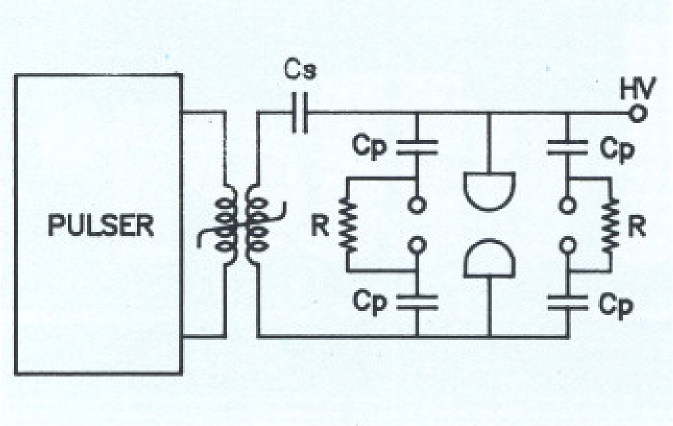



**Schematic of the discharge circuit is shown. Cs and Cp are storage and peaking capacitors.**

by preionization, and thus making the medium between the discharge electrodes slightly conducting. The sustainer capacitor containing the energy for the discharge is kept connected across the electrode. It can be charged to the optimum voltage, and sustains the weak discharge created by the pulser. The voltage across the sustainer by itself cannot produce a discharge, and this is produced only when the pulser is operated. One then has the extra advantage of changing the voltage of the sustainer-capacitor to obtain the best vibrational excitation, thus improving the efficiency of the laser. The pulser handles a small energy (~ 1 Joule) and produces a 20 kV pulse with a risetime of 120ns. In our design, the pulser is also responsible for the preionization by causing sparks between capacitively loaded pins arranged by the side of the discharge electrodes. The pulser is a 4 stage MPC circuit. The electrodes are "Ernst" profile electrodes which produce a discharge of dimensions 1.5 cm x 1 cm x 30 cm. The optimized gas mixture is $CO_2$, $N_2$ and He in the ratio of 1:1:6 with a total pressure of 1 atmosphere. The sustainer is a 50 nF capacitor charged to 13 kV. The laser pulse was 6 microsecond long with an energy of 520 mJ. If one considers the energy of the sustainer capacitor the efficiency of the laser is ~12%.

At present the laser is being operated at single shot basis. Efforts are on to make a laser working at ~ 100 pulses/sec.

### Laser material processing

The 5 kW CW $CO_2$ laser developed indigenously at this Centre is being used extensively for various studies in laser material processing. Studies on cutting of mild steel and stainless steel sheets, welding, surface-transformation-hardening of different types of steels, surface modification of Al-Si alloys by laser melting and resolidifaction, surface alloying of Cu with Cr; of mildsteel with Si, Al and with high speed steel powder, have all been successfully done with this laser. Laser surface modifications have been found to improve surface properties such as microhardness, wear and corrosion resistance etc. The advantages of laser processing over the conventional processing techniques are fast heating and rapid cooling, resulting in surface characteristics usually not possible with the latter. Surface microhardness of various types of steels was improved upto factors of 2 to 3 by laser transformation hardening process. Surface alloying of mild steel with high speed steel powder, Si and Al produced marked improvement in the microhardness (upto a depth of 1 mm), and also in wear resistance. Laser melting and rapid resolidification of Al-Si alloys resulted in refinement of microstructure and improvement in microhardness by more than 100%. With improved surface characteristics, these materials will have increased engineering applications.

Studies in the applications of this laser have been extended to cutting of marble slabs and curing of thermosetting powder coating. Profile cutting of marble of thickness upto 15 mm has been carried out. At higher thicknesses, cracks appeared transverse to the direction of cutting. However, these could be minimized by cutting in multiple passes instead of single pass, at lower laser power or faster cutting speed.

In another study, thermosetting pure epoxy powder coating on mild steel sheet has been cured with the $CO_2$ laser radiation. Curing time was drastically reduced from several minutes usually required in oven curing to a few seconds. A major advantage in this method is that the heating is limited only to the coating and the interface, facilitating curing of coatings on heat sensitive substrates; for example low grade plastics (polyethylene, PVC, polypropylene etc.) could be coated with high grade polymers (epoxy, polyester, PVDF, ECTFE etc.). Laser cured coatings met the industrial standards in terms of adhesion, hardness and corrosion resistance. This facility has also been utilised by many academic institutes and research organisations to carry out various laser material processing studies.

## ACCELERATOR PROGRAMME

**Indigenous development of S-band 2 MW peak power magnetron with microwave test facilities**

India's first S-band 2 MW pulsed magnetron has been successfully developed for CAT by Central Electronics Engineering Research Institute (CEERI), Pilani.

2 MW magnetron is a vital microwave component for 8/12 and 20 MeV electron accelerators (Microtrons and

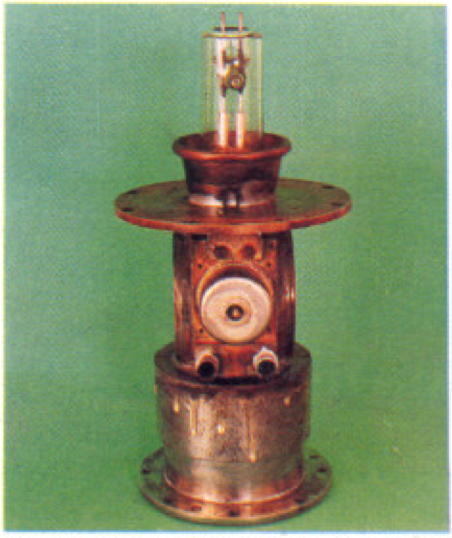
Cover: *Toroidal grating monochromator for use on Indus - 1 beamline .*

2 MW microwave test facility operational at CAT.

LINACS). These electron accelerators find wide applications in industrial radiography, medical radiotherapy, sterilisation of medical components, medical isotope production and electron injectors for synchrotron radiation sources. Imported magnetrons are very costly and are available after long delivery periods. The operating life as well as shelf life of these tubes is invariably small. CAT realised that CEERI has an established expertised in the development of microwave components, and sought its collaboration in the development and production of magnetrons. The magnetron tube has been designed and developed by CEERI with a view to replacing imported magnetrons, as these will be used abundantly in India in electron accelerators working at DAE and elsewhere. The project was funded by the Board of Research in Nuclear Sciences of DAE. The designed and achieved specifications are summarised in the table.

Testing of the prototype magnetrons has been done on a 2MW microwave test facility developed at this centre. CAT has developed a crucial component of this facility viz. 47 kV pulse modulator. The microwave test facility at CAT consists of line type thyratron based pulse modulator along with 47 kV pulse transformer, water cooling system, magnetron electromagnet and allied microwave electronics including high power waveguide line, microwave dummy load and couplers for measurement of output microwave power, spectrum analysis and pulse parameters. The photographs show the prototype magnetron and the 2 MW microwave test facility.

| Parameters | Design value | Achieved value |
|---|---|---|
| Freq of operation | 2998 MHz | 2998 MHz |
| Tuning | Mechanical | Mechanical |
| Tuning range | 10 MHz | 18 MHz |
| Peak power output | 2 MW min | 2.3 MW min |
| Pulse width max | 4 $\mu$sec | 3.4 $\mu$sec achieved (4 $\mu$sec possible) |
| Duty ratio | $10^{-3}$ | $10^{-3}$ |
| Anode voltage | 47 kV max | 47 kV max |
| Anode current | 100 A | 110 A max |
| Magnetic field | 1525-1575 G | 1525-1575 G |
| Cooling | Water | Water |



Prototype 2 MW S-band Magnetron developed by CEERI & CAT.

### Synchrotron commissioning begins

Injector microtron had been commissioned earlier last year to give rated output beam of 20 mA at 20 MeV in one $\mu$sec long pulses. These pulses are available once every second for injection into a 700 MeV booster synchrotron.

This synchrotron is now undergoing commissioning tests. Initially, it has to be ensured that an injected pulse is sustained in the synchrotron for a period of a few msec. This optimisation at 20 MeV assures acceleration when magnets are ramped and RF cavity is turned on. Injection septum magnet of the synchrotron ring is energised by a pulse power supply synchronised to microtron pulse output. This septum magnet bends incoming electron beam to launch it into the synchrotron orbit. Three synchronised injection kicker magnets located in the ring steer the beam so that it completes second and subsequent turns in synchrotron.

An injected pulse of one $\mu$sec duration is equivalent to 11 turns in the synchrotron. At present, the injected pulse could be retained in the synchrotron for a few tens of $\mu$sec, during which the electrons made a few hundred turns. This event confirmed correct operation of several crucial components of the synchrotron ring and beam transport line TL-1.

The RF cavity has been independently set to hold 30 kV at 31 MHz. Its power supply can be operated from control room console. Dipole, quadrupole and steering magnet power supplies give stable performance when operated from control room. Ultra high vacuum in the booster, and in transfer lines TL-1 and TL-2 is retained non stop for testing injection.