IN9700293

BARC/1996/E/011

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GOVERNMENT OF INDIA
ATOMIC ENERGY COMMISSION

BARC/1996/E/011

MIRROR BOXES AND MIRROR MOUNTS FOR PHOTOPHYSICS BEAMLINE

by

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1996

BIBLIOGRAPHIC DESCRIPTION SHEET FOR TECHNICAL REPORT

(as per IS : 9400 - 1980)

01	Security classification :	Unclassified
02	Distribution :	External
03	Report status :	New
04	Series :	BARC External
05	Report type :	Technical Report
06	Report No. :	BARC/1996/E/011
07	Part No. or Volume No. :	
08	Contract No. :	
10	Title and subtitle :	Mirror boxes and mirror mounts for photophysics beamline
11	Collation :	15 p., 9 figs., 1 tab.
13	Project No. :	
20	Personal author (s) :	(1) P. Meenakshi Raja Rao; B.N. Raja Sekhar; N.C. Das; H.A. Khan; S.S. Bhattacharya; A.P. Roy; (2) A.S. Raja Rao
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22	Corporate author(s) :	Bhabha Atomic Research Centre, Mumbai-400 085
23	Originating unit :	Spectroscopy Division, BARC, Mumbai
24	Sponsor(s) Name :	Department of Atomic Energy
	Type :	Government
30	Date of submission :	April 1996
31	Publication/Issue date	May 1996

contd...(ii)

40 Publisher/Distributor : Head, Library and Information Division, Bhabha Atomic Research Centre, Mumbai

42 Form of distribution : Hard Copy

50 Language of text : English

51 Language of summary : English

52 No. of references : 5 refs.

53 Given data on :

60 Abstract : Photophysics beamline makes use of one metre Seya-Namioka monochromator and two toroidal mirrors in its foreoptics. The first toroidal mirror (premirror) focuses light originating from the tangent point of the storage ring onto the entrance slit of the monochromator and second toroidal mirror (post mirror) collects light from the exit slit of the monochromator and focuses light onto the sample placed at a distance of about one metre away from the 2nd mirror. To steer light through monochromator and to focus it on the sample of 1mmX1mm size require precision rotational and translational motion of the mirrors and this has been achieved with the help of precision mirror mounts. Since INDUS-I operates at pressures less than 10^{-9} m.bar, the mirror mounts should be manipulated under similar ultra high vacuum conditions. Considering these requirements, two mirror boxes and two mirror mounts have been designed and fabricated. The coarse movements to the mirrors are imparted from outside the mirror chamber with the help of X-Y tables and precision movements to the mirrors are achieved with the help of mirror mounts. The UHV compatibility and performance of the mirror mounts connected to mirror boxes under ultra high vacuum condition is evaluated. The details of the design, fabrication and performance evaluation are discussed in this report.

70 Keywords/Descriptors : INDUS-1; SPECIFICATIONS; MIRRORS; MONOCHROMATORS; PERFORMANCE TESTING; BEAM DYNAMICS; TOROIDAL CONFIGURATION; ULTRAHIGH VACUUM; PRESSURE DEPENDENCE; BEAM POSITION

71 Class No. : INIS Subject Category : E1634

99 Supplementary elements :

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INTRODUCTION :

INDUS-I is a 450 Mev synchrotron radiation source (SRS) being constructed at CAT, Indore,INDIA[1]. The radiation emitted from this storage ring is useful for performing experiments in the soft X-ray to infrared region. A beamline dedicated to experiments on photophysics at INDUS-I is under fabrication. This beamline uses a toroidal mirror for focusing the light [40 m rad (H) x 6 mrad (V)] from the tangent point of INDUS-I onto the entrance slit of a one metre Seya-Namioka type of monochromator and a second toroidal mirror for focusing the monochromatic light emerging from the exit slit of the monochromator onto the sample (1 mm x 1 mm spot size) positioned at a distance of 1 metre from the centre of the focusing mirror. The detailed optical and mechanical layouts of the beamline formed the basis of the mirror box and mirror mount designs[2,3]. A side view of the photophysics beamline is shown in Fig.1. Ultimate pressure in the beamline will be maintained at $< 10^{-9}$ mbar and this is the prime requirement for connecting the beamline to the storage ring. Installation of the beamline to get maximum flux at the sample position requires precise and reproducible rotational and translational movements of the mirrors about X, Y and Z axes under ultra high vacuum conditions. The fine movements are achieved with the help of UHV compatible mirror mounts. The details of design, fabrication and testing of the mirror mounts and mirror chambers are described below.

DESIGN CONSIDERATIONS :

1. Mirror Mounts : In case of mirror mounts for holding both pre and post mirrors, their alignment and fine movements, the considerations are :

   a) Rotational and translational motions in three mutually perpendicular directions (X, Y and Z) should be independent. They should not disturb the prevailing UHV conditions of the beamline.

   b) Accuracies of translational movements should be of the order of one mm.

   c) Accuracies of rotational movements should be of the order of milliradian.

2. Mirror Boxes : The UHV mirror boxes needed several ports of various sizes not only to connect them to the beamline but also to connect mirror mounts, gauge heads etc. In addition ports also were provided for handling the mirror mounts and viewing the beam spot on the mirror. The following is a brief description of the of the ports of the mirror boxes.

S.No	Flange	Quantity	Description	
(1)	203CF	1 No	Mirror mount	(Port 1)
(2)	152CF	5 Nos	Beam entry	(Port 2)
			Beam exit	(Port 3)
			Mannual alignment	(Port 4 & 5)
			Sputter ion pump	(Port 6)
(3)	35CF	3 Nos	BA gauge	(Port 7)
			Roughing pump	(Port 8)
			Pirani-Penning Gauge	(Port 9)
(4)	16CF	1 No	View port	(Port 10)

DESIGN DETAILS :

Based on design considerations mentioned above and following guidelines from beamlines of UVSOR, Japan[4], mirror chambers and mirror mounts were designed and fabricated. The two mirror boxes are mirror images of each other with a few minor differences depending on entry and exit of light[2,3] A schematic of the mirror boxes and mirror mounts are shown in fig.2 and fig.3 respectively. Figures 4 and 5 show the photographs of the mirror box and mirror mount respectively. The mirror is enclosed in a frame provided with adjustable screws on the mirror mount. This arrangement facilitates the rotation of the mirror around an axis which is perpendicular to the plane of the mirror. The mirror frame is mounted on a copper block having an angle equal to mirror tilt. The mirror frame has an arrangement for locating mirror accurately by using fine pitch positioning screws. Two pivot joints provided on the frame impart the rotation necessary for angle correction. Rotation of the mirror is controlled from outside by a bellow sealed mechanism using a micrometer head and a spring loaded plunger. The tube which imparts this rotation also acts as a carrier for coolant to the mirror frame. Multi plane adjustment of the mirror is provided by using three long bellow sealed shafts located at right angle triangle geometry. The mirror mount is welded to a 203CF flange and this flange is connected to port.1 of the mirror box.

MATERIALS AND FABRICATION :

SS 304L has been used for fabrication most of components of mirror mounts and mirror boxes. The bellows and coolant channel used are made of SS 316. Supporting block of the mirror holder is made of copper for better thermal conductivity. The chambers and mounts are TIG welded from inside, cleaned, electropolished, and degassed in a vacuum furnace at a temperature of 800^0C for 8 hours. This procedure reduced the bulk degassing thereby saving time taken for achieving ultimate pressure.

TESTING SETUP :

The mirror mounts were connected to the mirror chamber after degassing all the components and the mirror box in a vacuum furnace. A 270 l/sec sputter ion pump was used to achieve the ultimate pressure. A pirani gauge was used to measure pressure up to 10^{-3} mbar. A Bayard-Alpert nude ionisation gauge (model IG5M of M/S Edwards, U.K) was used to measure pressure from 10^{-4} mbar to 10^{-9}mbar and A penning gauge and a leak detector were connected to the chamber with the help of a "T" through a turbo molecular pumping station(Model TURBOPAC 5150 of M/S Alcatel, France). Rest of the ports of the chambers were blanked off. Two sight glasses were provided for the entry and exit of collimated laser light from He-Ne Laser used for testing the mirror mount mechanism. All gauges, gauge control units pumps and their accessories were given power through regulated power supply. Heating of the chamber, mount, ion pump etc. for degassing purpose were carried out using different heating elements operated through temperature controllers. All the vacuum sealings were done by metal gaskets made of OFHC copper or aluminum. The experimental setup showing different instruments used for leak detection and evaluation is shown in fig.6 and fig.7.

TESTING PROCEDURE :

To start with the mirror chamber was leak tested for welding and gasket leaks of the order of 10^{-10}std.cc/sec. A pressure of 1.0 X 10^{-8} mbar was achieved with the help of a turbo molecular pump (Roughing pump) and a sputter ion pump without baking the chamber or the sputter ion pump (unconditioned). Residual gas spectrum was recorded using quadrupole mass analyzer to ascertain the various components of residual gases and their relative concentrations as shown in fig.8. After baking sputter ion pump and the chamber for about 8 hours at 250^0 C and pumping the chamber with sputter ion pump, a pressure of 1.0 X 10^{-9} mbar was achieved. The residual gas spectrum was recorded at this pressure again. Residual gas spectrum recorded at this pressure is shown in fig.9. From fig.8 and fig.9 it can be seen that water vapour, CO_2, N_2 and hydrocarbons which were major constituents before degassing were suppressed and H_2 was the only predominant gas component after baking. Thus hydrocarbon free ultra high vacuum essential for SRS was achieved. After achieving the ultimate pressure the mirror mounts were tested for their performance under UHV conditions (i.e reproducibility and minimum attainable translational and rotational displacement) using a He-Ne laser. This test was performed by rotating the mirror about an axis which is perpendicular to the incident beam direction and measuring the image displacement on a screen placed at a distance of 1250 mm (corresponding to distance between pole of the first mirror and entrance slit of the monochromator). The minimum rotation of the micrometer screw imparted a rotation of 0.0033^0 to the mirror which resulted in an image displacement of 75 μ at the entrance slit. This is adequate as entrance slit width is planned to be of the order of 100μ. For the second mirror mount similar procedure was repeated and same result of 75μ is obtained as the minimum displacement of the image and is considered to be very good for a spot size of 1 mm X 1 mm at the sample position.

CONCLUSIONS :

Two mirror chambers and two mirror mounts for photophysics beamline were designed, fabricated and tested. The mirror mounts are tested for their performance at atmospheric pressure and at a pressure of 1.0 X 10^{-9}m.bar. The residual gas spectrum recorded at 1.0 X 10^{-9} mbar indicates that H_2 is the major constituent of the residual gases. The minimum displacement of the image at the entrance slit (for mirror M_1) and at sample (for the mirror M_2) is 75 μ. This value is adequate as slit openings are 100μ for entrance as well as exit slits and the sample size is 1 mm x 1 mm.

ACKNOWLEDGEMENTS :

The authors acknowledge with gratitude the technical help extended by BARC and CAT workshops and UHV group at CAT. Dr. Saraswathy Padmanabhan and Ms. Aparna Shastry's help during the course of work is acknowledged.

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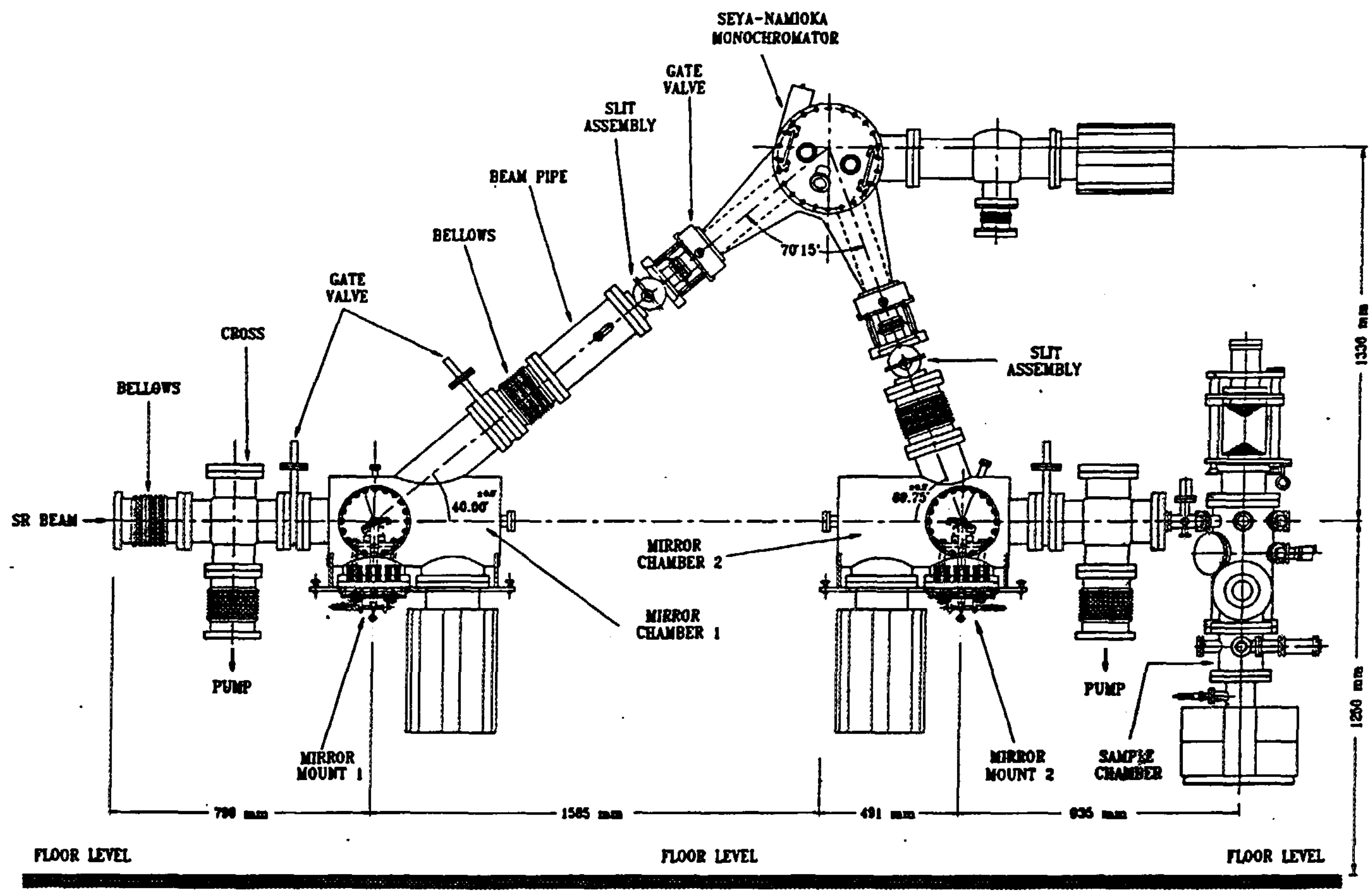

Fig.1. Mechanical layout of photophysics beamline

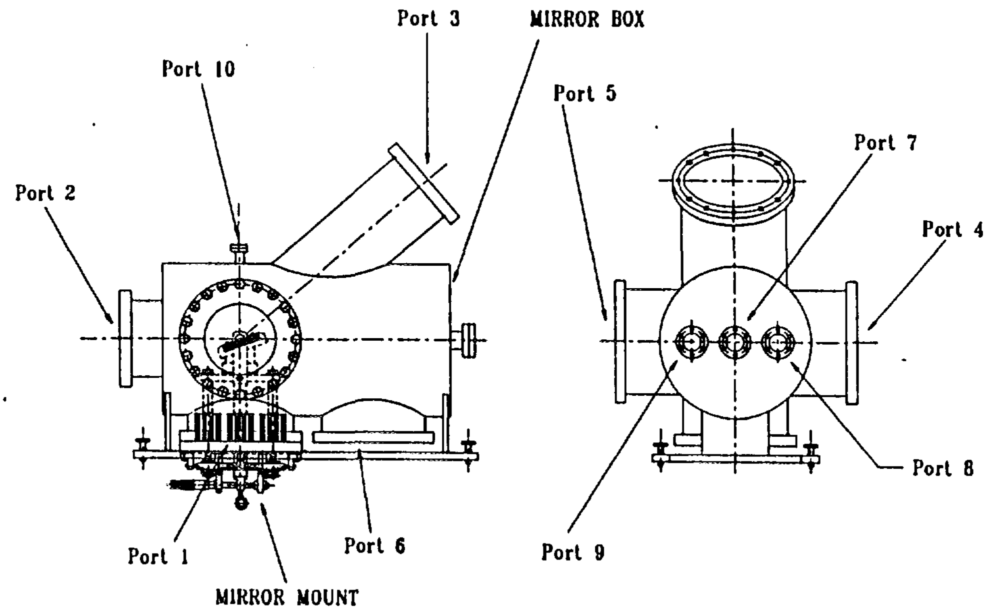

Fig.2. Schematic of Mirror Box M1

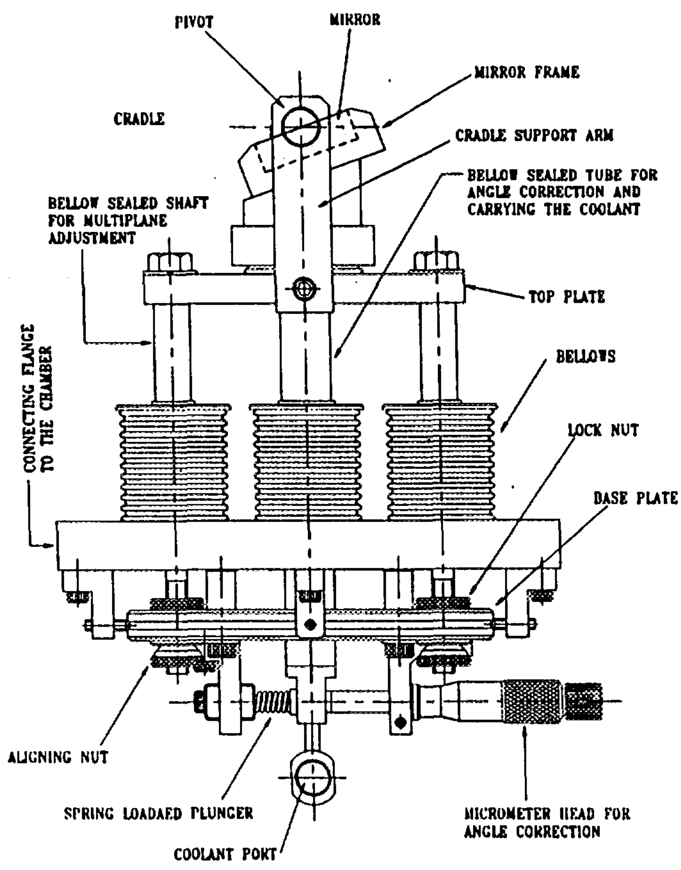

Fig.3. Schematic of mirror mount M1.

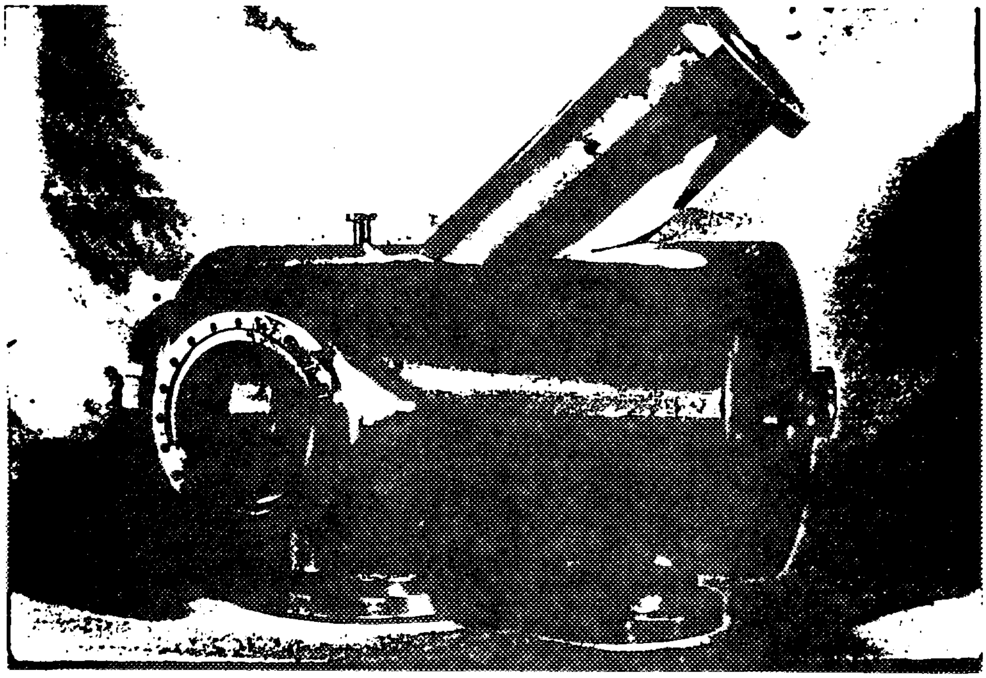

Fig.4. Photograph of Mirror Box

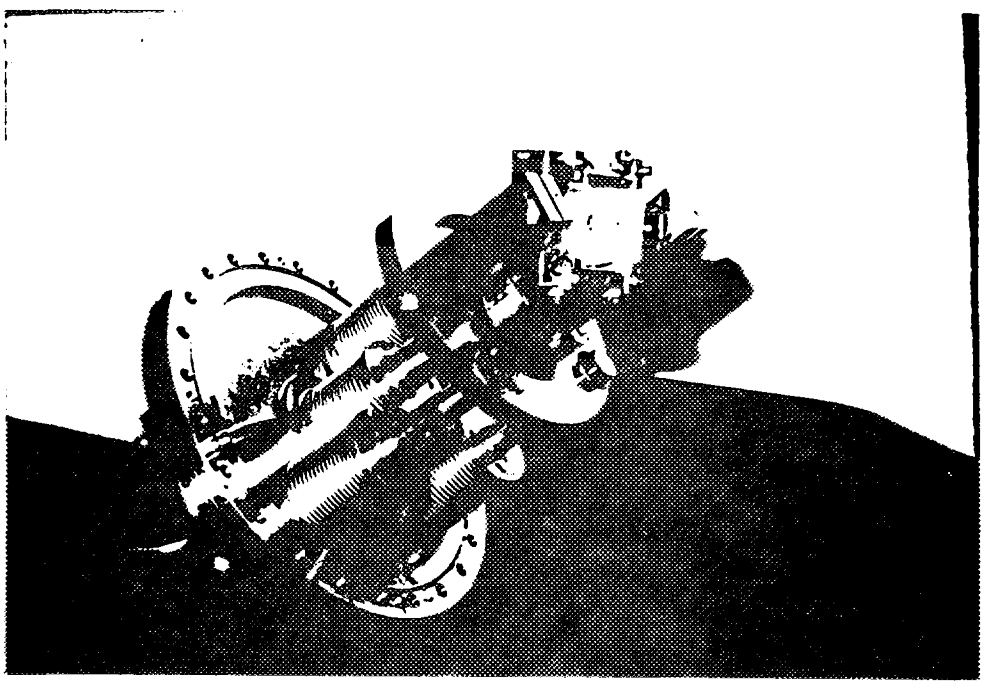

Fig.5. Photograph of Mirror Mount

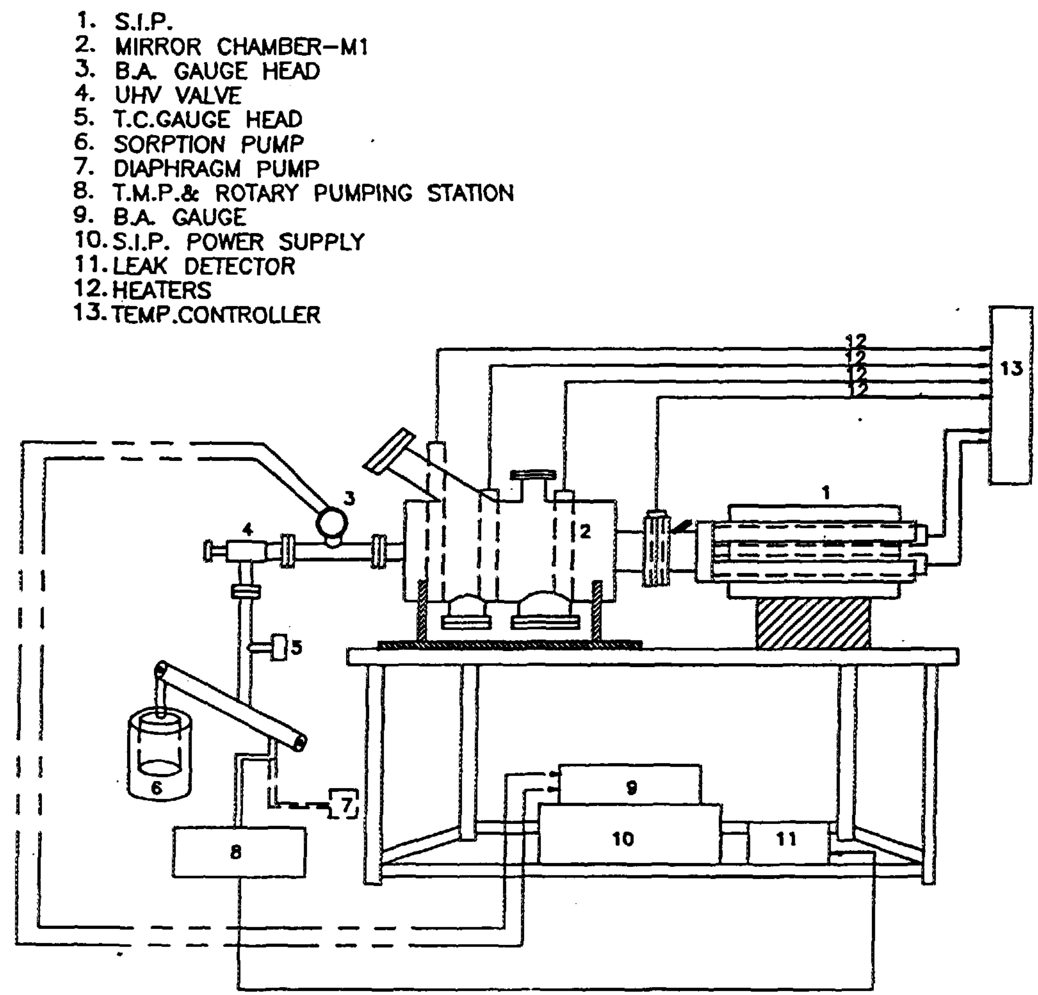

Fig.6. Side view of the testing setup

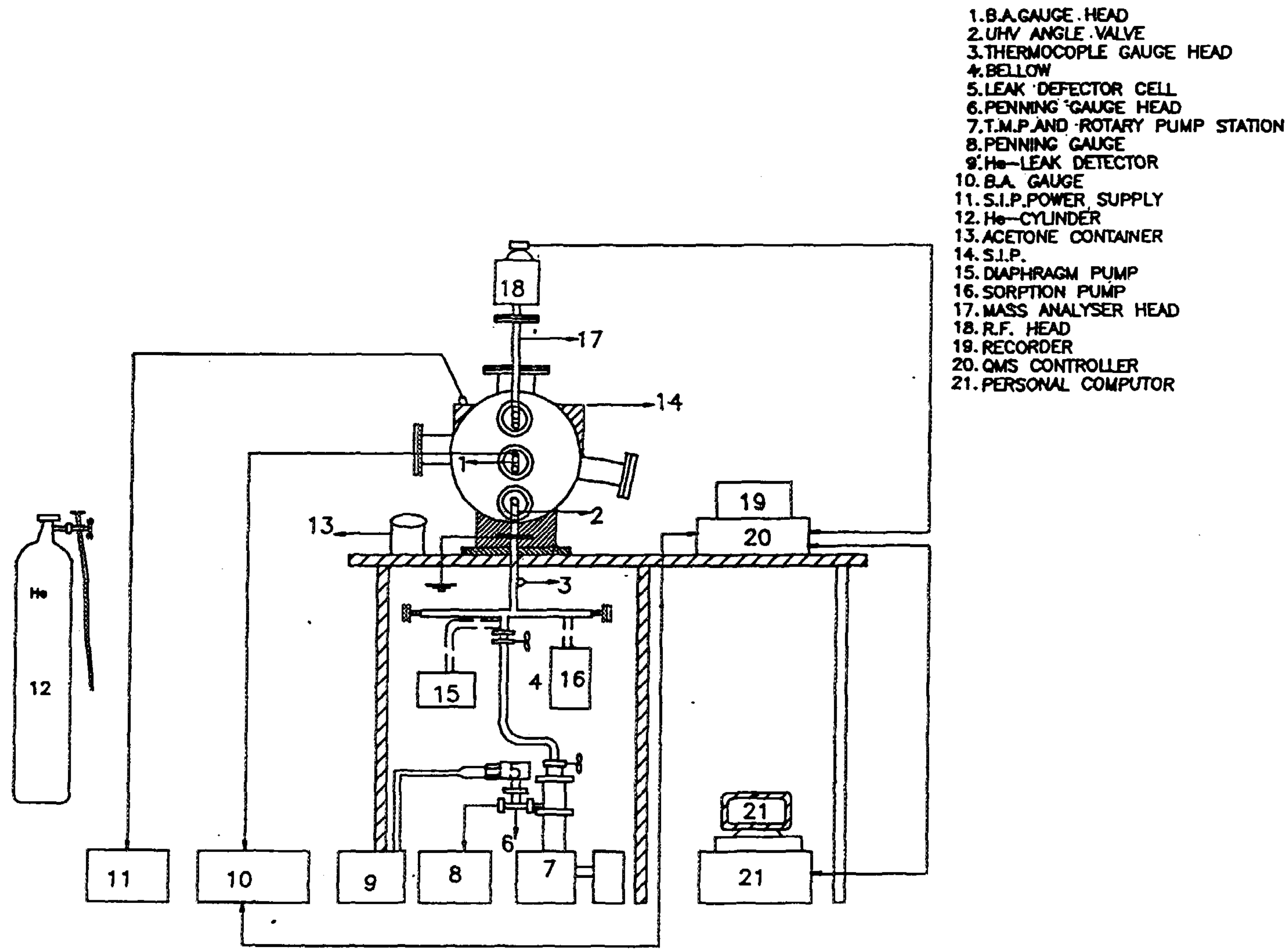

Fig.7. Front view of the testing setup

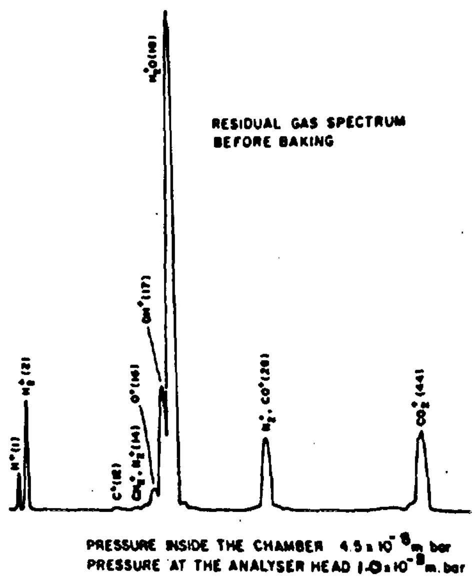

Fig.8. Residual gas spectrm before baking the mirror chamber

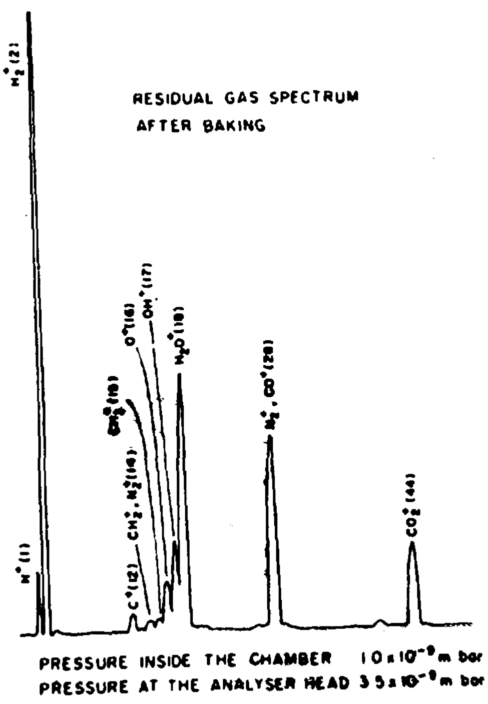

Fig.9. Residual gas spectrum at ultimate pressure

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