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OPTO-MECHANICAL DESIGN AND
FABRICATION SERVICES

FINAL REPORT

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SUMMARY

This subcontract was for Optomec's support of LANL Group MEE-12 (formerly P-12) in the technical specialty area of opto-mechanical design and fabrication. The work was performed over a two year period from February 3, 1986 to February 28, 1988. Seven individual tasks were defined by MEE-12 and completed by Optomec personnel. Either Edward J. Yavornik or Thomas A. Swann acted as Principal Investigator of the various tasks, which are discussed in the following sections. The working relationship between Optomec personnel and MEE-12 personnel was somewhat informal. Optomec personnel worked closely with MEE-12 personnel almost as if they were part of the MEE-12 staff. Some of the work was done at Optomec's facility in the Los Alamos Small Business Center and some of it was done at the Los Alamos National Laboratory at the discretion of MEE-12. Only a small amount of hardware was fabricated under this contract. Some drawings were prepared by Optomec and then released through the MEE-12 drawing system. However, most of the work involved preparing conceptual designs, and optical and mechanical analyses to support the efforts of MEE-12 design and drafting personnel and then helping to oversee the subsequent resulting fabrication and assembly. There was a small amount of travel involved in the project and there was one technical paper published as a result of this work. There were no patent disclosures as a result of any of this work.

All work defined in the subcontract was completed.

PROJECT TASK DESCRIPTIONS

Each of the seven tasks defined under this subcontract are discussed in the following sections:

TASK 1 - PANCHUELA

This task involved design support for an X-Ray Spectrometer Instrument for the "Panchuela" down-hole experiment at the Nevada Test Site. Thomas A. Swann was Principal Investigator for this task, which involved 420 man hours of effort. Mr. Swann prepared conceptual designs and selected hardware for four optics related subsystems of the instrument. In addition, an alignment procedure was determined in conjunction with the design to insure that any necessary alignment features required were incorporated into the design. Final detail drawings for the instrument and fabrication of the instrument were conducted by MEE-12.

personnel. After the hardware was fabricated and assembled, Mr. Swann aided in the alignment of the instrument in a consulting capacity.

TASK 2- MAGNETIC OPTICS I

The objective of this task was to develop and experimentally demonstrate an optical alignment method for aligning the 180 degree bend achromatic magnetic section of the Ground Test Accelerator. This work was part of the Neutral Particle Beam Program. Thomas A. Swann was again Principal Investigator for this task, which involved 110 man hours of effort. A conceptual approach was generated and refined by Mr. Swann under the direction of MEE-12 personnel and a simple experiment was conducted to verify that the approach was able to meet the positioning tolerances required. The approach consisted of an optical instrument which could simultaneously view with an alignment telescope three fiducials on each of the 17 magnets in the 180 degree array. The experiment conducted verified that the approach could meet the positional tolerances required. A "White Paper" entitled Optical Device for Alignment of NPB 180 Degree Magnet Array, dated July 15, 1986, was subsequently prepared and submitted, however, further funding to develop this approach was not allocated.

TASK 3- MAGNETIC OPTICS II

This work was also part of the Neutral Particle Beam Program. The objective of this task was to develop magnet support and manipulation concepts for the 17 magnets of the 180 degree bend achromatic magnetic section of the Ground Test Accelerator. Edward J. Yavornik was Principal Investigator for this task, which involved 760 man hours of effort. In addition to the magnet support and manipulation concepts, which were developed, Mr. Yavornik also participated in the preparation of the magnet specification control drawing and procurement documents and accompanied MEE-12 personnel in plant visits to evaluate prospective magnet suppliers.

TASK 4- ARGONNE TELESCOPE

This work, which was also a part of the Neutral Particle Beam Program, involved design support for the triplett magnet telescope assembly and its support structure. Edward J. Yavornik was again Principal Investigator for this task, which involved 814 man hours of effort. Thomas A. Swann also participated in this task. The entire telescope assembly consisted of a 50 foot long vacuum beam line containing permanent magnet eyepiece and objective lens assemblies. This was a large and heavy (1000 lb) unit and it was required to be manipulated to microradian precision. Mr. Yavornik did the conceptual design for the telescope and worked

directly with MEE-12's design personnel to produce the drawings required. He then worked closely with the shops and the vendors involved in producing the parts for the assembly. Mr. Swann prepared the design and produced, in Optomec's facility, the hardware for the stepper motor servo control system which controlled the precision alignment of the triplet magnet assembly. Both Mr. Swann and Mr. Yavornik took part in the assembly and checkout of the telescope at Los Alamos prior to it being shipped to Argonne National Laboratories for assembly into their system.

TASK 5- ARGONNE BEAM DIAGNOSTICS

This task involved design and experimental support for the Beam Diagnostics system for the Argonne Neutral Particle Beam Experiment. Thomas A. Swann was Principal Investigator for this task, which involved 466 man hours of effort. Initially, Mr. Swann took part in the selection of motorized linear actuators and the associated controls for these actuators which were required to move various components of the beam diagnostics system into and out of the beam line. Mr. Swann also took part, in a consulting capacity, in the selection of vacuum components for seals, feed-thrus, etc. When the linear actuators, which were selected, were received by MEE-12, Mr. Swann performed various experiments to determine the operating capabilities, such as speed, resolution and repeatability, as well as controlling and programming the control of the actuators. Finally, Mr. Swann helped in the interfacing of the actuator controller to the system control computer.

TASK 6- MARX TANK MODIFICATIONS

The objective of this task was to generate a conceptual design and detail design drawings for the modification of an Antares Marx tank for use in the Aurora Laser Program. Thomas A. Swann was again Principal Investigator for this task, which involved 80 man hours of effort. The task involved putting a removeable door, which had to be approximately 12 foot square, in the side of an existing steel tank, which in operation is filled with oil. Design considerations included the sealing technique for this door and the structural integrity of the door and its attaching hardware. Drawings were made by Mr. Swann, which were released through the MEE-12 drafting section for the modification of this tank. Mr. Swann also monitored the progress of the work on the tank as it was done.

TASK 7- CTR TOROIDAL GAP DESIGN

This task involved the design of the Poloidal Gap for the Los Alamos ZTH Reversed Field Pinch machine. Edward J. Yavornik was Principal Investigator for this task, which involved

1216 man hours of effort. This was a complex design considered state-of-the-art in its field. Appendix A is a copy of a technical paper describing the design in more detail. This paper, for which Mr. Yavornik was lead author, was presented at the National Magnetic Fusion Conference, and was the only technical publication to arise out of any of the work done on this subcontract.

CPRF/ZTH SHELL POLOIDAL GAP DESIGN AND FABRICATION*

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ABSTRACT

Design is in progress on a new generation Reversed Field Pinch (RFP) machine, designated as ZTH, to be assembled at Los Alamos National Laboratory during FY 86-92. The front end of the machine will consist of an external electrically conducting shell that supports an internal vacuum liner containing the plasma. The external shell will contain insulated toroidal and poloidal gaps to permit penetration of magnetic fields and voltage to the plasma. Many perturbations of the magnetic field induce toroidal shell currents with poloidal Fourier components having mode numbers $m > 1$. A typical butt-joint poloidal gap will convert these image currents into potentially damaging magnetic field errors with a large spectrum of toroidal-mode numbers. The ZTH shell poloidal gap will use concentric overlapping tapered shells in its construction, which will serve to minimize these errors.

DISCUSSION

The poloidal gap design consists of three concentric stainless steel conductors, each appropriately lined with tapered copper and separated from each other by Kevlar electrical insulation. The center conductor is electrically connected to a flange at one end of the poloidal gap, and the inner and outer shells are electrically connected together to the flange on the opposite side of the gap. The inner conductor contains water cooling passages to protect the gap from heat generated within the vacuum liner of the machine. Optimally, the overlapping tapered gap will be as long as the minor diameter of the shell. The boundary dimensions of the gap assembly will be identical to each 22.5° segment of the standard conducting shell. Figure 1 shows the final gap configuration and Fig. 2 shows the relative orientation of the stainless steel overlapping conductors.

Fig. 1. Final Gap Configuration.

Fig. 2. Gap SS/Copper Component Configuration.

It is now expected that the required copper will be explosively bonded to flat stainless steel plates. This process forms a bond joint that is slightly stronger than the weaker of the two base metals. The taper in the copper will be machined with the bonded assembly held in the flat condition. The water jacket will also be machined into the inner stainless plate in the flat condition. A 1/8-in.-thick stainless steel sheet will be welded over the water flow channel to complete the inner shell configuration.

The three concentric shells making up the gap will be die-formed with the same dies that are used for the standard sections of the ZTH shell. Uniform thickness is necessary for die-forming and will be achieved by placing two opposing tapered parts together to create an assembly of uniform thickness for forming. The dies will be capable of accepting spacers of proper thickness to accommodate variable diameters as required.

In the assembly, the three copper clad gap conductors will be separated by a Kevlar layup with a minimum of 1/4-in. thickness. The Kevlar insulation will be bonded to the center conductor section. After inspection and curing, a heavy coating of epoxy resin will be applied to the Kevlar on the center conductor and to the inside surfaces of the inner and outer conductors. They will then be pressed together to form the final configuration. Final machining of the flange surfaces and bolt holes will then take place. Figures 3, 4, 5, and 6 illustrate the details of the final gap configuration. Figure 7 shows the gap assembly located in the ZTH torus.

Fig. 3. Outer Conducting Toroidal Flange Section.

Fig. 4. Inner Insulated Toroidal Flange Section.

Fig. 5. Shell Poloidal Flange Cross-Section

Showing Gap Center Conductor.

Fig. 6. Shell Poloidal Flange Cross-Section

Showing Gap Inner and Outer Conductors.

Fig. 7. ZTH Torus