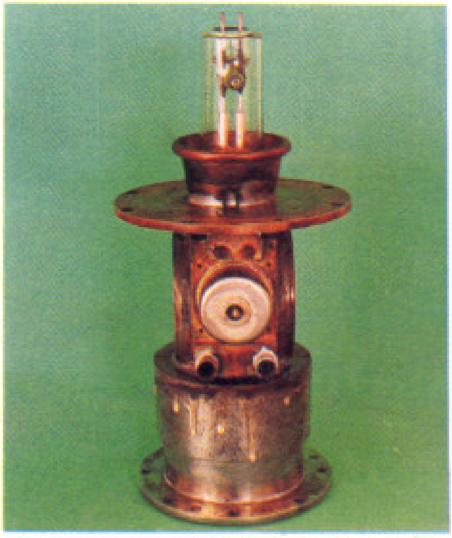
2 MW microwave test facility operational at CAT.

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 μsec	3.4 μsec achieved (4 μsec 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 μsec 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 μsec 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 μsec, 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.

Radiation monitoring of area around the accelerator building when beam injection is turned on has confirmed the adequacy of radiation safety measures adopted. In the meantime, assembly of magnets in the ring, and vacuum envelope of Indus-1 synchrotron radiation source (SRS) is in progress.

15 kV/ 50 mA dual anode soft x-ray source power supply for BARC

The dual anode soft x-ray source power supply, developed by the power supplies group of the Accelerator programme, has been successfully commissioned at Metallurgy Division, BARC on Nov 30, 1994. The unit consists of a 0 to 15 kV, positive polarity, high voltage power supply with 0.05% stability at full load and a dual port; and a current controlled DC power supply with emission stabilisation for filaments I and II.

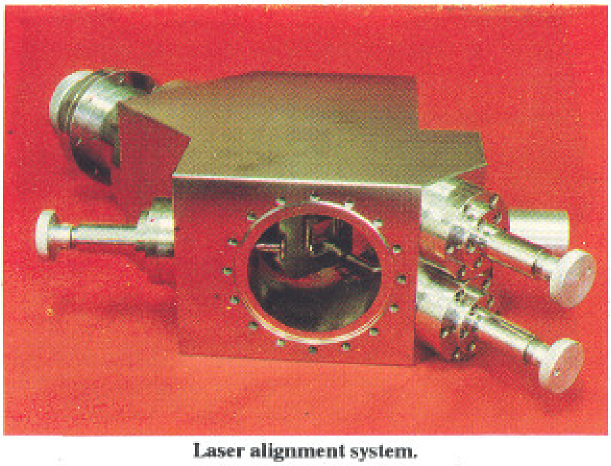
The primary controlled, thyristor based high voltage (HV) power supply has features like slow start, over voltage/over current protection, short circuit protection, and regulation against a wide range of load and line variations. The HV transformer is fed through phase controlled antiparallel thyristors on primary side and the secondary is rectified and filtered to give a variable HV dc output. The HV is connected to the X-ray tube through an indigenously developed 20 kV coaxial connector. A damping resistor of 10 kΩ at the output of this power supply prevents the propagation of dangerous HV transients towards control electronics. In addition to this, the damping coils and surge protection devices across the current sensing shunt and the output port of HV divider ensure a great deal of safety to control circuit. The on/off operation of HV is accomplished by two soft-touch momentary switches on the front panel. Initially the firing pulses are inhibited. With HV on command, first the contactor gets on and then, after a delay of about a second, the control circuit is enabled and firing pulses are released in a slow start manner. In case of fault detection HV is immediately put off and it can be restarted by a reset switch after a healthy condition is restored.

The dual filament power supplies, rated for 5V/8A, are series regulated to ensure stable emission current. The maximum limit on the filament heating current can be set by a front panel potentiometer. The emission current can be set by a digital reference circuit with the help of two up and down press switches on the front panel. With HV supply off, the filament current is regulated at its maximum set value. The moment HV is applied to anode, emission stabilising loop is activated by sensing the emission current. Now the filament current is controlled by this loop as per the requirement of emission current. Both the filaments can be selected simultaneously or alternatively by a mechanically interlocked latching type gang switch on the front panel. A maximum upto 25 mA of emission can be taken from each filament at a time. Both the power supplies have interlocking with water flow and vacuum status. The unit operates on single phase, 230 V, 50 Hz mains.

INFRASTRUCTURAL DEVELOPMENT

Beam line components

The Workshop has developed several beam line components which are essential for use in the various beam lines of Indus-1 and Indus-2. All these components are UHV compatible and can be baked. Laser alignment system, beam slit assembly and beam aperture control assembly are some of the important devices developed and these are briefly outlined below:



Laser alignment system.

Laser Alignment System: The length of a typical beam line of Indus-1 is about 12m to 15m long. The entire beam line axis with all its components has to be in alignment with the axis of the synchrotron radiation beam emerging from the bending magnet chamber port of the storage ring. For this purpose a laser alignment system which uses a helium neon laser in place of SR beam has been developed. The system consists of a mirror placed at an angle of 45^{o} which can be placed on the axis of the beam or completely withdrawn to clear the beam path when required. A He-Ne laser positioned perpendicular to the beam axis is reflected in the line of the beam by a mirror after its axis has been precisely adjusted to coincide with that of SR beam. The entire beam line can be aligned using the He-Ne laser. All the movements are bellow sealed to ensure UHV compatibility.