monitoring the build up of laser radiation using a photodiode. When the laser radiation reaches its maximum, the signal from the photodiode triggers an avalanche transistor circuit (ATC). The fast ATC developed indigenously gives a 3.5 kV step pulse with a rise time of 1.5 ns to the Pockell's cell for rotating the polarization of the laser pulse by 90°. An intracavity polarizer then deflects the pulse out of the oscillator resonator. The laser pulse from the oscillator has an energy of 0.5 mJ. This is amplified to 3 mJ by two passes through a Nd:Phosphate glass laser amplifier. For temporal characterization of the pulses a Two Photon Fluorescence (TPF) setup using a vidicon camera read out system has been developed. In the retro-reflection geometry of TPF a 6 ps pulse was observed.

The picosecond laser system has been used to measure the rather low two photon absorption coefficients in composite materials like colour glass filters.

CO_2 Laser

A high repetition rate transversely excited (TE) CO_2 laser has been developed providing laser pulses of 200 kW peak power at 500 Hz. The 100 W average power output of the system is presently limited by the capacity of the roots blower which is used for removing heat from the laser gas mixture by circulating it through a heat exchanger. The laser utilizes a single row of resistance ballasted multiple pin electrode as anode and an oil cooled copper tube as cathode for electrical discharge. An electrical pulser system which gives 20 kV peak voltage pulses at upto 500 Hz repetition rate is used for laser excitation. Presently this laser is being used for studying laser power coupling to highly reflecting materials such as copper and aluminum. This laser will also be used for scribing, cutting and drilling holes in ceramics.

Another development is a 20 W cw CO_2 laser excited by capacitively coupled high frequency (50 kHz) pulses. The high frequency excitation allows smooth variation of the laser output power from 10% to 100%. Such a smooth variation is required for many applications notably in laser surgery. A further advantage of this excitation scheme is that contamination of laser gas by internal discharge electrodes is eliminated, facilitating operation of the CO_2 laser system in sealed-off mode.

Copper Vapour Laser (CVL)

A 30 W average power CVL with 38 mm beam diameter and an energy conversion efficiency of 0.9% has been developed. Copper Vapour Lasers with average power varying from 10 W to 30 W are now being routinely made at CAT and several of these units have been supplied to other DAE units.

For many applications, it is desirable that the CVL oscillator provide a low divergence beam. Towards this objective several unstable resonator configurations were investigated. In particular, self filtering unstable resonators were applied to the CVL for the first time. The best results were obtained using a positive branch self filtering unstable resonator. This allows more than 70% of the oscillator output energy in diffraction limited divergence angle as compared to only about 10% with a positive branch unstable resonator CVL. The low divergence has allowed focusing of the beam to very small spot sizes. The laser has been used to drill holes with a diameter of 50 μm (1/20th of a mm) in 0.5 mm thick copper plate.

ACCELERATOR PROGRAMME

Microtron

A 20 MeV microtron is being developed for its use as an injector for the 700 MeV booster synchrotron. A microtron for beam injection has the advantage of smaller beam emittance and energy spread, and a lower cost compared to linear accelerators of the same energy. The microtron being developed is of classical type. It has been designed to provide a 20 MeV electron beam with a current of 30 mA in pulses of 1 to 2 μs duration at a repetition rate of 1 to 2 Hz. The transverse emittances and the energy spread of the beam are expected to be 3 πmm mrad and 0.2% respectively.

The salient design parameters of the machine include dipole magnet of 1.4m diameter (weighing 2 MT). The magnet has been designed to provide a nominal magnetic field of 2 kG with a uniformity of 0.2 % over a diameter of 0.8m encompassing 22 orbits of the accelerating electrons. The acceleration occurs in a 20mm long cylindrical RF cavity energized to 980 kV by a 5 kW klystron at 2856 MHz. The electron emitter would be a Lanthanum hexaboride (LaB_6) pin of 3mm diameter mounted in the flat face of the cavity with a capability to provide peak emission current of more than 3 A.

Fabrication of major components of the microtron viz main magnet, vacuum vessel and the RF cavity is well underway. Prototypes of other subsystems like LaB_6 emitter, electron current probe, extraction tube and high voltage power supply for the Klystron are also being developed. In addition to this ongoing programme, it is planned to develop microtrons for other specific applications such as radiotherapy and activation analysis.

Magnets

A wide variety of magnets - dipole, quadrupole, sextupole, septum and kicker, are used in synchrotrons and

storage rings (see CAT Newsletter, December 1988). Whereas the dipole magnets of the INDUS-I storage ring are made from forged steel blocks of very low carbon content; the other dipoles, quadrupole and sextupole magnets are made from precision punched CRGO (Cold Rolled Grain Oriented) steel laminations. For injection and extraction of beam in the rings, septum and kicker magnets are used. Because of the pulsed nature of their magnetic fields, these magnets require special materials which are also being developed indigenously.

Detailed design of the magnets for INDUS-I has been completed. The fabrication of these magnets is at various stages of completion. The excitation coils for all the magnets are under fabrication at CAT where facilities for winding, insulation and impregnation have been commissioned. Hollow copper conductors of various sizes upto 12 mm square with 7 mm diameter hole are being used for these coils. A setup for magnetic field mapping and instruments for field characterization are also being developed.

Vacuum System

The booster synchrotron vacuum envelope has been assembled with dummy pieces for equipments to be incorporated in the ring viz RF cavity, septum magnets etc. The envelope also has indigenously designed and fabricated bellow type vacuum chambers for the dipole segments. Various tests carried out on these segments show that they are adequately leaktight and rigid against atmospheric pressure. The envelope has been evacuated to 10^{-9} torr without the beam. This is adequate to get vacuum better than 10^{-7} torr in the actual ring with the circulating beam.

A large number of sputter ion pumps are required for these accelerators and other UHV applications at CAT. In order to meet this demand, sputter ion pumps, their power supplies and control units have been fabricated at CAT and a programme for production of these pumps is underway.

Control System

A programmable microprocessor based system to control a single power supply for feeding excitation current to a dipole magnet of the synchrotron has been developed. With this controller one can programme the output currents with 16 bit resolution and periodically monitor the same with 12 bit resolution. Further, a system for controlling and monitoring the pressure in the accelerator has been completed. It consists of a console, an equipment interface unit (EIU), a latch and a relay unit. A PC/XT and a colour monitor form the console. The software, developed in 'C' language, gets the status of different units from EIU and displays it on the monitor.

Power Supplies

A prototype power supply has been developed to feed a single dipole magnet of the synchrotron. Its current can be ramped from 30 A to 1000 A in 150ms at 1 Hz. Further, during the ramping down, the magnet current is reduced to 30 A within a time of the order of 200 ms so that the next injection cycle can start. This is achieved by feeding back the stored energy in the magnet to the AC mains using thyristor bridges in inversion mode. The power supply is rated to give regulation and long term stability of 0.01%. It has several special sub-systems viz. transistorised active filter, water cooled power transformer and Zeranin current shunt with very low temperature coefficient of resistance.

The other developments include a 400 VA, 20 kHz switched mode power supply for the filament of the 80 kV electron gun and a 5 kVA, 5kHz class A SCR inverter developed for use in x-ray power supplies and DC industrial accelerators.

CONSTRUCTION PROGRAMME

The construction group at CAT looks after civil, public health, electrical, air-conditioning, ventilation and maintenance works of the entire complex.

During 1989 the work on the construction of Laser Fusion Laboratory, Chemical cleaning and Glass Blowing Laboratory and the Prototype Production Unit progressed very well and all these buildings are at various stages of completion. Several other development works in laboratory area notably development of approach roads has also been taken up. The colony now has 110 more houses of various categories. The school building has been completed and the school will soon be shifted to it from its present location. Construction of several other facilities like welfare centre, shopping centre has also been completed. Further, subsequent to the clearance of INDUS-I building design, work on this and the central airconditioning plant building has been started.

COVER: *A view of the vacuum envelope of the booster synchrotron.*