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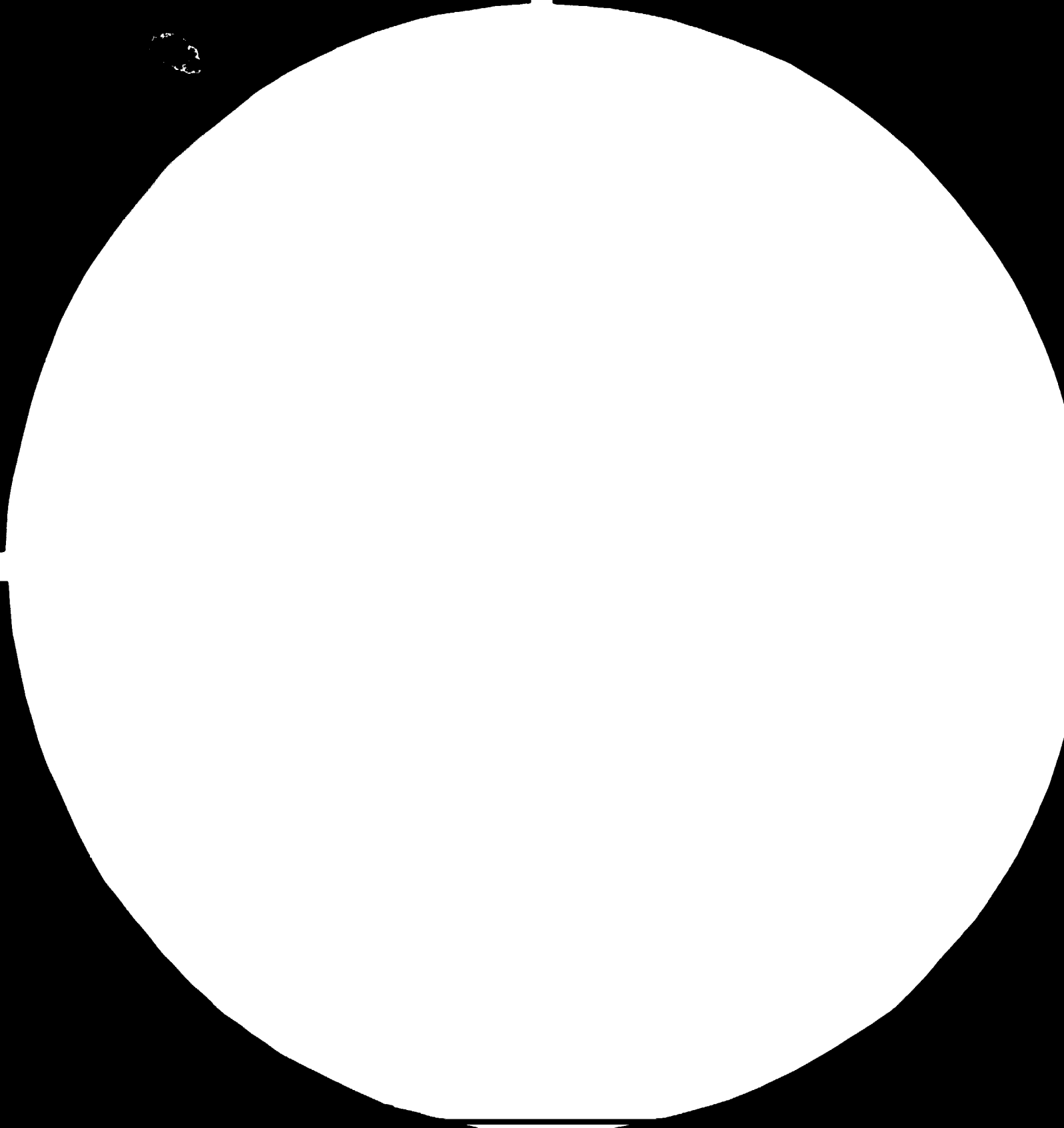

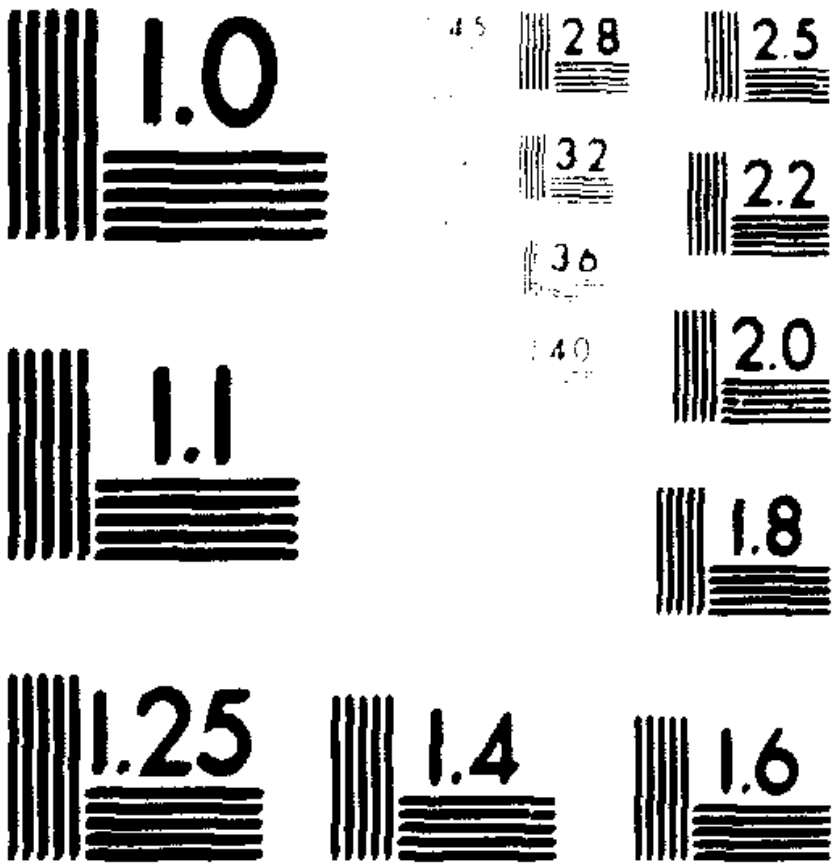

23 February 1984

RESTRICTED ENGLISH

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COAL GASIFICATION

DP/IND/80/004

INDIA

Technical Report*

(Return Mission January 1984)

Prepared for the Government of the Republic of India
by the United Nations Industrial Development Organization,
acting as executing agency for United Nations Development Programme

Based on the work of Karl H. van Heek,
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Vienna

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Summary

From January 13th to 24th, 1984 I have visited the Regional Research Laboratory in Hyderabad to act as a Chief Technical Advisor of the UNDP funded coal gasification project. The main activities of my visit have been:

- Discussion on status, commissioning, organisation and working programme of the pilot plant including visits to the plant site.

- Status and further programme of the supporting work including visits to the laboratories.

- Discussion on further objectives, final outputs and continuation of the programme and preparation of the Tripartite meeting.

- Meeting and discussion with the UNIDO officials Dr. May and Dr. Maung and attendance on the Tripartite meeting.

- Assistance in preparation of work specifications for the experts and discussion of the training programme.

Good progress has been made by the RRL project team during the last year: The pilot plant has been commissioned with assistance of two experts from Lurgi. The plant was operated with oxygen steam to 24 bar and with air-steam up to 15 bar using Ramagundam coal. The Lurgi experts also provided training to RRL staff in the operation of the pilot plant. Obviously it has been a good decision to give a subcontract to Lurgi for commissioning, although it may have caused some delay.

From the instruments provided by UNDP funds the IR gas analyser is connected and ready for utilisation in the next runs.

The mass spectrometer has also been started up during my stay by an engineer of Balzers' representative in Hyderabad and can be operated in principle without the computer. Mass spectrometer and computer for data logging shall be commissioned in March 1984. Organisation of the pilot plant is in principle satisfying. However, strengthening of the capabilities of the personnel in charge of the instrumentation and computer utilization is needed to make optimal use of these devices.

As to the supporting work the TGA is installed, commissioned and used for first trials. The Xytel-catalyst screening unit is installed and expected to be ready for the first trials after a spare part has arrived. Obviously the two operators have received good instruction during their training period at Bergbau-Forschung, FRG, and Xytel, USA. Modelling of the reactor has been pushed by the visit of Prof. Denn, whom I met during my stay in Hyderabad, and will be strengthened by the training visit of a RRL scientist in Denns laboratory as well as by the return visit of Prof. Denn and the visit of Prof. Klose.

The main aim of the next pilot plant programme will be to come to stable continuous operation over longer periods, to connect the gasification part with the gas cleaning section and to perform experimental runs with steam oxygen and steam air at different pressures and throughputs for the generation of reliable gasification data.

I wish to express my sincere thanks to the director of RRL, the national project director and all colleagues of RRL for the open information and the free discussion on status, problems, organisation and future work of the project. The organisation of my visit was excellent and the kind hospitality and manifold assistance during my stay are very much appreciated.

STRUCTURE OF GASIFICATION PROJECT

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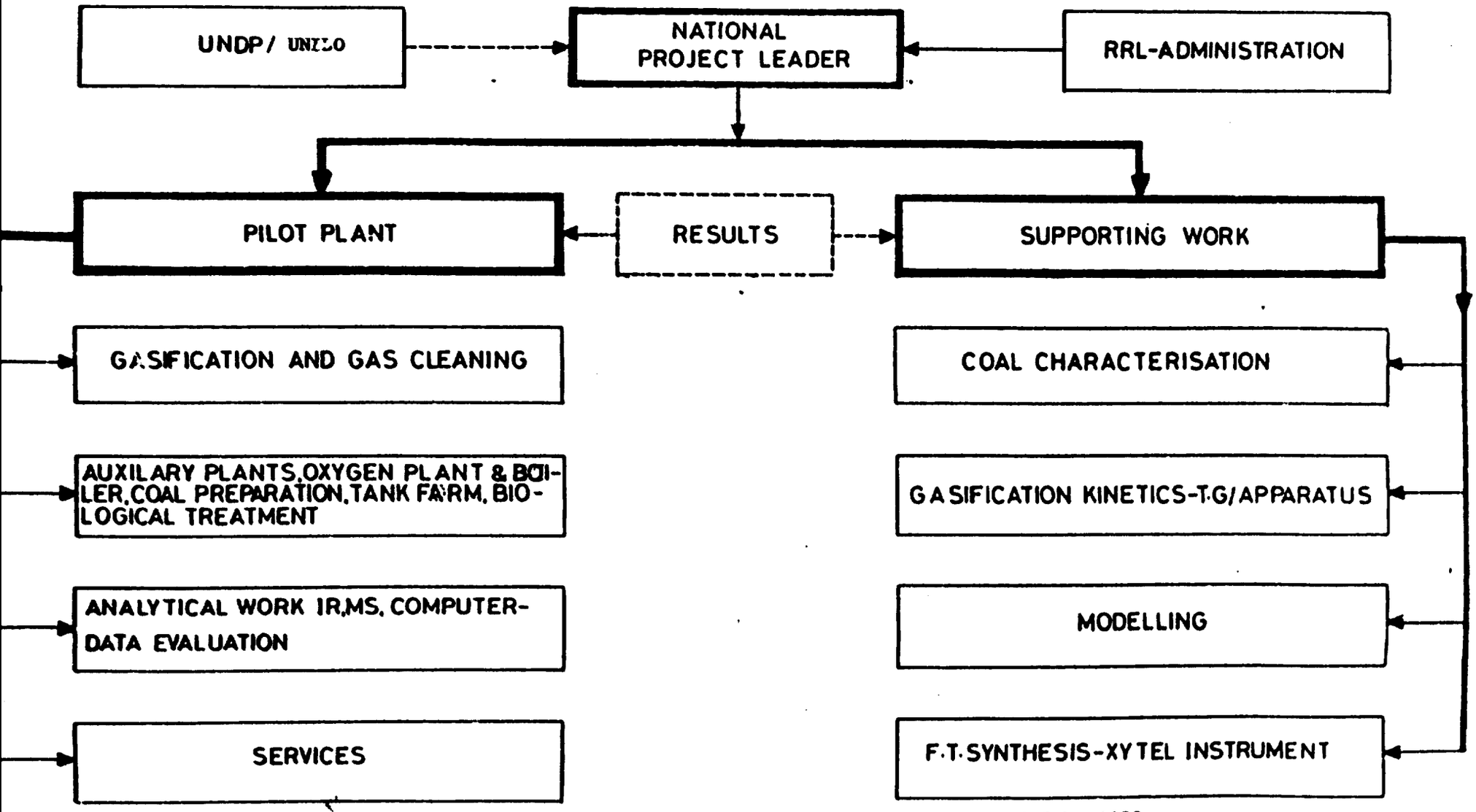

Status of Feb. 1983

Time table of the mission

Date	Day		Action
January			
13/14	Fri/Sat		Travel Essen - Bombay
15	Sun		Travel Bombay - Hyderabad
16	Mon	Morning:	Visit to Pilot Plant RRL (Anjaneyulu)
		Afternoon:	- Discussion of pilot plant status (Anjaneyulu) - Attendance to seminar of Prof. Denn, expert to the project - Discussion with the RRL-director on continuation of the program and preparation of the Tripartite Meeting (Thyagarajan, Vaidyeswaran, Anjaneyulu, Rao)
17	Tue		Dicussion on status and continuation of the project (Anjaneyulu, Rao)
18	Wed	Morning:	Visit to supporting work, inspection of TGA, XYTEL and HP-GC, demonstration and discussion of status (Rao, Satyanarayana, Narasimhan, Prasad)
		Afternoon:	- Discussion of organizational questions concerning the pilot plant (Anjaneyulu) - Evaulation of several possibilities for further work program with regard to probable extension of the project (Vaidyeswaran, Anjaneyulu, Rao)
19	Thu	Morning:	General discussions with UNIDO officers (May, Maung) about the project; joint visit to supporting work
		Afternoon:	- Visit of the pilot plant along with UNIDO officers - Assistance in final preparation of the Tripartite Meeting
20	Fri		Tripartite Meeting

Date	Day		Action
23	Mon	Morning:	Discussion on revised schedule of activities of the project (Vaidyeswaran, Rao, Anjaneyulu)
		Afternoon:	- Pilot plant: inspection of status of MS & Computer and IR gas analyzers (Rao, Anjaneyulu, Mariadas, Ventkataramana, Ehsan)
24	Tue	Morning:	- Discussion on further objectives and final outputs of the project (Vaidyeswaran, Anjaneyulu, Rao) - Meeting with Prof. Ramana Rao, Andra Pradesh University, concerned with coal characterization for the project - Meeting with a service engineer (Amalraj) from Balzers representative (Toshniwal Bros. Ltd., Hyderabad)
		Afternoon:	- Discussion of TGA maintenance, spares etc. (Narasimhan, Prasad, Rao) - Assistance in preparation of work specifications for the experts Denn, Locke and Konrad etc. and training program (Vaidyeswaran, Rao, Anjanejulu)
		Evening:	Departure from Hyderabad
25/27	Wed/Fri		Private
29/30	Sat/Sun		Travel to Essen via Bombay

1. Status of the Pilot Plant

1.1 Coal Preparation

This unit has the same status as last year. In total about 400 t of coal have been crushed and screened. About 180 t have been fed to the gasifier and similar quantity to the boiler.

1.2 Boiler

The boiler was commissioned and operated for full load of 2.5 t steam/h at 30 bar and a steam superheat of 400 °C.

1.3 Oxygen plant

This unit is operational since 1981. It was operated for 5 months in 1983.

1.4 Gasification

Pre-commissioning and commissioning have been performed. All the instruments for control were tested. Continuous gas analysers were installed. (Details in Chapter 2).

1.5 Gas cleaning

The system was hydraulically tested. Insulation was completed. This unit will be commissioned during 1984 and connected to the gasifier section as agreed at the last implementing meeting in Febr. 1983.

1.6 Gas liquor separation unit and biological treatment section

The gas liquor separation unit - tank farm - was commissioned and operated. For the biological treatment section civil works are in progress. In the first gasification trials waste water was disposed on the surface.

1.7 Control and Instrumentation

All essential process control instruments like for temperature, pressure, flow- and level control have been commissioned and operated. Sampling lines including the cooling drying, and conditioning units have been installed. The IR analyzers are installed, connected to lines for process- and calibration gas but were not used during the first test runs, where gas analysis was made by an Orsat apparatus. However, the IR analyzers are ready for the next run. Proper operation has been demonstrated.

No work was done with the MS and computer during the entire year. A necessary part of the software especially for the logging of the plant data has been ordered with Balzers. The unit is expected to be commissioned in March 1984.

During my stay I have met Mr. S.J. Amalraj, a service engineer from the Balzers' representative Toshniwal Bros. Ltd., Hyderabad. He had been trained by Balzers for several weeks and had performed already the necessary repairs in the cooling system in December 1983, so that vacuum operation was o.k. I have asked him to start up the MS system which had been done at the day of my departure and mass spectra have been recorded. Nevertheless the proper operation of the MS itself has not been demonstrated by Balzers (see last report p. 8). RRL expects that a service engineer from Balzers will come to commission the entire equipment - MS plus Minc computer - and demonstrate the operation. Especially the logging of the operational data at the plant must be included in the commissioning. On the whole I have confidence that good help could come from the Hyderabad representative both during commissioning and possible trouble shooting during later operation.

Apart from that RRL should try to operate the instruments without waiting for support from outside and also start operation the instruments separately. E.g. the Balzers MS can be run without computer assistance. In this case the mass spectra

or single peaks can be recorded and the partial pressures of the gas will be calculated manually. Also possibilities should be sought - possibly by assistance of the computer department - that the computer can be run. Scientific calculations, pilot-plant data evaluation etc. could be done on the basis of programs written by RRL members and - where necessary - by feeding of the input data by hand.

It was my impression, that the use of the IR and MS also in future will be done more sufficiently, if also some organisational measures are made. I would recommend that there should be one engineer responsible for the IR apparatus and of course other control instruments, who directly reports to the plant manager besides the support of the electronic workshop of RRL. For this one could consider Mr. Venkataramana, who has been trained on the MS. In addition it could be very useful if one or two suitable scientists are dealing with the operation of the computer. These should be fully dedicated to the development of the computer programmes which can be of great value for the performance and evaluation of the pilot plant tests.

1.8 Electrical Installation

In addition to the installation a standby power generator (62.5 kW) is installed and was used during the start-up trials.

2. Commissioning of the Pilot Plant

A good detailed survey is given by RRL in the documents for the Tripartite meeting held on 20.1.1984 which I fully agree. First of all it should be mentioned that RRL has erected the plant on its own and has performed all the pre-commissioning trials before the arrival of the LURGI experts. Assistance

from CFRI was also made use of for this purpose. Before the LURGI experts arrived, the apparatus has been tested for gas tightness. The plant was successfully commissioned on December 3th by the two member team from LURGI who were with RRL for about two months during October - December 1983. The plant was operated with oxygen-steam up to 24 bar and with air-steam up to 15 bar. The tests were conducted with Ramagundam coal from Singareni Collieries and the rated capacity could also be achieved. LURGI experts also provided training to RRL staff in the operation of the various units of the gasifier like ash lock and coal lock and also in emergency and voluntary shut down of the plant.

To sum up: Firstly it has been a good decision to give a subcontract to Lurgi for commissioning, although it may have caused some delay. Secondly, it has to be stated that the RRL-project team has made good progress in the last two years. Thereby it should be considered that the moving bed pressure gasification system involves high technology as the plant has to run at elevated pressure, high temperature, and in presence of pure oxygen under pressure and is therefore rather difficult and involves may risks to operate.

3. Working Program of the Pilot Plant

As the project has been extended at the Tripartite meeting (Jan. 20th, 1984) to the end of 1985, two years are available for a first phase of experimental tests. The final aim within this time is to perform

- experimental runs each of 7 - 10 days' duration with 4 or 5 coals at different pressures (2 or 3) and different (2 or 3) throughputs with oxygen-steam;

- air-steam gasification during the above runs up to 15 bar;

- commissioning and operation of gas cleaning.

As a precondition other tasks of the program should not be overlooked especially as the very next steps are concerned such as mentioned in my previous report

- training of personnel
- stabilizing plant operation
- collecting of data making use of the IR-gas analyzer, MS and successively the computer.

Also the measurement of temperatures and possibly gas compositions inside the gasifier should be kept under consideration.

The scope of the working program seems to be very realistic and can be done within the next two years.

4. Supporting Work

4.1 Coal and Product Analysis

For the selection and petrographical characterisation of the coals of interest for future gasification RRL cooperates with a team of the Andra Pradesh University, Hyderabad, the leader of which, Prof. Ramana Rao, I have met. Also, as mentioned in my previous report, equipment and trained staff is there at RRL to carry out analytical work to characterize the coal to be gasified in the pilot plant. It seems to be necessary that from the total amount of coal which is going to be gasified during an operation period a larger number of samples have to be characterized. By this the homogenity of the total charge can be assessed. This protects the operation from possible failures due to a sudden change in the qualities of the coal. Moreover, this is necessary to perform more reliable heat and mass balances.

To perform these measurements possibly the coal analysis facilities at RRL need to be strenghtened in personnel, instrumentation and perhaps also by concentrating the laboratory facilities. Moreover, a quick carbon analysis device (such as the coulombmeter made by Ströhlein, Germany) would be very useful if placed at the pilot plant.

4.2 Studies on Gasification Kinetics and Gas Conversion

The TGA unit received from Bergbau-Forschung was installed by two members of Bergbau-Forschung one of whom - Mr. Sulimma - came as an expert under the project November 1983 and tests were made with char prepared from the coal used in the gasifier. The TGA is operated by Mr. Narasimhan and Mr. Prasad, Mr. Narashimhan has received a four weeks' training during September/October 1983 at Bergbau-Forschung. Moreover, both scientists have received instructions and training during the stay of Mr. Sulimma at RRL. During my visit the TGA was in operation and runs have been performed, however, still some smaller teething problems have to be overcome with the help of Bergbau-Forschung.

The TGA will be useful for kinetic studies the results of which can be used for the determination of the reactivity of the coal and help in the interpretation of the results of the pilot plant. Furtheron the kinetic data form a basis for the computer modelling of the gasifier. Such studies can be along the lines similar to those done by Bergbau-Forschung with German coals and I am of the view that interaction with other organization such as BF should be continued.

The Xytel catalyst screening unit (CSU) has also been installed and tested for gas tightness. Responsible for this instrument

is Mr. Satyanarayana who obviously has received a good training by Xytel. At the moment the instrument was not operational, however, due to a transport damage in the electronics. A spare part has been underway.

Studies using catalysts prepared in the laboaratory have been made for synthesis of low molecular weight olefins starting with CO + H_2 mixture from cylinders in a different bench scale reactor. The preliminary results have been encouraging. Once a catalyst which gives good conversion has been developed, it can be prepared on 500 gm scale and used in the Xytel CSU. On the whole it is my impression that the Xytel catalyst screening unit is a useful unit. In this way FT synthesis work done at RRL - important not only for gasoline synthesis but also for chemicals - can be continued whereby the Xytel unit is a prestep to tests performed with coal gasification gas in a side stream of the pilot plant later on.

4.3 Modelling

During my stay in Hyderabad I met Prof. M. Denn who was proposed and elected as an expert provided by UNIDO for the project. He gave good and instructive seminars - one of which I have attended - and very intensive discussions with the RRL members concerned with modelling. As one result he has proposed as a first step a simple model for the reactor which is compatible to the computer facilities at RRL. Due to the training and expert schedule of the project Mr. Mallikharjunan from RRL will visit the group of Dr. Denn in summer 1984. Also a return visit of Dr. Denn in December 1984 is planned. In this way a good basis can be established for straight forward work in this field.

5. Experts and Training Programme

The following training proposals have been discussed and agreed

- Mr. TSR Anjaneyulu
  Operation of large gasifier, information about in-reactor measurements
  4 weeks; FRG/CSSR/UK; March-April 1984

- Mr. M.M. Mallikarjunan
  Modelling of gasifier
  4 weeks; USA with Prof. M. M. Denn; June 1984

- Mr. M.A. Khaleel Akhmal
  Design & Operation of large scale gasifier
  4 weeks; GDR; First half 1984

- One scientist
  for study on FT synthesis
  FRG; June 1984

- One scientist
  on modelling of gasification process
  USA/GDR; Nov. 1984

As for experts the following proposals have been considered and found to be useful

- Prof. M. M. Denn, USA, 1 week,
  December 1984 (revisit)

- Prof. E. Klose, GDR
  Modelling
  2 weeks; April 1984

- Dr. B. Konrad, CSSR
  Data collection and evaluation
  2 weeks; April 1984

- Mr. B. Locke, UK

  Design and Operation of large scale plants and gas clean-up facility

  2 weeks; Oct.-Nov. 1984

- Expert

  Data logging and evaluation

  4 weeks; during second half of 1984

Special discussion was done to define well the subjects of the visit of the 3 experts last mentioned in order to meet optimally the requirements of the project with the regard to the special knowledge and qualifications of the expert. The resulting job description are as follows:

For Mr. B. Locke:

- Design and scale-up strategies of large scale moving bed pressure gasification processes;
- Principles of techno-economic evaluation of large scale gasification system for generation of medium Btu gas and synthesis gas;
- Guiding tne experimentel programme in the RRL pilot plant for the above objects;
- Advice on gas cleaning and purification system;
- Advice on raw gas conversion including shift conversion and methanation to convert the raw gas to town gas (medium Btu, SNG and $CO+H_2$ for synthesis purposes);
- Advice on FT synthesis including catalyst;
- Advice on particle size fed to gasifier, utilization of 0-6mm size, pelletization and conversion to formed coke;
- General advice on slagging pressure gasification system;

For Mr. B. Konrad:

- Labortory scale evaluation of coal for gasification and correlation of laboratory data with gasification characterization in pilot plant including effect of particle size, pressure, and gasifying media;
- Crude gas cleaning, shift conversion, and cracking of tar vapors and conversion to methane;
- Development of equipment and machinery for pressure gasification system;
- General guide lines on optimization and techno-economic evaluation of pressure gasification system and gas cleaning;
- Overview on gasification technology on lignites and bituminous coal;

For the expert on data logging:

Qualification: Chemical or Mechanical Engineer or a technologist with expertise on evaluation of computerised data for a coal gasification plant preferably operating under pressure; Experience on gas analysis using mass spectrometer and IR analyzers desirable also programming in a PDP type of computer.

Job requirements: To guide the project team on evaluation of data from coal gasification pilot plant and computation of such values as thermal efficiency, steam decomposition, carbon conversion and assist in developing a computer programme for such computation.