "hot spot strip type" quench heaters designed for the SSC magnets. This power source can independently drive four of these heaters although they are expected to be connected in pairs for normal operation. The heaters are strip-like in character, but have cutouts that produce local high resistance points which get very hot quickly and therefore rapidly generate local quenches. The multiplicity of points and the high temperature are expected to initiate new quenches quickly and produce a rapidly rising quench resistance, thus reducing the magnet current to zero with a minimum of heating. This quench heater scheme will be used only if the double diode passive quench protection concept proves unsuccessful in tests. The trim coil power supplies in the magnet test facility have been modified to have regulation and control precision in the low-current range, as required by the trim coils in the Reference Design D magnets. Considerable electronic engineering effort is being expended in the control system for the long coil winder. Design and testing will continue for several months.

6. Cryogenic Systems. SSC Technical Note No. 28 entitled "Conceptual Design of a Cryogenic System for SSC Magnet D" by D.P. Brown and K.C. Wu has been issued. The design outlined in this note was then used as the basis of a cost estimate for the SSC-D Cryogenic System. The resulting estimate was $142.3 million. The work on the preliminary cost/benefit study of refrigeration for a shield which operates below 77K (for tunnel oxygen deficiency safety advantages) has been continued. When operated at this temperature, a shield using nitrogen as the working fluid is limited to a temperature range of about 65K to 75K, i.e., $\Delta T = 10K$, by the properties of the fluid. A shield using helium as the working fluid has no limitations on its ΔT and at the range of 25 to 30 K ΔT and the same mean temperature (70K) it is competitive with the nitrogen cooled shield in power required to circulate the coolant. The method of producing the refrigeration for a shield of this type was also studied. It appears that a stand-alone nitrogen plant has a slight edge over a helium-condensing-nitrogen plant, except that, in general, the nitrogen plant solution will have higher (not yet quantified) distribution losses by virtue of having only a few plants for the whole ring. This work will be continued and a technical note prepared when the work is complete.

B. FNAL.

1. Magnet Models

a. 5 cm 824 Dipole Dry Winding. Two SJ series magnets, SJ-1002 and SJ-1003 were wound and collared. Both had inner to outer coil shorts.

The collars were removed from SJ-1001 to examine the inter-coil insulation. Revealed was a bulge of the insulation at the ends due to the parting plane turn of the inner coil. The insulation apparently sheared during collar compression. This was corrected by banding the inner coil at the ends with 0.001 in. Mylar to help constrain the inner turns. The magnet was again collared without inner to outer coil shorts; however, a turn-to-turn short appeared in one of the inner coils. The magnet is shelved for future repair.

Learning from SJ-1002, the inner coil of SJ-1003 was shortened by 0.5 in. to allow the outer turns to constrain the inner, thus preventing extrusion of inter-coil insulation. This appears successful inasmuch as inter-coil shorts such as found in SJ-1002 did not occur. Instead another problem area became evident involving the bus leads as they exit the magnet. Lack of proper tensioning of these leads during collaring allowed them to buckle and shear the inner coil insulation. This magnet is currently undergoing repairs.

SJ-1004 is now being wound. Assembly technique modifications gleaned from SJ-1002 and 1003 will be employed on this magnet.

Strain gauges are being readied to monitor coil stress in collared magnets. We plan to incorporate these in SJ-1004.

b. 5 cm 824 Dipole, Wet Winding. Coils for two magnets have been completed. An apparent asymmetry exists in all coils. We are attempting to understand this by reviewing tooling as well as measuring fixtures and techniques.

c. 4 cm Design D (Dry Winding). Collars were received from BNL and coil winding has begun. The first 4 cm assembly is anticipated in mid-July.

The SSC thick wedge magnet SG1006 (this magnet had been reworked having been discovered shorted in an earlier cold test) was retested. The first quench current was 5750 A. The quench current leveled off at 7250 A to 7300 A at 4.25K. This magnet showed a relatively poor training performance possibly indicative of a lower than necessary azimuthal loading.

The ac losses in the magnet were somewhat higher indicating again a possible problem, the curvature of the energy-in/energy-out curve being almost 1.5 times greater. The shape was not typical of the other magnets in this series. The ramp sensitivity of this coil was however the same as others in this series.

The SSC prototype SJ1001 (Opti 824) magnet started cold testing but developed a cold short after the first quench at 5835 A and had to be returned to the factory.

d. Superconductor. Cables and wires, recently manufactured, were tested. Most of the cables tested were from the 12 in. billet extrusion done for SSC prototype "B" conductor and the measured $J_c(\rho_{eff}=4\times10^{-12}\Omega$ cm)(5T,4.25K) = 2675A/mm^2 in cabled form. This was a very high number, but later magnet performance (SG series) and Cu/NbTi volume checks seemed to confirm this value.

The long cable testing magnet RD1001-Fe and measurement fixture was completed and is awaiting testing. This fixture will allow measurement of critical current in a cable (~1m) as a function of field angle and magnitude (6T max) for a normal operating range (4.7K 3.2K) up to 14 kA cable current.

2. Facility Development

The computer interface for the new ten-channel output and input "Morgan" coil magnetometer is complete. That means ten Fourier coefficients are measured simultaneously.

The initial tests were completed of four computer-controlled lock-in amplifiers for measuring harmonics.

3. Cryostat Development

a. Magnetic Effects Model. The data analysis of Phase I and Phase II of the test program is complete. A comprehensive report documenting the test program is being prepared. The report is expected to be complete in August, 1985.

b. Heat Leak Model.The attempts to develop a reliable vacuum seal for the 4.5K and 10K internal volumes have been abandoned after several weeks of intensive effort to affect a seal. It has been concluded that proper sealing would require disassembly of the end vessels, an activity which cannot be done with the time and funds available. Accordingly the plans to measure the 4.5K heat leak by an alternate method; i.e., temperature rate of rise of the dummy cold mass, will be abandoned. The model has been mothballed and is awaiting possible future tests, depending on future interests of the SSC R&D program.

c. Suspension R&D. Measurements of MLI insulation in the Heat Leak Suspension Dewar continue. The measurements of the initial MLI system have been evaluated; i.e., aluminized Mylar with fiber glass mat, showed the measured heat leak to be a factor of two higher than the predicted heat leak. After completion of the measurements, the dewar was carefully disassembled and it was found that the superinsulation had partially slid down on the mounting can. The area exposed to the 300K radiator was sufficient to account for the discrepancy in the measured versus predicted values. The superinsulation has

been reapplied to the surface in a more secure manner and the measurements will be repeated.

Plans are being developed to measure the effectiveness of the thermal intercept linkage for the M10 and heat leak models by close simulation in the suspension heat leak dewar. The test arrangement will use the instrumented post that was previously measured in the dewar, connected to 10K and 80K shields as was done in the construction of the two models. The purpose of the measurement is to verify and further investigate the 10K temperature difference that was measured between the 10K shield and the 10K intercept on the post during the magnetic effects model measurements. This information is expected to substantiate conclusions drawn from the performance of the heat leak model. The measurement of the heat intercept effectiveness will follow directly the measurement of the initial MLI system.

The measurement of the G-10 creep of shrink fit joints on support posts at 105°F is continuing.

Plans are being developed and hardware fabricated to measure the creep of G10 tubes when loaded with an axial compressive load. The stress levels in the tubes will be 6 to 12 per cent of the ultimate tensile stress which closely corresponds to design loads for post-type supports for an SSC magnet. It is planned to begin these measurements during July, 1985.

The mockup test fixture required for evaluation of the assembly and adjustment characteristics of a tension member support system is essentially complete. Final outfitting is in progress at this time. The model will be used to position and adjust the mock single phase assembly according to the procedures as prescribed in the Design D Cost Design. The adjustment evaluation is expected to begin in July, 1985.

The elliptical arch model has been completed and instrumented with strain gauges for structural evaluation. The structural evaluation has begun with in plane loading. The results are expected early in July, 1985.

Folded post support members corresponding to the current Design D configuration are being manufactured for structural and thermal evaluations.

d. Cryostat Design. Work has been completed on the conceptual design for a cold iron cos θ magnet cryostat. The suspension system selected is the folded post. The information developed for the conceptual design has been provided to BNL for inclusion into the comprehensive Design D selection package. The modified Design B selection package was completed and forwarded to the CDG and the Tollestrup Committee.

The National Bureau of Standards (Boulder) continues to work on material evaluations for the Design D cryostat. Data pertaining to the structural and thermal properties of the selected cryostat materials as specified by the Design Criteria have been received and are being included into the latest issue of the Design Criteria. Input is anticipated in the near future with regard to the radiation effects and creep effects on fiber reinforced plastic composites.

4. Accelerator Physics

a. Calculations Department.

1. Magnet Aperture. Calculations continued concerning application of the aperture criterion, with emphasis on effects of random multipoles. The work was reported to Maury Tigner and Alex Chao of the CDG in a meeting on June 16.

2. Magnet Design. Optimization was essentially completed on a Tevatron-style 4 cm coil to provide comparison with the design currently adopted by the BNL-LBL-Fermilab collaboration. Though the Tevatron design

appears capable of slightly higher efficiency than others, the choice would appear to be dictated by fabrication considerations.

3. Collective Effects. A Department member spent much of June at the CDG, collaborating in the study of collective effects in the SSC, in particular, the prediction of longitudinal and transverse impedances.

b. The Photo Sublimation Experiment at NSLS for the SSC. In the planned SSC, the beams would have sufficiently high relativistic velocity (γ) to emit significant levels of synchrotron radiation. To set the scale, the radiation is similar in power (100 mW/m) and characteristic energy (a few hundred eV per photon) to that provided for existing synchrotron radiation laboratories by machines such as the VUV ring at The National Synchrotron Light Source (NSLS) at Brookhaven.

This would make the SSC the first machine where synchrotron radiation falls on a cryogenic beam pipe. New phenomena can, in principle, occur and make machine operations difficult or impossible.

One such effect might be the release of large quantities of very slowly moving neutral atoms or molecules from the walls of the beam pipe. The similarity of this hypothetical process to evaporation from the solid state led to the name of the present measurement ("photo sublimation").

In this conjectured process, the neutrals would cross the diameter of the beam pipe very slowly (with energies at or well below those corresponding to a temperature of 5K) and, therefore, have a good chance of being hit by a beam proton, causing the beam proton to be lost, the emittance to increase, or to be ionized and trapped if the beam is of antiprotons.

The measurement is designed to simulate the SSC beam tube as closely as possible. This includes the use of a long tube (nearly 5 m) so as to allow the incident photons to scatter as in the real machine. The measurement is as

unobtrusive as possible. Two quadrupole mass spectrometers are situated behind 5 mm holes in the wall of the beam pipe. The emerging neutrals cross an ionized chamber (cross beam type), where their probability to be ionized is proportional to the time spent in the chamber, i.e., inverse to their velocity. This is exactly the weighting necessary to get the probability of beam interactions, a reasonable consequence of the fact that we are just replacing the SSC proton beam by a low-energy electron beam inside the ionizers.

c. Status of the Experiment. The experiment consists of two phases:

In the first phase, a room-temperature aluminum tube is exposed to synchrotron radiation, while measuring the nature and quantity of released gases and the progress of "cleanup," as gases are depleted from the wall during the course of the measurement. This phase has been completed. Data, although not fully analyzed as yet, follow closely previously-published results from CERN. Thus, we have convinced ourselves that we understand use of the beam lines, normalization, and our instrumentation.

In the second phase, a cryostat containing a stainless-steel tube, will be exposed to the synchrotron radiation. The cryostat was built by Fermilab Accelerator Division Cryogenic Systems. A first cooldown to design temperature took place without any difficulty on June 20 and 21, 1985. During the following week, the cryostat was taken to BNL and installed on the beam line. The vacuum system connections and tests were performed there and the system was up and running in one day. Synchrotron light transmitted through the (warm) cryostat at the fully-forward (0°) position confirmed the surveying alignment used to position the cryostat.

C. LBL.

1. Magnet Models. In June, the fabrication and assembly of D12C4 was completed and the magnet was installed in the Bldg. 58 cryostat. Cool down was started by the end of the month. Fabrication and assembly work also continued on D12C5 and the mechanical completion of this magnet is scheduled for mid-July. Both of these magnets utilize punched stainless-steel collars supplied by BNL. As mentioned last month, particular attention has been given to the design and construction of these magnets to maintain a high coil preload in the area where the coil starts the end flare. Maintaining a high coil preload in this area is expected to reduce the amount of training required to reach short sample performance.

a. D12C4. In June, the following tasks were completed:

- Fabrication of collar keys.
- Assembly of the two inner and two outer coils on the hard mandrel together with the end cones. Installation of coil voltage taps was also made at this time.
- Installation of coil load cells in the upper and lower halves of the center collar hard pack.
- Calibration of coil load cells, in the center collar pack, were made up to a coil pressure of 10,000 psi.
- Installation of collars on the coil assembly.
- Assembly of the coil ends.
- Installation of the coil/collar assembly into the yoke blocks.
- Installation of instrumentation wiring and magnet coil interconnecting cable splices.
- Installation of the four collar position indicators and their associated signal lead wiring.
- Installation of the bore tube and trim coil in the magnet assembly.
- Installation of the magnet in the test cryostat.

A room temperature coil preload of 11,000 psi was achieved in the inner layer coils and 6,000 psi in the outer coil layers of D12C4.

b. D12C5. In June, the following tasks were started or completed:

- Modification of center collar pack halves to accept coil load cells completed.
- Fabrication of G-10 coil end saddles completed.
- Fabrication of coil load cell gauge blocks completed.
- Fabrication of coil end assembly cones completed.
- Forming of coil interlayer Kapton insulation completed.
- Insulating of coil wedges completed.
- Winding and curing of both inner and outer coil layers completed.
- Fabrication of collar packs started.
- Mechanical measurement of cured coils at coil pressures up to 10,000 psi completed.
- Installation and wiring of strain gages on gage blocks completed.
- Coil assembly started.

Fabrication of parts for D12C6 was started this month, and coil winding is scheduled for the second week in July. Completion of this magnet is scheduled for early August.

2. Analysis

a. POISSON Computer Program. Improvements have been made on the calculation of the effects of magnetization on field quality. A program (DUMP COMPARE) has been written to subtract the vector potentials from two dumps. This is used to isolate the magnetization field from the main field.

b. Magnet Cross-Section Design Program (BNL). Work on getting R. Fernow's program, MAG2PL, to run on an LBL computer was completed. The program can also be run on the Cray computer at LLNL.

c. Dipole End Design Program. Work progressed on the program. The program consists of three sub-programs:

- Generator - generates coordinates and currents for a set of current filaments which model the actual coil ends.

- Multipole calculator - calculates integral field multipoles, and shifts specified groups of conductors longitudinally in order to eliminate certain higher-order multipoles.

- Local field calculator - calculates local field at a specified grid of points, particularly in the conductor.

The first two have been completed and debugged. The third is in progress.

3. Instrumentation and Measurements

Testing of SSC model dipole D12C3 was conducted from June 6 to June 12, 1985. This magnet has aluminum collars and was the first model to incorporate the highest current density high homogeneity superconducting cable. The strand J_c in the inner layer is over 2500 A/mm^2 at 5 Tesla, and a cable made from this material was difficult to measure in the standard Brookhaven critical current test fixture.

The first quench occurred at a central field of 6.0 Tesla and the conductor limit of 6.4 Tesla occurred on the fourth quench--an excellent training behavior. In HeII, below 2.0K, the first quench was 7.4 Tesla, but another twelve quenches were required to reach the conductor limit of 8.2 Tesla, which is somewhat slower than average. Perhaps the aluminum collars mechanically deflected under the overload stresses generated at the higher fields.

Extensive stress data using strain gages was taken as was magnetic field data.

4. Superconductor

Cable. The final lot of cable required for the BNL 4.5 m model dipoles has been completed. This brings the total length produced at LBL to 12,000 ft and the total at NEEW to 9,000 ft (during Feb.-June 1985). With the exception of the 2600 ft of cable which showed serious I_c degradation, all

this cable has been satisfactory for use in Design D dipoles. However, I_c measurements indicate a significantly lower critical current in the cable than the values for the individual strands would indicate (i.e., typically 10-15%). We have allowed for a 15% decrease in the Design D cable specification; however, now that the FY85 cable production requirements have been met, we plan to focus our attention on the causes for this I_c decrease in cable.

Experimental work has begun on two-level cables. If successful, this approach would allow the fabrication of fine filament material in a single extrusion process and should, therefore, be cost effective. Wires containing 4-6,000 filaments would be drawn to 0.009 in. or 0.011 in. diam. (for outer and inner cables, respectively) and then formed into a 7-element sub-cable; this sub-cable would be used to produce the 23- and 30-strand Design D cables.

D. TAC.

1. Reviews

June was the month for reviews at TAC. They are listed below:

June 3,4	Magnet review by the Central Design Group Committee
June 12	Program Management group meeting
June 19-21	DOE/CDG Review at LBL
June 24,25	GAO
June 26	DOE/TAC Annual Review
July 1,2	Magnet Technical Review Panel

2. Long Magnets

General Dynamics has in place the tooling for assembly of the 28 m magnets. The tooling is much simpler than anticipated even as recently as the Reference Designs Study. The tooling for the coil winding is a simple aluminum I-beam 28 m long. The tooling for the beam tube assembly is actually done with about six stands on the floor and a cart that fits under the beam tube that moves along as one is assemblying the one foot long plastic ears on each side of the beam tube. The tooling for assemblying the four 23-ft long iron core laminations is a simple beam structure, again 28 m long. The fourth tooling line is a more substantial beam 28 m long with clamping every few feet and a pressure device on the top actuated by putting air pressure every few feet and a pressure device on the top actuated by putting air pressure in a fire hose that is contained in a metal box. This fixturing can apply up to 1500 lbs/in. along the full length of the 28 m magnet. It is this tooling that is used to put the precision humps in the long helium containment structure so that when it is placed on the five supports the structure will come out exactly level (within 10 mils). All of the final welds on the helium containment vessel are done on this fixture.

C. Project Cost Data

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SSC Program	Table	Figure
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Fermi National Accelerator Laboratory	C-3	3
Lawrence Berkeley Laboratory	C-4	4
Texas Accelerator Center	C-5	5
SSC Program Summary	c-6	6

TABLE C-1

CENTRAL DESIGN GROUP - SUPERCOLLIDER

JUNE 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.1	ADMINISTRATION	51	230	96	377	1803	1935
1.2	PROGRAM PLANNING & MANAGEMENT	19	1	10	30	219	380
1.3	ACCELERATOR R & D	37	53	44	134	817	1680
1.4	CONVENTIONAL SYSTEMS DEVELOP.	5	114	17	136	425	1130
	PROGRAM COSTS	112	398	167	677	3264	5125
	COMMITTMENTS					270	

TABLE C-2

BROOKHAVEN NATIONAL LABORATORY - SUPERCOLLIDER

JUNE 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
2.1	GENERAL	20	34	20	74	563	800
2.2	MAGNET MODELS	88	26	44	158	1672	2305
2.3	TOOLING	26	13	15	54	655	800
2.4	MAGNET MEASUREMENT & DEVEL.	19	10	11	40	355	400
2.5	POWER SUPPLIES & QUENCH PROT.	15	3	6	24	278	280
2.6	CRYOGENIC TESTING	27	18	13	58	421	500
	PROGRAM COSTS	195	104	109	408	3944	5085
	COMMITMENTS					332	
	EQUIPMENT						497

TABLE C-3

FERMI NATIONAL ACCELERATOR LABORATORY - SUPERCOLLIDER

JUNE 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
3.1	GENERAL	3.8	2.9	2.9	9.6	132.6	340
3.2	MAGNET MODELS	53	41.3	40.6	134.9	2439.6	3320
3.3	FACILITY DEVELOPMENT	5.8	2.4	3.5	11.7	246.3	340
	PROGRAM COSTS	62.6	46.6	47	156.2	2838.5	4000
	COMMITMENTS					15.2	
	EQUIPMENT					25	25

TABLE C-4

LAWRENCE BERKELEY LABORATORY - SUPERCOLLIDER

JUNE 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
4.1	GENERAL	3	1	2	6	93	115
4.2	MAGNET MODELS	16	2	9	27	272	395
4.3	ANALYSIS	6	0	3	8	102	125
4.4	INSTRUMENTATION/MEASUREMENTS	3	0	2	5	84	155
	PROGRAM COSTS	28	3	5	46	551	790
	COMMITMENTS					98	

TABLE C-5

TEXAS ACCELERATOR CENTER - SUPERCOLLIDER

JUNE 1985 COST AND COMMITTMENT REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
5.1	GENERAL	0	65.5	26	91.5	619	825
5.2	SHORT MAGNET MODELS	70.9	-36.5	13	47.4	774	1150
5.3	LONG MAGNET MODELS*	70.9	0	0	70.9	153	1660
5.4	TOOLING	0	0	0	0	0	630
5.5	THEORETICAL ANALYSIS	70.9	0	0	70.9	166.4	130
5.6	FACILITY DEVELOPMENT	0	0	0	0	219.8	605
	PROGRAM COSTS	212.7	29	39	280.7	1932.2	5000

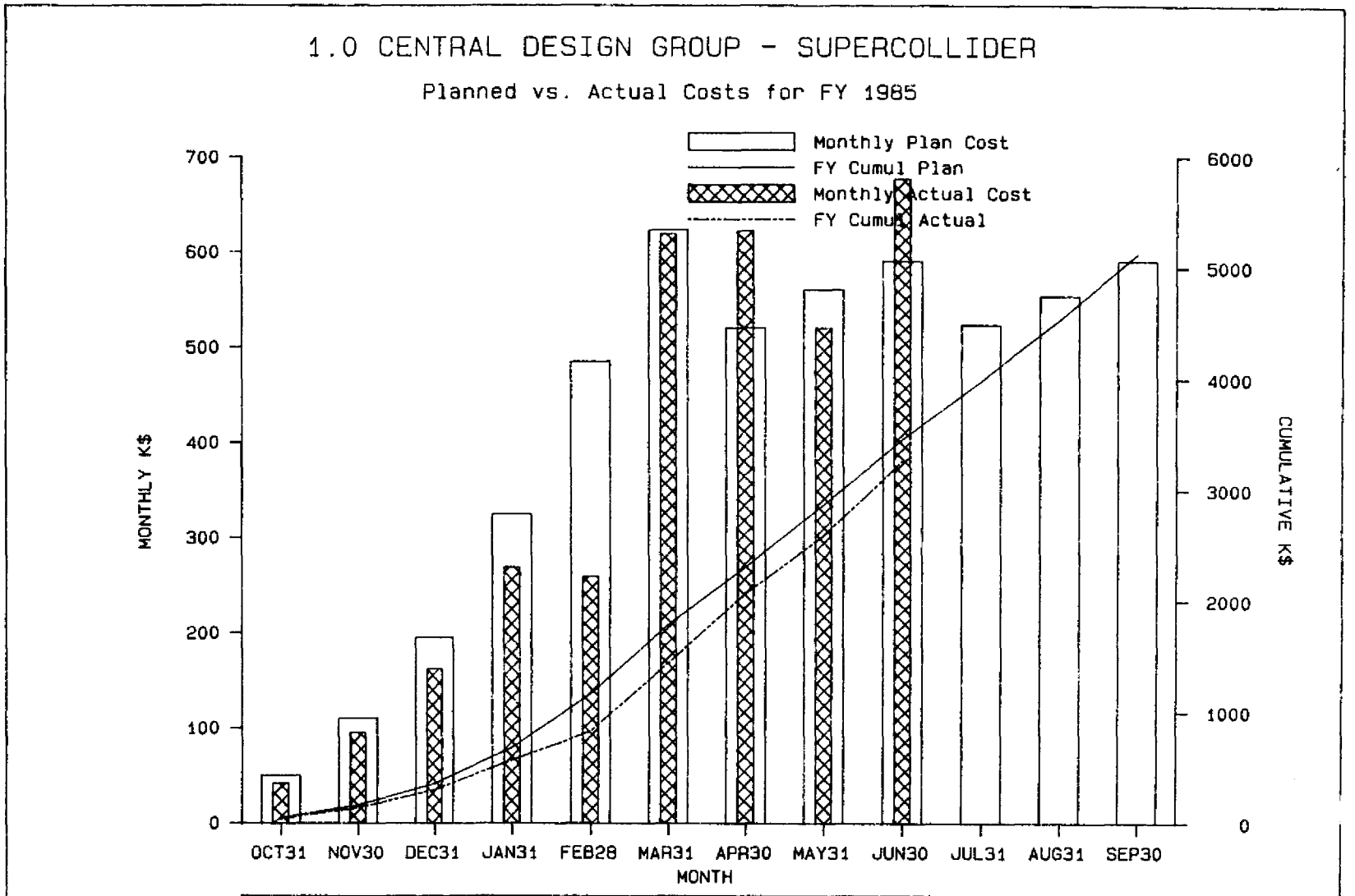
*Does not include 1062 K$ obligation to General Dynamics Corp. for fabrication of long magnets

TABLE C-6

PROGRAM SUMMARY - SUPERCOLLIDER

JUNE 1985 COST REPORT (K$)

	PROGRAM ELEMENT	LABOR	MAT'L & SERVICES	G & A	MONTH TOTAL	YEAR TO DATE	ANNUAL BUDGET
1.	CDS PROGRAM	112	398	167	677	3259	5125
2.	BNL SSC PROGRAM	195	104	109	408	3944	5085
3.	FNAL SSC PROGRAM	63	47	47	156	2839	4000
4.	LBL SSC PROGRAM	28	-3	16	47	551	790
5.	TAC SSC PROGRAM	213	29	39	281	1932	5000
	TOTAL SSC PROGRAM COSTS	610	581	378	1569	12525	20000



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	50	110	195	325	485	623	520	560	590	523	553	590
FY Cumul Plan	50	160	355	680	1165	1788	2308	2868	3458	3981	4535	5125
Monthly Actual	42	95	162	269	259	619	622	520	677			
FY Cumul Actual	42	137	299	568	827	1446	2068	2588	3265			

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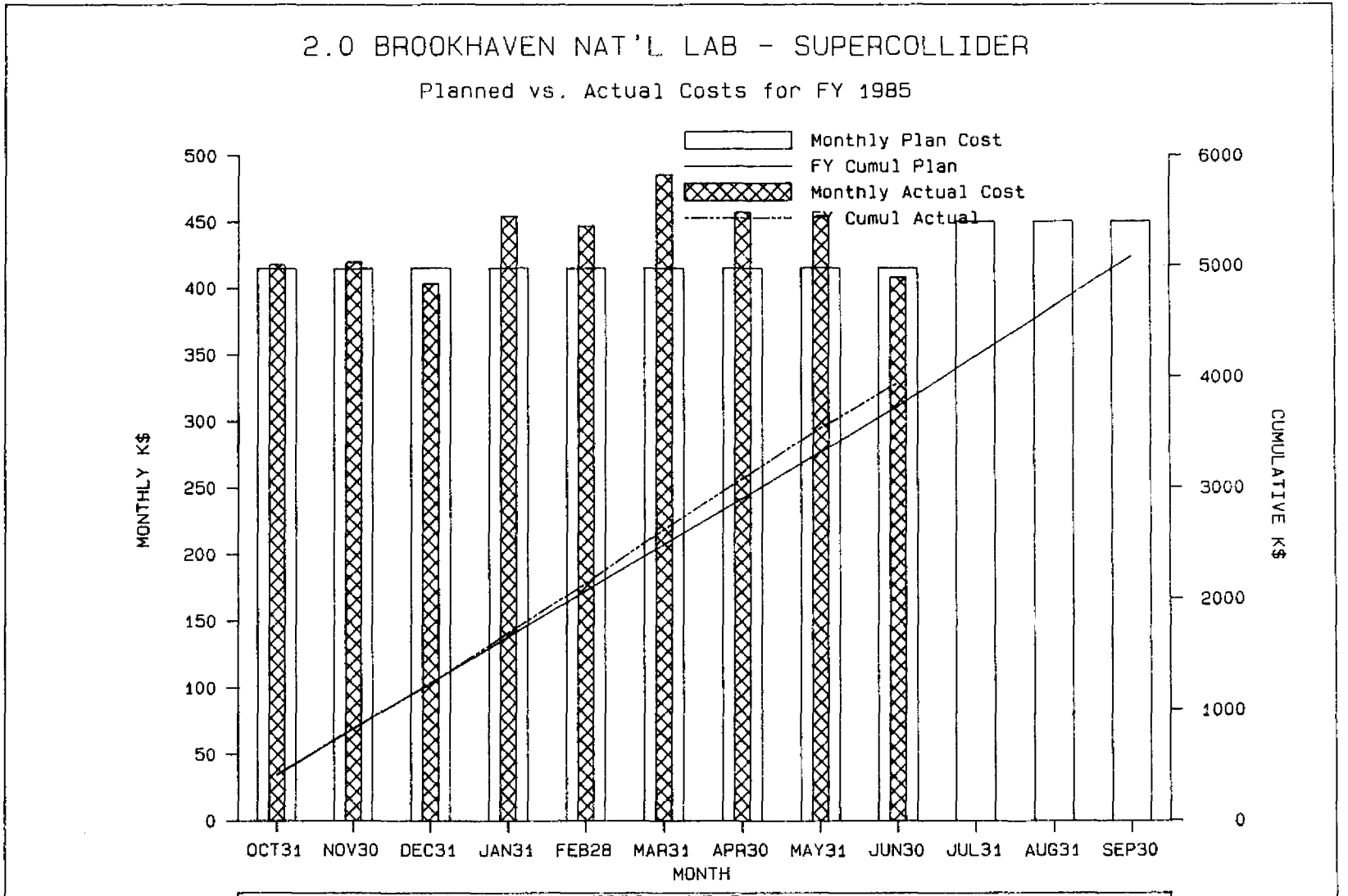
Fig. 1



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	415	415	415	415	415	415	415	415	415	450	450	450
FY Cumul Plan	415	830	1245	1660	2075	2490	2905	3320	3735	4185	4635	5085
Monthly Actual	418	420	403	454	447	486	457	454	408			
FY Cumul Actual	418	838	1241	1695	2142	2628	3085	3539	3947			

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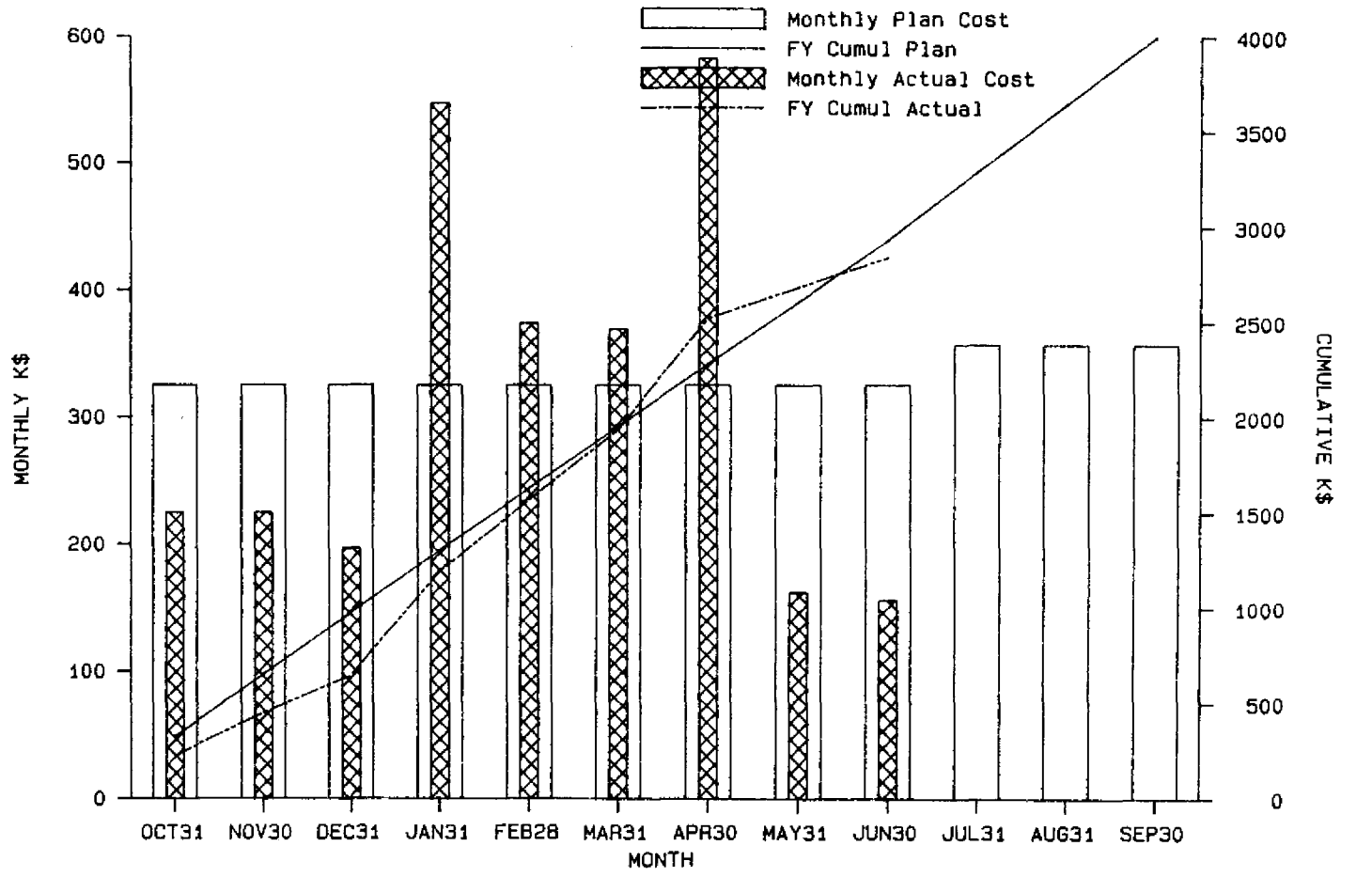
5-AUG-85

Fig. 2



	FISCAL YEAR 1985											
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Monthly Plan	325	325	325	325	325	325	325	325	325	357	357	357
FY Cumul Plan	325	651	976	1302	1627	1953	2278	2603	2929	3286	3643	4000
Monthly Actual	225	225	197	547	374	370	582	162	156			
FY Cumul Actual	225	450	647	1194	1568	1938	2520	2682	2839			

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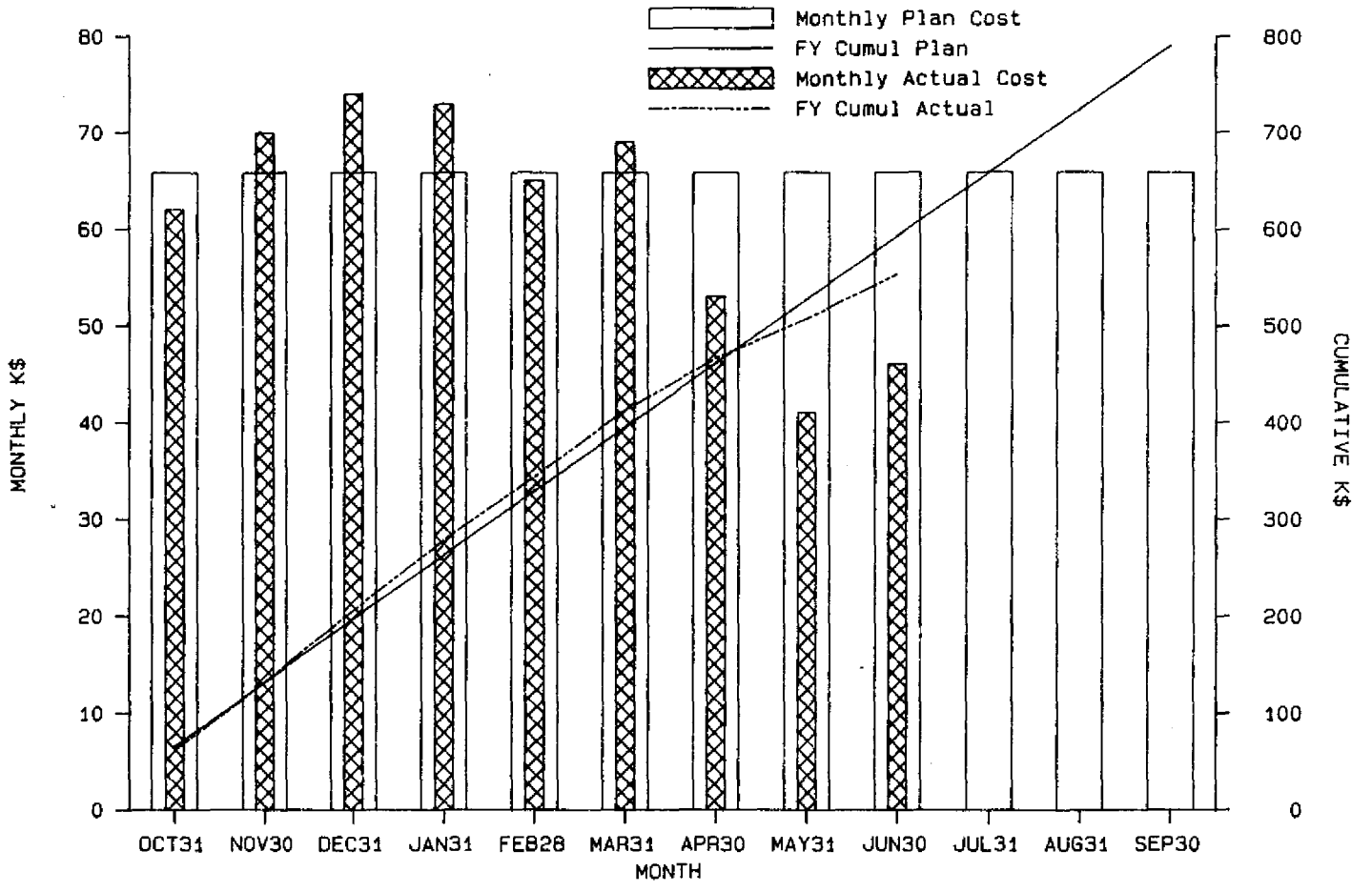
Fig. 3



	FISCAL YEAR 1985											
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Monthly Plan	66	66	66	66	66	66	66	66	66	66	66	66
FY Cumul Plan	66	132	198	263	329	395	461	527	592	658	724	790
Monthly Actual	62	70	74	73	65	69	53	41	46			
FY Cumul Actual	62	132	206	279	344	413	466	507	553			

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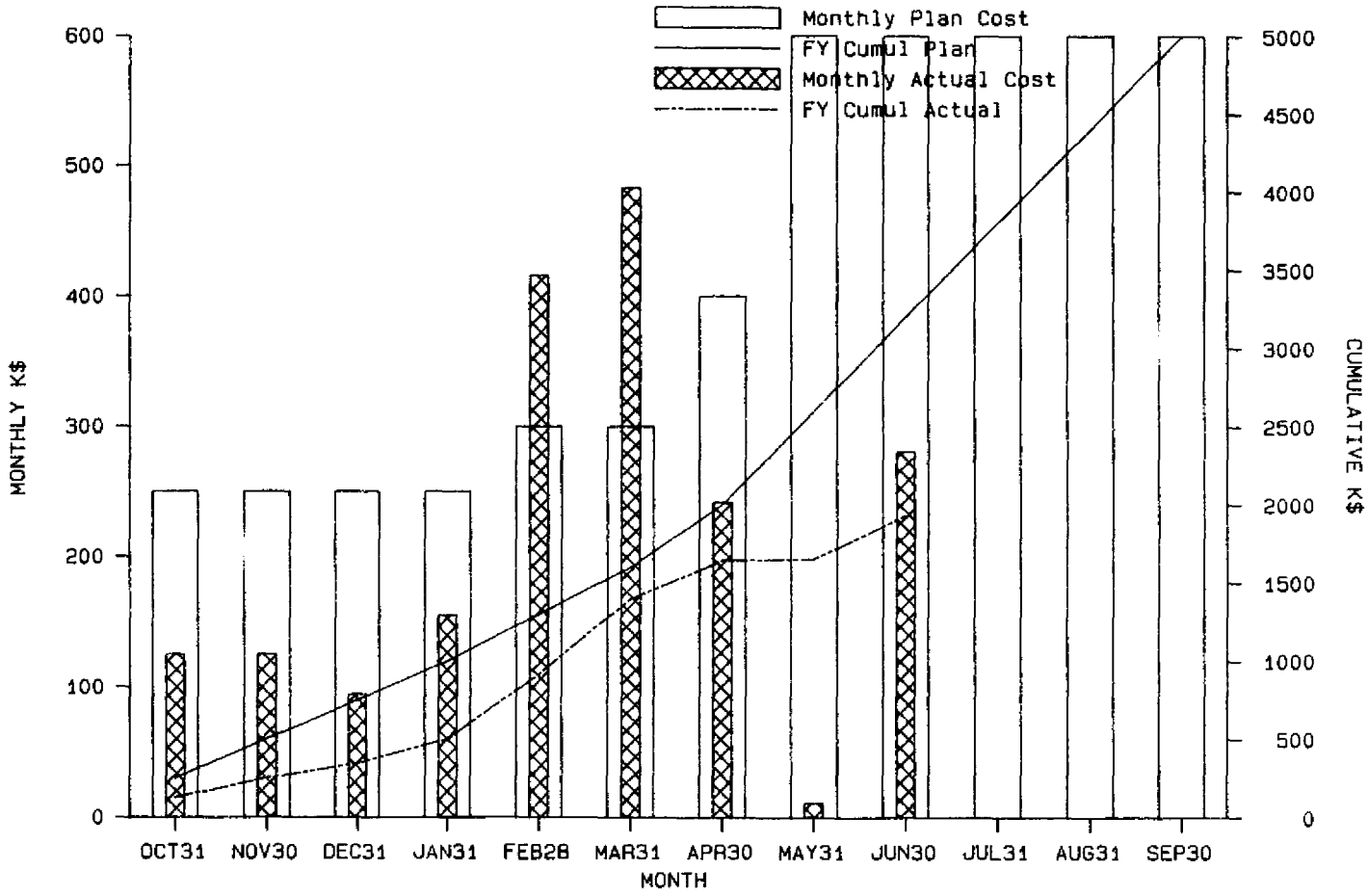
Fig. 4



	FISCAL YEAR 1985											
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Monthly Plan	250	250	250	250	300	300	400	600	600	600	600	600
FY Cumul Plan	250	500	750	1000	1300	1600	2000	2600	3200	3800	4400	5000
Monthly Actual	125	125	94	155	416	483	242	11	281			
FY Cumul Actual	125	250	345	500	916	1399	1641	1652	1932			

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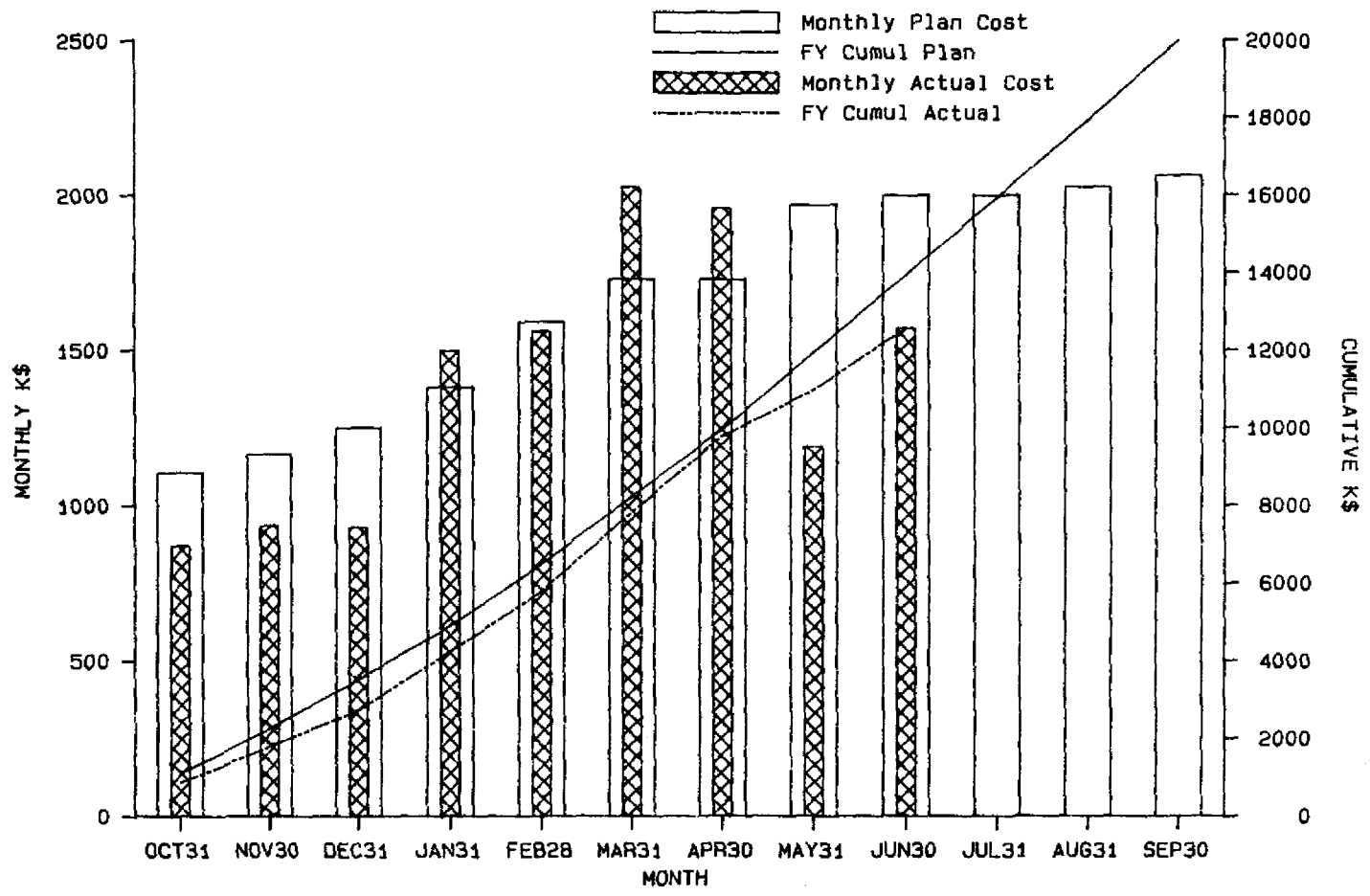
Fig. 5



	FISCAL YEAR 1985											
	OCT31	NOV30	DEC31	JAN31	FEB28	MAR31	APR30	MAY31	JUN30	JUL31	AUG31	SEP30
Monthly Plan	1106	1166	1251	1381	1591	1729	1726	1966	1996	1996	2026	2063
FY Cumul Plan	1106	2273	3524	4905	6496	8226	9952	11918	13914	15910	17937	20000
Monthly Actual	872	935	930	1498	1561	2026	1956	1188	1568			
FY Cumul Actual	872	1807	2738	4236	5797	7823	9780	10968	12536			

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9:20 am
5-AUG-85

Fig. 6