### Development of UHV grade Aluminum to stainless steel tubular transition joint

The RF Cavity for the storage ring of the SRS facility will be made of aluminum alloy 6061 T 6 and will operate under Ultra High Vacuum ($10^{-9}$Torr). The use of metal gasket on all port flanges therefore becomes unavoidable. There is, however, considerable difficulty, in making demountable joints with aluminum alloy flanges using metal seals. This is because of the low hardness of non heat treated aluminum alloys. To overcome this problem tubular UHV grade transition joints between aluminum and stainless steel were developed and these will be used in the RF cavities for Indus-I and Indus-II.

Conventional fusion welding technique cannot be used to make these transition joints because highly brittle intermetallic compounds are formed during this process. Therefore techniques like explosion bonding, and friction bonding were tried. The explosion bonded pieces were found unsuitable for UHV grade transition joints as they had leaks of the order of $10^{-7}$ Std-CC/Sec in the direction of symmetry of the wavy interface of the bond. However these joints passed all the mechanical tests for strength and ductility and thus can be used for less demanding vacuum applications. Friction welding of Aluminum (99.0%, annealed) to Stainless Steel AISI-304 has yielded satisfactory mechanical properties and leak rate. The joints passed the bend test and the tensile test with joint strength of 16 kgf/mm$^2$. No detectable leak was found in helium leak tests at the sensitivity level of $10^{-9}$ Std-cc/Sec. These tests ensure that the developed transition joints would be suitable for UHV applications. The joints were developed in collaboration with Welding Research Institute, Tiruchirapalli using a continuous drive friction welder. Work is also in progress for developing transition joints using diffusion bonding technique.

### RF cavity for booster synchrotron

The RF cavity for the 700 MeV booster synchrotron for the SRS facility is under fabrication at CAT and is expected to be ready soon. It has been designed to operate at 31.613 MHz with a provision for tuning the frequency and to sustain a gap voltage of 45 kV under high vacuum conditions ( $10^{-7}$ torr). The design values for shunt impedance and unloaded Q are 397 kΩ and 5410 respectively. The cavity, made of aluminum alloy 6061, is a cylindrical structure of 880mm diameter and 900mm length, with re-entrant drift tubes having capacitive plates. The fabrication of the cavity has involved development of UHV grade weld joints of 25mm thickness in aluminum alloy 6061 with minimum distortion due to welding so that stringent tolerances required in the cavity can be achieved.

**The RF cavity under inter-stage helium leak test during fabrication.**

# INFRASTRUCTURAL DEVELOPMENT

### IN-HOUSE FACILITY FOR GLASS & CERAMIC WORK

The glass & ceramic techniques section provides in house facilities for glass and ceramic working. It has two glass blowing lathe machines (one 75mm and the other 200mm bore), annealing ovens of 610 X 610 X 610mm$^3$ and arrangements for table top glass blowing. Diamond cutting and lapping machines have been installed for cutting and grinding of glass and ceramics. The section also has a hydrogen furnace (150mm diameter X 300mm length) and a RF induction heater of 18 kW capacity for development of ceramic to metal seals of both tubular and feed through types. A controlled atmosphere furnace, for temperatures upto 1550°C, with chamber size of 250 X 300 X 350mm$^3$ is being commissioned.

The glass and ceramic technique section has also taken up work related to development of several critical components for accelerators and lasers such as ceramic to metal sealed feed throughs, electron guns for linac and electron beam welding machine, emitter for microtrons, sealed off fixed anode X-ray tubes of 1.5-2 kW, quadrupole residual gas analyser gauge heads, sealed off sparkgaps and various types of laser tubes. Of these, self triggered spark gaps with breakdown voltages ranging from 8 kV DC to 15 kV DC have already been developed and work on sealed off nitrogen laser tubes is in an advanced stage of completion. An electron gun for linac using $LaB_6$ emitter has been made and is under test. The cathode assemblies for 20 MeV microtron have also been made. The emission current from these was found to be about 75% of that of imported single crystal cathodes. A fixed anode X-ray tube has been sealed off and is awaiting tests. Development and production of various types of flash lamps and arc lamps is also planned in this section.

## COMPUTER FACILITY

A supermini computer system MAGNUM MULTI-RISC-2 with 32 MB main memory and 15 Wheatstone MIPS in double precision and a twin CPU based minicomputer system MAGNUM have been installed to augment capabilities for scientific computations. The centre now has a 2D-graphics workstation (NEXUS-3500) which is used as a dedicated system for scientific graphics and as a TEKTRONIX terminal for other computers. A one day course for familiarization with this system was also organised. Besides, an Electronic Design and Analysis (EDA) work station has been commissioned for PCB layout design.

The Computer Centre organised several other courses of both introductory and advanced levels to keep the users informed and developed several general utility softwares. It has also developed a package for the analysis of accelerator beam. The PC based package has the capability of displaying two images simultaneously with 256 gray levels and has provision for back ground subtraction, noise reduction, beam profile plotting, computation of mean standard deviation and other parameters.

## CONSTRUCTION PROGRAMME

The construction of Laser Fusion Laboratory has been completed and the laboratory is now in use. Work on the Indus-I laboratory, erection of a 132 kV substation, a fire station and construction of 131 residential quarters is progressing well. Work has also been started for the construction of Laser Research and Development Laboratories and Accelerator Development Laboratory.

# HIGH POWER TRANSVERSE FLOW CW $CO_2$ LASER

High power CW $CO_2$ lasers with powers ranging from 1 to 10 kW are finding increasing use worldwide for several industrial applications such as welding, cutting, surface hardening, cladding and alloying. Even in India these lasers are being used though mainly for cutting metal sheets. Perhaps a major obstacle in a wider use of such systems in our country is their high cost ( ~Rs. 20 Lakhs/kW laser power). Realising that th*e availability of a cheaper indigenous laser system should help in fuller utilisation of the potential of this promising technology, a programme on the development of high power transverse flow CW $CO_2$ laser was initiated in 1986. The first indigenous laser system is now operational. Though optimization of the system is still in progress, laser output power of more than 2.5 kW has already been achieved.

In this article we first provide a brief introduction to CW $CO_2$ lasers and then describe the design and operational characteristics of the high power transverse flow CW $CO_2$ laser developed at CAT.

$CO_2$ Lasers are one of the efficient laser systems. About 15-30% of the excitation electrical power can be converted into laser radiation. Rest of the electrical power gets dissipated as heat in the laser gas. If not removed, this results in an increase of gas temperature, which increases the thermal population of the lower laser level and the collisional decay of the upper laser level population. Both of these effects reduce the available population inversion and hence limits laser operation. The heat dissipated in the gas has therefore to be quickly removed before the temperature of the laser gas rises too high for an efficient laser action. In conventional CW $CO_2$ lasers, heat is removed via diffusion through the wall of the laser tube which is cooled by water flowing continuously through a jacket put around the tube. Diffusion cooling limits the laser output power from this type of system to about 50 W/m active length. The laser power from such diffusively cooled systems can be increased by increasing the active length achieved by placing several discharge tubes in series and/or parallel. Diffusion cooled laser systems upto 10 kW maximum power have been reported. However, for output powers beyond 1-2 kW such systems become rather cumbersome and therefore an alternative cooling technique, *viz.* the convective cooling is usually employed for high power CW $CO_2$ lasers. In convective cooling, the laser gas is circulated through the discharge zone and then through heat exchangers at a high speed with the help of a suitable gas circulating system. The laser output power scales up with the gas flow velocity. Two different gas flow configura-