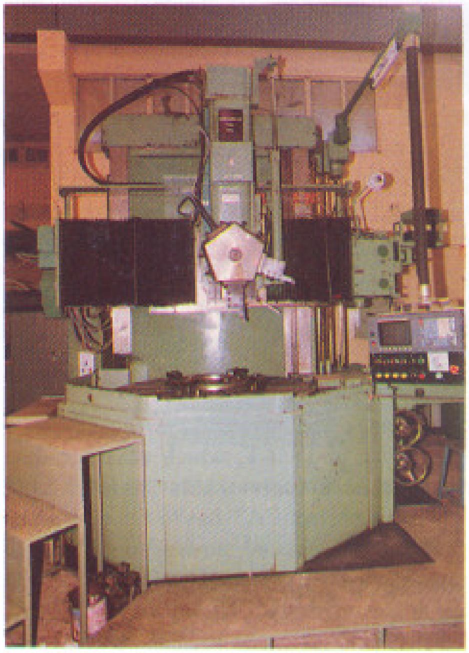
used, which are eliminated here. The SRS ring will house a special EOT crane of 10 MT capacity with 5.3 m span. This crane will facilitate the handling of material in circumferential as well as radial direction. The service gallery of 2.5 m span (cantilever) is also supported over 1.5 m thick shielding wall, to accommodate power supplies & control panels.

Architectural and Civil engineering Division, BARC designed this building. The construction management is looked after by construction group CAT.

CNC Vertical Turret Lathe

A new CNC vertical turret lathe "Dynacut 150" of Kirloskar make has been commissioned at CAT workshop. The lathe was purchased as a manually operated machine and was later retrofitted with FANUC-OT "C" CNC system at CAT workshop.

Jobs of up to 1500 mm diameter and 1000 mm height with a maximum weight of 10 tonnes can be machined with this machine. The CNC system controls two axes i.e. X & Z simultaneously. By this facility any contour can be generated on the job diameter or its face. The X-axis moves the turret head on cross rails horizontally (left to right) and Z-axis moves the turret head in its guide in vertical direction from table face. The turret head carries five tools at a time and any tool can be power indexed for operation remotely by the operator. The CNC system also has a colour monitor with graphics facility.



CNC Vertical Turret Lathe installed at CAT

Development of high power microwave devices, test facilities and components for accelerator applications

The development of electron accelerators for various applications such as, radiotherapy applications, irradiation of food items, sterilisation of medical products, has been taken up at Centre for Advanced Technology, Indore. In this endeavour electron accelerators of energy 20 MeV and 12 MeV have been developed and are currently in use. CAT has also taken up the development of microtrons and linear accelerators with high average beam power capabilities.

The acceleration of electrons in cyclic accelerators is achieved by energising the accelerating cavities by means of a microwave system. This supplies microwave power in the peak power range from 2 to10 MW, depending upon the energy and current requirement. The microwave power is supplied in pulses of 2-10 μsec duration repeating at typically 50-1000 Hz. The microwave system plays a crucial role for development, operation and beam quality of the electron accelerators.

A typical microwave system consists of a microwave high power tube like klystron or magnetron, a pulse modulator to energise the microwave tube and a waveguide line for transmitting the high output power from the tube to the accelerator cavity. The waveguide line consists of a four port circulator, dual directional coupler, waveguide pressurising unit, microwave window and dummy loads. Pulse modulators used at CAT are line type modulators consisting of a regulated high voltage DC power supply, charging choke, charging diodes, a pulse forming network, a thyratron switch and a pulse transformer, whose secondary is connected to the device. In case of klystrons based microwave system the high power klystron needs a driver amplifier and a microwave generator. Devices like klystrons, magnetrons, thyratrons and four port circulators, are at present, imported from foreign sources. The operating life of the klystrons, magnetrons and thyratrons is very limited. During the lifetime of an accelerator, many such devices are required. Any delay or embargo on these components will severely affect the development/ production and operation of these accelerators. Hence the indigenous development of these devices is very necessary. CAT in collaboration with several institutes in India has taken up the work of developing these components indigenously.

5MW pulsed S-Band klystron and high power test station:

Development of an S-Band 5MW peak power klystron is nearing completion under a CAT-CEERI collaboration.

Specifications of 5 MW S-Band klystron developed under CAT-CEERI collaboration		
Peak power output		5 MW
Frequency of operation		2856 MHz
Instantaneous Bandwidth		5 MHz min
Gain		50 dB
Efficiency		40%
Pulse duration		5 µS
Electrical		
	Beam voltage	130 kV max
	Beam current	95 A max
	Heater voltage	8 V
	Heater current	35 A
Mechanical		
	RF output	WR 284wave guide
	RF input	Co-axial
	Cooling	Liquid
	Focusing	Electromagnet

This klystron will be used for energising 10-20 MeV electron accelerators for various industrial, medical and scientific applications. Main specifications of the 5MW klystron are listed in Table above. For evaluating the performance of the indigenous klystron, a klystron test station has also been developed at CAT. The test station consists of a klystron modulator with interlock and control system, high voltage deck in-housing pulse transformer, pulse measurement systems and klystron support structure with oil tank. Various interlock and sequencing schemes are also incorporated in the modulator for safe and reliable operation.

The 5MW klystron consists of the electron gun, five cavities, collector and an electromagnet. All these parts of the klystron are brazed in Hydrogen environment. Vacuum is created inside the klystron tube. Hence for successful operation of the tube each part of the klystron should qualify for vacuum, high voltage, electron bombardment and high power microwaves.

To study the behaviour of cathode at high voltages, a gun

Results of life test conducted on indigenous 2MW magnetron	
Peak output power	2 MW
Average power	2 kW
Frequency range	2991-3004 MHz
Microwave output pulse width	4 µsec
Repetition rate	250 Hz
Total hours of continuous operation	550 Hrs
Peak Anode voltage applied	42 kV
Peak anode current	100 amp
Heater voltage	8.3 V
Heater current	9 amp

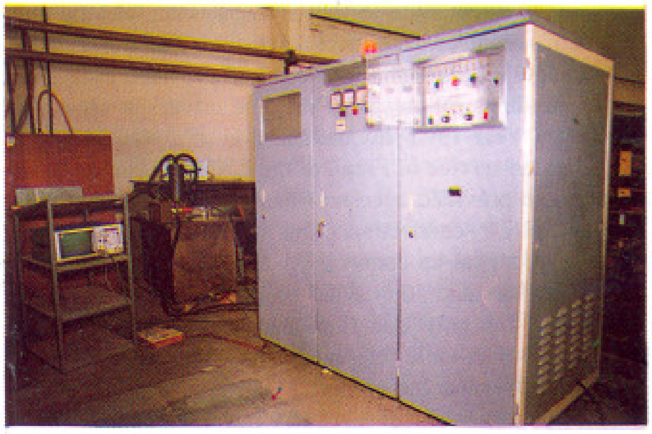
collector test module (GCTM), consisting of cathode and collector portions of klystron with high voltage ceramic insulator, has been developed by CEERI and was tested, using the test facility developed at CAT. Studies of the diode characteristics of GCTM were done up to 126 kV.

To test the GCTM as well as 5MW klystron proto types, a line type klystron modulator has been developed. This consists of a 13 kV DC power supply, a charging choke, charging diode assembly, pulse forming network, high voltage thyratron and high voltage pulse transformer.

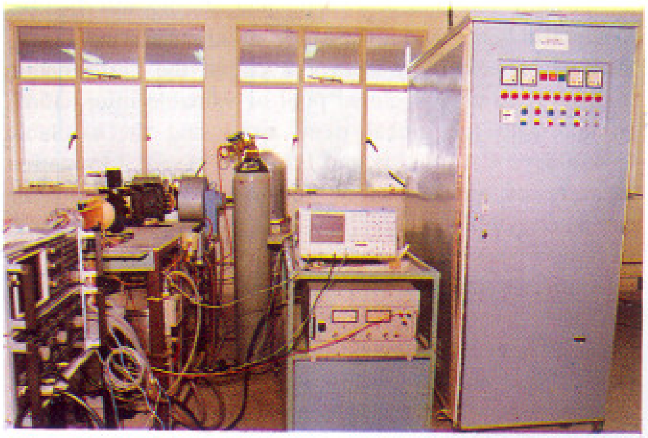
Life test of Indigenous 2MW pulsed S-Band magnetron:

A 2 MW S-Band pulsed magnetron is developed under joint collaboration between CAT and CEERI, Pilani. Several lab prototypes were evaluated on 2 MW microwave test facility, developed at CAT, and one magnetron has also been subjected to life test

The results of the magnetron life test are listed in table above. The Magnetron is subjected to a 42 kV, 100A cathode pulse. Magnetron output is fed to waveguide line, which includes circular to rectangular transition, circulator, cross-guide coupler and water load. Magnetic field is provided by means of an electromagnet. Waveguide line is



5MW Klystron test station showing the klystron modulator and high voltage tank (visible at back).



2MW Indigenous magnetron under going life test at microwave test facility at CAT.

pressurised with 30 psig dry nitrogen for high peak power handling and to avoid the breakdown. Water-cooling is provided for load as well as for the magnetron.

The magnetron was subjected to cold test as well hot test. In cold test, measurements were performed on non-operating magnetron, using signal generator. This test is carried out with the help of Vector Network Analyser. Return loss and VSWR of the resonant structure is measured for the frequency band. This is the primary test of magnetron that is carried out before subjecting the magnetron for life test.

In hot test, data is collected in the operating condition of magnetron. In this test the power, frequency electronic efficiency, tuning range, cathode-heating effects and stability are monitored. After the magnet current set to the desired value, anode voltage is applied to the magnetron and increased until stable oscillation begins. Around 30 kV anode voltage the oscillations are observed. The rate of rise of voltage is 110 kV/ μsec, so that as the magnetron passes through Π mode, oscillations have time to build up and the magnetron can lock-in to the desired mode of operation. If the rate of rise of voltage is too high, magnetron will not lock in to the mode and load the modulator. The presence of rf output is observed by crystal detector diode 1N21B, which is connected to the directional coupler ports through the attenuaters. Stability of the output is judged by viewing the forward and reflected pulse.

Again the anode voltage is increased and this procedure is continued until a limit is set by mode shifting, arcing or overheating of cathode. If one of this occurs voltage is again reduced to the starting value, magnetic field is increased and the process is repeated. Spark gap protection is provided on secondary of the transformer to protect the modulator. Also the hydrogen thyratron tube is protected

Various high power microwave waveguide components developed at CAT. Seen in the photograph are: microwave windows, dual directional couplers, circular to rectangular waveguide transitions, high power ceramic and glass type water load, vacuum wave guide section and bends.

from the back swing in the pulses, by putting a diode resistor assembly across the tube. The highest end frequency observed is 3004 MHz and the lowest frequency is 2991 MHz. The left side band observed is 21 dB down and the right side band is 22.6 dB down.

After reaching the desired power, pulse repetition rate is increased to 250 Hz. A Calorimeter is provided for monitoring the average power dissipated in the rf load. Temperature of the inlet and outlet is sensed and a electronic circuit displays the power.

P Shrivastava and P R Hannurkar

CATNet: Computer Network at CAT

"Information" is the major driving force behind the progress. Due to the proven reliability and fast data processing capability, computers have long been adopted as the only tool for processing and storing information. Computers being the universal information carrying agents, are interconnected by networks called the "information highways" to have a global pool of valuable information. In line with the global trend and using the available technology, CATNet is an Ethernet based information highway of approximately 400 interconnected diverse computer systems at CAT. CATNet aims to provide a real working solution to an ***"office at desktop"*** concept for the scientific, engineering and administrative communities at CAT.

CATNet is evolving ever since its inception in the early 90's. This article mainly focuses on the present infrastructure details of the CATNet and associated services. CATNet was conceived in the early 90's as a network of the 3 Unix servers and 20 odd PC's. Ethernet with a speed of 10 Mbps being the fastest networking technology available during those days, was adopted as the technology for the CATNet. TCP/IP being the in-built network protocol suite in the UNIX servers was the only protocol suite used to connect any machine on the network. The remote access to this network was provided to users of other buildings by means of the line drivers at speeds of 9600 bps. Year 1993 saw the addition of a very important value added service of Email to the CATNet. Hundred odd users were provided access to this service, which was an offline UUCP connection. The UUCP connection was made over a Dial-up connectivity to NCST, Mumbai. Low email traffic and the STD connectivity to Mumbai demanded for only one time per day download of the mails. The unreliable telephone line connectivity used to affect the downloading of mails.

Presently, the focus of CATNet has shifted from mere email service and computing resources provider to Internet and Intranet services provider. The integration of CATNet