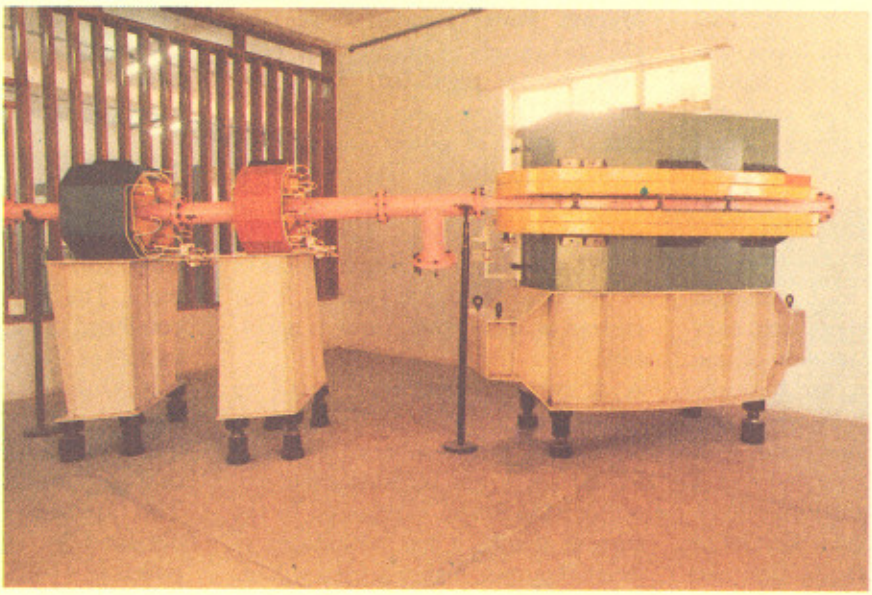
Newsletter

CENTRE FOR ADVANCED TECHNOLOGY

Year---1 Nos.---3 & 4 December 1988



DEVELOPMENTS AT CAT

Thin wall S.S. Vacuum chamber for Booster Synchrotron - In a booster synchrotron, the electrons move in vacuum chamber. This vacuum chamber has to satisfy two conflicting requirements. Firstly, the wall of the chamber has to be mechanically strong enough to withstand atmospheric pressure. In the booster synchrotron of INDUS-I, the magnetic field is ramped from a minimum value of 340 Gauss to a maximum value of 13 Kilo Gauss in about 0.3 sec. This generates eddy currents in the envelope of vacuum chamber which distort the magnetic field and produce sextupole components. The wall of the vacuum chamber has, therefore, to be thin enough to keep the magnetic field distortion within acceptable limits. For INDUS-I booster synchrotron, the upper limit on wall thickness from this consideration comes out to be 400 microns. For vacuum chamber of cross-section 30mmx120mm and length of 1.6metres, this wall thickness is inadequate to withstand external atmospheric pressure.

To satisfy these requirements, two alternative designs were explored for this thin walled chamber, namely, a ribbed structure and a bellow type structure. A 1.6metre long, 30^0 curved chamber having ribs has been fabricated. Ribs have been spot welded to the thin wall oblong tube from outside. Using expanding tools, wrinkles are

selectively introduced on the inner wall of the tube to get a curved shape. By this approach, segmental construction is avoided resulting in minimum weld joints. A bellow type chamber is also being developed which will avoid welding and would be a better configuration for UHV.

Magnet Design - Magnets play a very important role in particle accelerators. There are different types of magnets which are used in accelerators, namely, Dipole magnets, Quadrupole magnets, Sextupole magnets etc.

Dipole magnets bend the charged particle beam, whereas quadrupole magnets keep the beam focussed. For correcting chromaticity of the beam, sextupole magnets are used. Septum magnets help to inject or eject the beam without disturbing other bunches in the main orbit. Kicker magnets are used to push the beam into the septum aperture with minimum losses.

In a microtron, the magnetic field homogenity has to be maintained over a comparatively large region of one metre diameter. There are basically three types of methods by which this can be achieved. The first one is with a taper in the pole tip, second with a notch in the flux path and third with an air gap between pole and yoke. Out of these three alternatives, the first one was selected for the 20 MeV microtron , which , at present, is under development at CAT. This design is expected to give a field variation of about 2-3 Gauss over a maximum field of 2 KG.

Dipole magnets for the booster synchrotron and for the storage ring INDUS-I have been designed. For booster synchrotron the magnetic field is about 1.3T over a pole width of 12cms. with a maximum field error of 200 ppm. These Dipole magnets are 60 degrees, separated function and sector type magnets . The first prototype magnet is being assembled from 0.27mm thick CRGO laminations.

Dipole magnets for the storage ring INDUS-I are designed to give a maximum magnetic field of 1.5T, with a field index of 0.5 over a pole width of 7 cms. The field gradient error is less than 1%. These dipole magnets will be made from forged blocks of magnetic steel machined to close tolerance. Design of quardupole magnets for beam transport lines 1 and 2, booster synchrotron and storage ring INDUS-I is also complete. These magnets will give a good field region of 5 cms. radius with 0.3% error in the gradient. These will be made from laminations.

Fabrication of lamination pressing unit, coil holding brackets and assembly ribs is complete. A coil curing oven (H-2.5m, W-1.5m, D-.5m) and a vacuum impregnation plant is also installed.

Magnet Power Supplies-Power supplies for variety of magnets are basically current regulated.. These are either DC, slow ramp or fast pulsed type. Design of power supplies for booster and storage ring magnets is completed. These are designed against mains voltage variation of $\pm$10% and load resistance variation of $\pm$ 5%. Current stability of 0.01% for current of about 8000 Amps. is necessary.

A dc current transformer based on second harmonic detection was developed using supermalloy tape wound cores, for measuring current up to 1000 Amps. Compared to the current shunts, it has advantages of isolated output, higher sensed voltage and much lower dissipation. This DCCT has also good frequency response due to use of ac feedback loop in the DCCT amplifier chain. This finds use as a precision high current sensor in the feedback loop of regulated magnet power supplies.

A prototype pulsed power supply for feeding septum magnet has been designed, fabricated and tested. The load current for this is a half sine wave having peak current of 200 Amps. and half period of 100 microsecs. repeating at 1HZ. rate. Fast turn off SCRs have been employed as switching devices. The pulsed load current is sensed by a fast current transformer.

RF Power Amplifier-RF cavities are used to impart energy to circulating electrons in the booster synchrotron and to compensate for the energy lost due to synchrotron radiation in storage ring INDUS-I. The booster synchrotron and storage ring INDUS-I both have RF cavities operating at 31.613 MHz. These cavities are excited to generate 32 KV using RF power amplifier. Power required to generate this voltage is about 10 KW. A power amplifier capable of supplying 12 KW using indigenous tetrode tubes is being developed.

This amplifier requires 200 watts of drive power. A solid state driver amplifier for this RF system has already been designed., fabricated and tested. The amplifier has been made general purpose so that it can also be used for other SRS systems, viz. Radio Frequency Knock-Out system etc. It has therefore been designed as a wide band width amplifier (2 to 35 MHz) using transmission line transformers.

The building block of the solid state amplifier is a 50 watts RF module. This is designed around two 2N5071 transistors operating in push pull mode. The output of two transistors is combined using 180^0 hybrid combiner to deliver 50 watts of power to a common 50 ohms load. The input power to the push pull stage is obtained through a 180^0 power splitter. The power gain of stage is 10 dB.

Two hundred watts of RF power is obtained by combining the output power of 4 such push pull stages. The signal from source is amplified using 2N3866 transistors. The low level output of this preamplifier is raised to 20 watts using power transistors 2N5071. Using three in-phase power splitters, this 20 watts of power is divided into 4 parts feeding four pushpull stages. Output of these push pull stages is then combined to get 200 watt of RF power. The overall gain of the amplifier is 43 dB.

COVER

Model of a typical synchrotron magnet lattice consisting of a dipole, quadrupole and sextupole along with beam (vacuum) chamber.

Laser Uranium Fluorimeter-A laser based uraniuum fluorimeter which may be used for exploration of uranium has been developed. The instrument can measure trace uranium in aqueous solutions, including naturally occuring waters upto one ppb level..

Most of the available techniques are indirect, requiring considerable chemical separation and are time consuming. Thus they are unpractical for purposes of hydrochemical exploration. The present technique is not only rapid but also does not require any chemical preconcentration.

Uranyl salts emit a characteristic fluorescence with three peaks at approx. 496, 514 and 540 nm, under UV excitation. The fluorescence thus produced can be measured quantitatively by a suitable photodetector.

The most serious interference in direct trace analysis of natural waters by this technique is due to dissolved organic compound which emits intense blue ,fluorescence and weak longer wavelength emission. This interference is considerably reduced by using a suitable optical filter and utilizing the difference in lifetimes of uranyl fluorescence and that of organic compounds in solution. The fluorescense lifetimes of most organic molecules seldom exceeds a few tens of nanosec, whereas uranyl ion fluorescence persists for a few tens of microsec. The analytical procedure involves the addition of a buffered complexing reagent to convert various uranyl species present into a single form for high luminiscence yield.

In the present set up, UV source is an indigenously developed small N_2 laser. The parameters of N_2 laser are: peak power 50--KW, pulse duration 10 nsec, wavelength-- 337nm, frequency 5-10 Hz. This UV beam is focussed on quartz sample cell. The fluorescence from contents of the sample cell passes through an optical filter that transmits light with wavelength longer than 450 nm only. The fluorescence light is detected by a PMT (photo-multiplier tube) which is electrically gated such that its output is available 15-20 microsec. after the laser pulse. Each output fluorescence pulse is integrated, digitized and an average value for about 50 pulses is stored. The laser output is monitored by a phototube and the peak power is again averaged for 50 pulses. The ratio of fluorescence and power output provides a quantitative measure of concentration of uranium in unknown samples.

50mm dia copper vapour laser-A copper vapour laser(CVL) giving 25W average power has been developed. Shown below is the basic scheme of this CVL system.

Operating temperature of laser is 1500^0C and is achieved by repetitive pulse discharge through helium, in the discharge tube. The average electrical power required to reach the operating temperature is 5.5 K watt. Once the operating temperature is reached, there is sufficient pressure of vapour of copper available for excitation. The same pulse discharge is used for achieving population inversion required for obtaining lasing. The laser has given 25 watts of average power with helium as buffer gas. If neon is used as a buffer gas instead of helium, the same laser will give 35 watts of average power.

Cryo-refrigerator. Cryogenics Group supplied a 20 K closed cycle helium cryo-refrigerator to Nuclear Physics Division, BARC, Bombay. Such cryo-refrigerators, working on Gifford Mc-Mahon (G-M) cycle are characterized by their simplicity and very high reliability. They supply small refrigeration loads of the order of a few watts only but have found ready applications, viz. cooling of electronic devices such as Masers in space communication systems, cooling of infrared detectors and cryo-pumping in space simulation and high energy accelerators.

The novel design of the cryo-refrigerator developed at CAT is that it uses a very simple spool valve mechanism, which is very easy to fabricate and assemble, whereas other design uses a crank actuated valve mechanism which is very complicated to fabricate. The unit supplied to BARC was run continuously at CAT for nine days (day and night) with a dummy aluminium sample of 50 mm length & 10 mm dia. A temperature drop of only four degrees was observed along the sample and the minimum temperature obtained was 8.8 Kelvin.

Equipment Commissioned

Vertical height measuring instrument. A vertical height measuring instrument TRIMOS VERTICAL TVD 1300 A with EPSON HX-20 Computer has been commissioned in the workshop. The instrument with high measuring accuracy and easy reading digital display will enable

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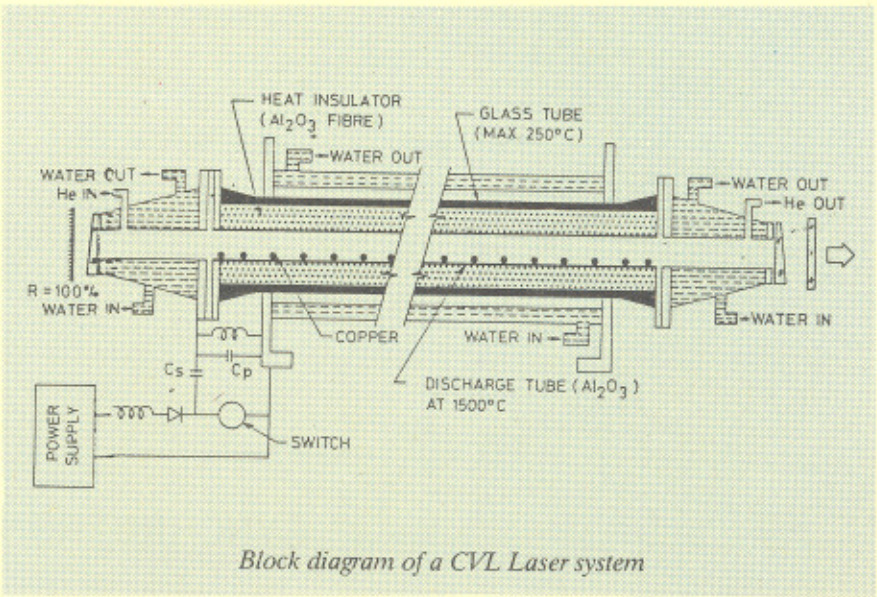

Block diagram of a CVL Laser system