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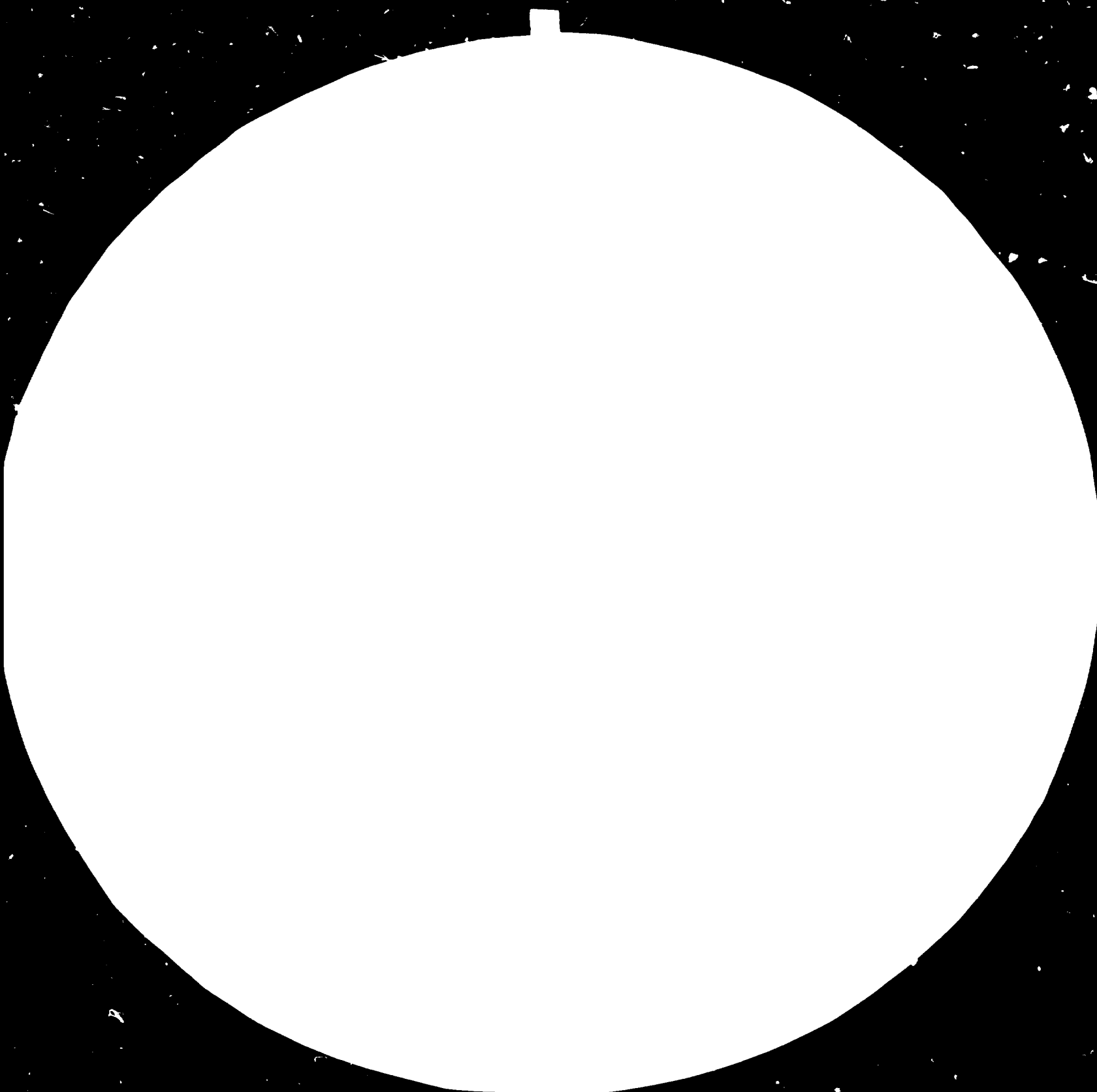
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MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL NUMBER

1963-A MICROCOPY TEST CHART NO. 2

China. Carbon fibre research project,
Mission report.

14214

Trip Report

UNIDO Mission to the People's Republic of China

September 18-29, 1984

UNIDO Project No. CPR/81/019/11-51

DG/CPR/81/019

Prof. Dr. E. Fitzer (West Germany)

[Handwritten signature]

Prof. Dr. D. F. Adams (USA)

[Handwritten signature] 10/12/84

8.10.84

1984

1. Schedule

- 9/13 Departure from United States
- 9/19 Joining of both experts for brief meeting in Narita Airport (Tokyo), to discuss subsequent joint travel to PRC.
Arrival at Beijing Airport; met by PRC delegation
- 9/20 Visit by PRC delegation at hotel, to establish agenda
Visit to UNDP offices for briefing by Mr. A. W. Sissingh
Initial discussions at the Institute for Chemical Technology, and tour of facilities
- 9/21 Further discussion of project document
Tour of facilities of the Institute of Aeronautical Materials, Beijing
- 9/22 Discussion of Project Document
Technical lectures by Professor's Fitzer and Adams at the Institute for Chemical Technology
- 9/23 Travel by air and automobile to Chang Chun and Liao Yuan
- 9/24 Tour of Liao Yuan Special Fiber Factory
Return to Chang Chun by train
- 9/25 Return to Beijing by air
- 9/26 Further discussion of project document
- 9/27 Completion of discussion of project document
Departure for Guangzhou

3.38

9/28 Meeting with Prof. Zeng Hannin of Zhongshan (Sun Yatsen) University and tour of facilities

9/29 Departure for Hong Kong and return to home

2. Current Status of Research on Carbon Fibers and Their Composites in China

Research on carbon fibers was initiated in the People's Republic of China (PRC) in 1975. The presently proposed program for the development and application of carbon fibers and their composites was initiated by the present UNIDO Experts during a consultation week in Beijing in 1980 and the seminar in Beijing in 1981.

A laboratory line for producing carbon fibers from polyacrylonitrile (PAN) precursor fiber currently exists in the Beijing Institute of Chemical Technology. A pilot plant for producing polymer, PAN precursor (HNO_3 wet spinning process), and carbon fiber has been in operation in Liao Yuan since 1982.

Necessary equipment for preparing and testing carbon fibre reinforced plastics (CFRP) exists in the Institute of Aeronautical Materials, Beijing. Simple CFRP samples are being fabricated for demonstration purposes.

Carbon fibers being currently produced by the Liao Yuan Special Fiber Factory have the following properties:

Strength : 2000-3000 MN/m²

Modulus : 200-230 GN/m²

These fibers are not surface treated; about 500 kg/year are being produced.

The Visiting Experts had the impression that current knowledge in both the areas of fiber manufacture and composites fabrication is limited.

3. The Project Document

A complete draft of the proposal document was available from the Chinese Delegation (Enclosure 1) at the beginning of the discussions. During the four days of discussions, this draft was altered and refined into a final form (Enclosure 2).

The proposed program organization is as follows: Two Institutes will be enjoined in the experimental work, i.e., the Institute of Chemical Technology and the Institute of Aeronautical Materials, both in the Beijing area. The Project Director will be Professor Chen Jian-yuen, President of the Beijing Institute of Chemical Technology. The Project Vice-Director will be Mr. Diao Shitoy, General Director of the Institute of Aeronautical Materials.

Project funds will be split between the two Institutes as indicated in table 1.

Table 1
Budget and Expenditure Plans of Both Participants
(in U.S. Dollars)

<u>Funding Source</u>	<u>Ministry of Chemical Technology (Polymer Institute)</u>	<u>Ministry of Aeronautical Technology (Aeronautical Materials Institute)</u>	<u>Total</u>
Input - Chinese Government (for hardware only)	0.30	1.52	1.82
UNIDO (55% for hardware. 45% for personnel)	0.50	0.50	1.00
<u>Expenditure Plan</u>			
Hardware	0.60	1.77	2.37
Personnel	0.20	0.25	0.45

The third participant in the project, the Liao Yuan Special Fiber Factory, will not be directly supported by project funds.

4. Summarizing Conclusions

The extensive discussions between the Chinese Delegation and the Visiting Experts were very cordial. Good progress in developing and finalizing the proposed project document was achieved once the limitations of both funding agencies involved, i.e., the Chinese Government and UNIDO, were understood by the Experts. These limitations are detailed below.

4.1 Limitations

The imposed limitations were as follows:

- 1) The splitting of funds provided by the Chinese Government and UNIDO was fixed between the two Research Institutes, and not open to change.
- 2) The split between hardware and personnel funds provided by UNIDO (as given in the First Draft - see Enclosure 1) had to be accepted.
- 3) The request by UNIDO to include a budget item for Chief Technical Advisors was to be included.
- 4) A Technical Advisory Committee (TAC) was to be established, with annual meetings to be held in Beijing.
- 5) At least a portion of the project budget was to be executed by UNIDO.

4.2 Resolution of Limitations

- 1) Both Limitations 1 and 2 were accepted by the Experts after the Chinese Delegation agreed to follow the Experts' proposal to

initiate the research in the two Institutes in parallel rather than in sequence. This required the addition of a budget item to purchase raw materials from foreign suppliers initially.

- 2) The scheduling of the research effort in parallel will permit both areas of research to proceed independently even though the funding level available to the Institute for Aeronautical Materials is much higher than that of the Institute for Polymer Chemistry.
- 3) The UNIDO proposal to establish Chief Technical Advisors was fully accepted by the Chinese Delegation, but for this particular project only.
- 4) The UNIDO request to establish a Technical Advisory Committee (TAC), with annual meetings to be held, was accepted by the Chinese Delegation, although it was thought by them to be unnecessary in the beginning of the discussions.
- 5) The Chinese Delegation agreed, as a result of extensive discussions with the Experts, to have UNIDO execute the \$1,000,000 input funds to be provided by UNIDO. It was clearly stated by the Chinese Delegation, in the presence of the UNIDO Representative, that this arrangement applied to this specific project only, and cannot be regarded as setting a precedent for other UNIDO projects.

4.3 Further Results

- 1) The original list of requested equipment was refined, as can be seen by comparing Enclosures 1 and 2.
- 2) The suggestion to include bench-scale equipment for spinning PAN precursor fiber similar to that delivered to Brazil was

gratefully received by the Chinese Delegation.

- 3) The indicated request for a carbonization line was understood by the Experts, after considerable discussion, as actually being a request for a complete carbon fiber fabrication line. This request is fully supported by the Experts as being a valid technical need.
- 4) Basic research equipment is already available at the Institute for Aeronautical Materials, the present requests being for required specialized equipment needed in the proposed project.
- 5) There is a clear need for technical interchange with foreign countries in both of the major research areas. The present project will greatly aid this progress.
- 6) As a result of the agreement by the two supported research groups to work in parallel rather than in sequence, the purchase of foreign raw materials will be necessary to permit work to begin immediately, especially by the Institute for Aeronautical Materials. This group has therefore added a request in their equipment list for \$50,000 for fiber material. High quality PAN precursor must be ordered also, about \$20,000 being needed to purchase two tons (2000 kg). This precursor fiber will be used by the Liao Yuan Special Fiber Factory.
- 7) Chief Technical Advisors - Professor Fitzer is willing to accept an offer from UNIDO under the same conditions as established for India (two trips to China per year, the balance of time for home base work). It is not possible to accept more than two man-months per year. Therefore, it is proposed (see Page 4 of Enclosure 2) that one additional Technical Advisor be

assigned, for correlation of the annual activities (three visits, each one-half month). Professor Adams will try to be available a total of one month/year (one half for visitation to China, and one half for home base work).

The Experts have worked out a plan for contacting candidate experts, finding locations for placing study teams and Fellows, and for visits to potential suppliers of equipment.

- 8) Special Technical Experts - Based upon prior experience in India and Brazil, it has been found to be advantageous to plan visits by experts for one-half man-months each, as a normal time period. Flexibility in arranging visits according to special needs and activities is requested, conforming to the wishes of the Chinese Delegation at the appropriate time. The subjects listed for the experts is the outcome of refining the proposal according to the Experts' consideration of perceived needs (see Table 1 in Enclosure 1 as compared to Table 1 in Enclosure 2).

Mr. Sissingh has promised to rearrange the information in the final draft of the proposal (Enclosure 2) in standard UNIDO project form within 3-4 days after the conclusion of the present meeting.

- 9) Study Tours - After studying the initial proposal by the Chinese Delegation, the visiting Experts were able to convince them that two seven-man study tours, each of six weeks duration, are not desirable. Mr. Sissingh has agreed to reformulate Table 2 of Enclosure 2 as required.

The Visiting Experts proposed:

- a) The maximum number of participants in an group should be

three.

- b) Careful selection of the tour visits in accordance with the specific interests of the individual group, being responsive to the needs of the project.
 - c) At least one member of each group must have adequate command of the English language to be able to absorb technical details without difficulty, and to participate in fruitful discussions.
 - d) In general, Technical Experts will first be selected, and then arrangements will be made where possible to have study tours and Fellows visit the Experts' institutions.
 - e) The small Study Groups will also be responsible for evaluating and selecting equipment.
 - f) Not only planning, but also the progress of the visits and discussions, must be coordinated in close contact with one or both of the Technical Advisors.
- 10) Fellowships - The plan as originally worked out by the Chinese Delegation (see enclosed plan, Table 3 of Enclosure 2) was not discussed or modified by the Experts. Being acceptable in principle, it will be worked out during the first year of the proposed project. The Chinese are planning these fellowship visits during the second year.

This delayed start is due to the intention by the Chinese to prepare the fellows very carefully. The Experts agree with this plan, and propose additionally that only candidates who are highly motivated toward the project be selected. Training locations will be proposed by the Chief Technical Advisors, after close contact

with the candidate Visiting Experts.

It was explained to, and understood by, the Chinese Delegation that probably only University sites will be available, but that hopefully industry experts will be involved in the actual training also.

5. Visit to Guangzhou

Zhoushan (Sun Yatsen) University, Guangzhou, Peoples Republic of China

President: Professor Li Yuesheng

Director - Composites Research Laboratory: Professor Zeng
Hanmin

Lecturers - Composites Research Laboratory:

Guonen He

Yongle Cheng

Jigcu Lee

Director - Instrumentation Analysis Center:

Dr. Zhao Shankai

This visit was included in the mission at the special request of the Experts because Professor Zeng was the Official Representative of the Peoples Republic of China at the Sao Jose dos Campos Conference in Brazil in December 1983. Meetings at Zhongshan University were held with all of the above named individuals. Tours were made of the Composites Research Laboratory and the Instrumentation Analysis Center.

The Experts had learned while in Beijing earlier in the mission that Professor Zeng and his group are not included in the proposed UNIDO project. Thus, scientific contacts and obviously scientific cooperation between the Beijing Institute of Chemical Technology and Zhongshan

University should be encouraged.

The Composites Research Laboratory, led by Professor Zeng, made an excellent impression, mostly because of the variety of projects involving carbon fiber composites, and less because of available equipment, which was the minimum needed.

Special topics addressed by this group include fiber-reinforced thermoplastics such as PPS and polysulfone, basic fiber-matrix interface research, systematic study of the microstructure of carbon fibers and intermediates, development of measurement techniques for Young's modulus and diameter of carbon fibers, the Iosipescu shear test method, etc.

The Instrumentation Analysis Center is completely new, both building and equipment, and contains all facilities needed for sophisticated precursor fiber, intermediate fiber, and carbon fiber analysis, as well as analysis of resin matrices (e.g., IR, emission spectroscopy, X-ray diffraction, SEM, high resolution TEM, high resolution mass spectroscopy, etc.). The Director, Dr. Zhao, appears to be very capable and cooperative.

It is strongly recommended that the group from Zhongshan University be included in the proposed project if possible, in the areas of fiber and polymer matrix basic research. The visit to Guangzhou was thus very worthwhile and necessary for the project.

Air tickets for travel from Beijing to Guangzhou had to be purchased by the Experts and reimbursement will be requested from UNIDO as this trip was part of our return flight from Hong Kong.

6. Specific Remarks

This visit to China appeared to go well, and to be very profitable for both the Experts and the Chinese Delegation. We were very pleased

with the positive impact the 1981 contacts and seminars in Beijing had, and thus plan to propose another seminar at the middle or end of the proposed project, similar to that held in Brazil in December 1983.

7. Organization of the Various Chinese Institutes

The following charts indicate the organization of the various groups involved in the proposed project.

7.1 Ministry of Chemical Industry

Minister Yong Guem Chie		
Chief Engineer An-Yu Zou	New Chemical Material Department Director: Jing Xongton	
Wang Genrong	Chief Engineer: Sun Hanjing	
Polymer Chemicals Mrs. Li Naigong	Chemical Reagents	Photo Chemicals
Carbon Fibers Mrs. Chei Zonhnsen		

7.2 Beijing Institute of Chemical Technology

President Professor Chen Jian-yuan		
Vice-President S. Wang		
Research Institute of Polymer Science	Six	Other Departments
Prof. W. V. Guan Ying		
Prof. Cheng		
Laboratory for Carbon Fiber	Laboratory for Photochemical Polymers	
Prof. Wang Pei Huun		

7.3 Beijing Institute of Aeronautical Materials

General Director
Jiao Simtary

Vice Director
Fan Tong

Metallic Div.

Non-Metallic Div.

Testing Div.

7.4 Liau Yuan Special Fiber Factory

President (Director)
Chang Zhom Way

7.5 Organization of the UNIDO Project

Controlling and Supported Ministries

Economic
Foreign Affairs

Chemical
Industry

Aeronautical
Materials

Project Leader (President)

Chen Jian-yuan, President
Beijing Institute of Chemical Technology

Vice-President

Jiao Simtary, General Director
Beijing Institute of Aeronautical Materials

Beijing Institute
of Chemical Technology

Beijing Institute
of Aeronautical Materials

Liau Yuan
Special Fiber
Factory

Prof. Wu
Prof. Wang

Mr. Fan Tang

Chang Zhom Way

ENCLOSURE # 1

UNITED NATIONS DEVELOPMENT PROGRAMME

Project of the Government of The People's Republic of China

PROJECT DOCUMENT

Title: Development and application of carbon fibre and it's composites

Number: CPR/84/003

Duration: 36 months

Primary function: Institution building

Secondary function: Personnel training

Sector: Science and Technology

Government Implementing Agency: Ministry of Chemical Industry

Estimated starting date: January, 1985

Government inputs: RMB ¥ 6,900,000 (in kind)

UNDP inputs: US \$ 1,000,000

Government share: US \$ 1,820,000

The project will be executed by the Government in cooperation with UNIDO and implemented by the Ministry of Foreign Economic Relations and Trade on behalf of the Government.

Signed _____ Date _____
on behalf of the Government

_____ Date _____
on behalf of UNDP

PART I. The Legal Context

The project document shall be the instrument referred to as such in Article 1. paragraph 1 of the Assistance Agreement between the Government of the People's Republic of China and the United Nations Development Programme, signed on 29 June, 1979. The Government Implementing Agency mentioned in this Project Document shall refer to the Government Cooperating Agency described in the Agreement.

PART II. The Project

A. Development objectives

Carbon fibre is a new sort of materials with high strength and modulus, low density and good heat and corrosion resistance. In recent years, the uses of carbon fibre in the fields of structural and functional materials have been developed rapidly and it appears to play an important role in the national economy

and the people's livelihood, so that the research and development of carbon fibre and its composites is required for realizing the science and technology modernization.

The development objectives for this project are as follows:

1. Research bases would be built up for developing various sorts of carbon fibres of high quality and developing prepregs and composites, so that research achievements on new technology and products would be performed for improving and directing pilot production.

2. A technical team that could successfully develop carbon fibre and composites would be established through systematic training.

B. Immediate objectives

1. Laboratories would be built up for developing precursors, carbon fibres, prepregs and composites and for determining related properties.

2. Processes would be optimized for improving quality of carbon fibre (for example, overcoming brittleness, broken filament, variation in strength and so on) and increasing the prepreg sorts for manufacturing composite components in practice.

3. Technical personnel engaged in this project would be trained systematically.

C. Background and Justification

In China, carbon fibre has been already developed since the sixth decade. At present, the carbon fibre with strength of 250-300 kg/mm² can be produced in laboratory. In recent years, the research work on composites has been enhanced and articles for recreational, medical and industrial uses and transport have been made on small scale. But there are still some problems, such as poor processing technology and quality control, unstability of product quality, lack of varieties and bad economic effectiveness. Therefore, it is need to accept technical assistance and exchange to solve these problems.

To conduct this project, there are two Recipient departments: Beijing Institute of Chemical Technology and Beijing Institute of Aeronautical Materials; the former will carry out the work on precursor and carbon fibre and the later on composites.

The Research Institute of Polymer Materials in Beijing Institute of Chemical Technology has developed carbon fibre using a carbonizing equipment of 5 tons. The Research Institute, which is in co-operation with Liaoyuan special Fibre Factory for developing carbon fibre, is equipped with facilities for property measurements and organizes a technical team for carrying out research work on fibre processing and structural conformation. In addition, Beijing Institute of Chemical Technology, which is a university of industrial technology, is comprised of departments of chemical engineering, Polymer, chemical industrial machinery, chemical industrial automation and engineering administration, etc, so there is enough capability to perform research work through internal cooperation.

The development of composites has been conducted for more than ten years in Institute of Aeronautical Materials, where there are laboratories on composites, property determination and non-destructive testing, etc.. Research work on preparation of prepreg and autoclave moulding of composites has been carrying on and some standards for testing materials have been established by 50 scientists and engineers of various specialities, recently.

We believe that through the activities of this project, much greater prog-

resses on the development of carbon fibre and it's composites would be made.

D. Outputs

1. Building and rebuilding for laboratories of precursor, carbon fibre, prepregs and composites and other offices by the Research Institute of Polymer Materials in Beijing Institute of Chemical Technology and Beijing Institute of Aeronautical Materials, respectively.

2. Establishment and modification of following equipment facilities to perform process optimization within three year after starting the project:

2-1. Experimental equipment for wet spinning (mainly nitric acid method);

2-2. Experimental equipment for carbonization (including surface treatment);

2-3. Experimental equipment for preparing prepreg by dry method;

2-4. Experimental equipments for composite fabrication and machining.

3. Establishment of laboratories of property measurements and following special research groups:

3-1. Surface treatment of carbon fibre;

3-2. Property and structure conformation of carbon fibre;

3-3. Preparation of prepreg by dry method;

3-4. Moulding of composite structural components.

4. Establishment and training of personnel for research and development work.

E. Activities

1. Invitation of foreign experts for consulting-22 m/m in total, which is detailed in Table 1.

Table 1. The plan for inviting foreign experts

Item	Mission and Speciality	Number of experts	Starting time	Duration (day)
I	II	III	IV	V
01	Consulting for the project document	2	Before imple- ment of the project	15 (each)
02	Chief consultant	1	in the beginning of the project in the middle at the end	15 15 15
03	Preoxidization and property measurement	1	the first half of the first year	20

(continued)

I	II	III	IV	V
04	Carbonization and surface treatment	1	the first half of the first year	20
05	Polyacrylonitrile precursor spinning, property measurement and conducting test run	1	the first half of the third year	35
06	Structure conformation of carbon fibre (X-ray, electron microscope)	1	the second half of the first year	20
07	Carbon fibre reinforced thermoplastics	1	the first half of the second year	20
08	Carbonization facility and engineering and conducting test run	1	the first half of the second year	60
09	Resin and prepreg technology	1	the first half of the first year	15
10	Prepreg technology	1	the second half of the second year	45
11	Composite moulding	1	the first half of the first year	15
		1	the first half of the third year	45
12	Moulding and property of composites	1	the second half of the first year	30
13	Mechanical properties of composites	1	the first half of the second year	30
14	Structure design and moulding of composites	1	the first half of the first year	30
		1	the first half of the third year	30
15	Structure design and mechanical properties of composites	1	the second half of the second year	30
		1	the first half of the third year	30
16	Non-destructive testing	1	the second half of the first year	30
17	Review implement of the project	1	in the middle of the project	30
		1	at the end of the project	30
18	Unpredictables			20

2. Study tour: 20 m/m altogether, the plan of which is shown in Table 2.

Table 2. The plan of study tour

Item	Purpose	Country	No. of persons	Duration (week)
01	equipments and technology for manufacturing carbon fibre	Japan, America, Brizal, Wet German	7	6
02	equipments and technology for manufacturing preregs and composites	England, France, America, Japan, West German	7	6

3. Fellowships: 57 m/m altogether

Table 3. The plan of fellowships

Item	Purpose	No. of persons	Starting time	Duration (month)
01	Carbon fibre technology	2	the first half of the second year	3(each)
02	Preoxidization technology	1	the first half of the second year	2
03	Surface treatment of carbon fibre	1	the second half of the second year	3
04	Precursor technology	2	the second half of the second year	2(each)
05	Active carbon fibre	1	the second half of the second year	3
06	Structure and property of carbon fibre	1	the first half of the second year	3
07	Prepreg technology	2	the first half of the second year	2(each)
08	Moulding and design of composites	2	the first half of the second year	3(each)
09	Moulding and design of composites	2	the second half of the second year	3(each)
10	Property measurment	2	the first half of the second year	2(each)
11	Nondestructive testing	2	the first half of the second year	2(each)
12	Moulding of composites	1	the second half of the second year	3
13	Operating of the equipments	3		3(each)

F. Inputs

1. Government inputs: RMB ¥ 6,900,000, including:

- 1-1. Charges for purchasing instruments and equipments;
- 1-2. Charges for civil engineering;
- 1-3. Charges for purchasing accessories;
- 1-4. Charges for project personnel and training home;
- 1-5. Charges for common materials;
- 1-6. Charges for translation and traffic during experts' stay in China.

2. UNDP inputs: US \$ 2,820,000, where Government share \$1,820,000 is included, are used for following items:

- 2-1. experts' service;
- 2-2. study tour;
- 2-3. fellowships for training;
- 2-4. procurement of equipments;
- 2-5. some raw materials;
- 2-6. unpredictables.

G. Work plan

1. The first year

1-1. The chief consultant will be invited to China to advice and cooperate making work plan, confirming the invited experts, training places and equipments and instruments to be purchased, etc.;

1-2. Two study tour groups will be sent for preliminary study to make revision of the project plan and decision on purchasing equipments;

1-3. Laboratories for research and development would be built and rebuilt by Recipient Departments;

1-4. The purchasing orders of instruments and equipments abroad would be confirmed;

1-5. The activities of consulting and training would be well done in according to the annual plan in the Tables 1 and 3.

2. The second year

2-1. After delivery of the equipments, installation and adjustment of the equipments will be made and research work on carbon fibre, prepreg and composites will be carried on using them, if possible;

2-2. The relative laboratories of property measurement will be built up and the work on adjustment of the instruments and masting measurement art shall be put into effect;

2-3. The activities of consulting and training will be realized in according to the annual plan;

2-4. Laboratories for special subjects, such as surface treatment of carbon fibre, property and structure conformation of carbon fibre, moulding and machining of composites and preparation of prepreg by dry method, will be built up and the relative research work will be carried on.

3. The third year

3-1. The experiments of processing optimization will be carried on to obtain products and articles with good quality;

3-2. The installation and adjustment of the equipment for fabricating precursor will be finished;

3-3. The activities of consulting will be finished in according to the annual plan;

3-4. The research work of special subjects (see paragraph 2-4) will be made;

3-5. The terminal report of the project will be made and the project shall be subjected to evaluation by UNDP.

H. Institutional Framework

1. The Ministry of Foreign Economic Relations and Trade as a equivalent department to the UNDP will be in charge of supervising implementation and coordination of the project.

2. The Government Implementing Agency is the Ministry of Chemical Industry.

3. The Recipient Departments are the Research Institute of Polymer Materials in Beijing Institute of Chemical Technology and Beijing Institute of Aeronautical Materials.

4. UNIDO as a Cooperating Agency will be in cooperation with Chinese Government in according to the "Service Agreement".

5. The project in practice will be implemented by Recipient Departments:

5-1. One chief director and one deputy director are in charge of this project:

5-2. Personnel

5-2-1. The personnel in the period of the first year and the second year:

There are fifteen engineers or scientists and fifteen technicians both in the parts of carbon fibre and composites.

5-2-2. The personnel in the third year:

There are forty five persons in the part of carbon fibre and fifty persons in the part of composites.

5-3. The places for implementing the project:

5-3-1. Research Institute of Polymer Materials
Beijing Institute of Chemical Technology
Beijing

6-3-2. Institute of Aeronautical Materials
Beijing

I. Future UNDP Assistance

In order to build up bases for research and development of various sorts of carbon fibre and composites, it is needed to accept future assistance in the next stage besides the assistance in this project, such as:

1. Establishment of experimental equipment for developing new polyacrylonitrile copolymer precursor to obtain the carbon fibre with good quality.
2. Establishment of experimental equipment for developing active carbon fibre and of relative laboratory for surface chemistry measurement.
3. The research work on pitch-based carbon fibre to be exploited.
4. Development of the composites, in which the fabric woven with hybrid fibres is used as reinforcement.
5. Development of moulding of carbon fibre reinforced thermoplastics.
6. Development of pultrusion moulding of carbon fibre composites.

Therefore, the future assistance is expected to carry out the subjects mentioned above.

PART III. Review, Evaluation and Report

A. Monitoring reviews:

The project will be subjected to periodic review in accordance with the policies and procedures specified by UNDP for monitoring and review of the project implementation.

B. Evaluation

The project will be subjected to evaluation in accordance with the policies and procedures established for this purpose by UNDP. The organization, terms of reference and timing of the evaluation will be decided by consultation among the Government, UNDP and UNIDO.

C. Progress and terminal reports

The sixth-month progress reports and the terminal report of the project will be prepared by the project director.

PART IV. Budget and Procurement

A. Budget

1. Government inputs: RMB ¥ 6,900,000

Table 4. The distribution of the Government inputs

No.	Item	1'st year	2'nd year	3'rd year	total
01	Instruments and equipments*	2,690,000	300,000		2,990,000
02	Civil engineering	1,180,000	1,340,000	130,000	2,650,000
03	Accessaries	100,000	100,000		200,000
04	Personnel	120,000	120,000	160,000	400,000
05	Materials	200,000	200,000	200,000	600,000
06	Unpredictables	20,000	20,000	20,000	60,000
	Total	4,310,000	2,080,000	510,000	6,900,000

* where some of budget for instrument is in kind.

2. UNDP inputs: US \$ 2,820,000

Table 5. The distribution of UNDP inputs

No.	Item	1'st year	2'nd year	3'rd year	total
01	Experts' service, 22 m/m	57,500	68,400	62,100	198,000
02	Study tour, 20 m/m	9,600			9,600
03	Fellowships, 57 m/m		136,800		136,800
04	Equipments and instruments	1,000,000	1,370,000		2,370,000
05	Others		19,200		19,200
	Total	1,163,500	1,594,400	62,100	2,820,000

3. The list of instruments and equipments for purchasing

Table 6. The instruments and equipments to be purchased

No.	Apparatus	Quantity	Price (\$)
01	Polyacrylonitrile wet spinning equipment	1	200,000
02	Carbonization test equipment	1	400,000
03	Dry method preimpregnating machine	1	600,000
04	Winding machine W5 (America)	1	100,000
05	Automatic press for composites,	1	350,000

(continued)

No.	Apparatus	Quantity	Price (\$)
06	Auto-laying up machine	1	200,000
07	High pressure water jet cutting machine	1	100,000
08	Infra-red thermography (AGA Thermovision 782)	1	110,000
09	Composite tester, (Shur Tronics)	1	30,000
10	Flaw scale (Canon Holosonics)	1	10,000
11	Universal test machine, MTS 809	1	170,000
12	Environment chamber for MTS	1	100,000
	Total	12	2,370,000

ENCLOSURE # 2

UNITED NATIONS DEVELOPMENT PROGRAMME

Project of the Government of The People's Republic of China

PROJECT DOCUMENT

Title: Development and application of carbon fibre and it's composites

Number: CPR/84/003

Duration: 36 months

Primary function: Development of research center

Secondary function: Personnel training

Sector: Science and Technology

Government Implementing Agency: Ministry of Chemical Industry

Estimated starting date: January, 1985

Government inputs: RMB ¥ 6,900,000 (in kind)

UNDP inputs: US \$ 1,000,000

Government share: US \$ 1,650,000

The project will be executed by the Government in cooperation with UNIDO and implemented by the Ministry of Foreign Economic Relations and Trade on behalf of the Government.

Signed _____ Date _____
on behalf of the Government

_____ Date _____
on behalf of UNDP

PART I. The Legal Context

The project document shall be the instrument referred to as such in Article 1. paragraph 1 of the Assistance Agreement between the Government of the People's Republic of China and the United Nations Development Programme, signed on 29 June, 1979. The Government Implementing Agency mentioned in this Project Document shall refer to the Government Cooperating Agency described in the Agreement.

PART II. The Project

A. Development objectives

Carbon fibre is a new type of materials with high strength and modulus, low density and good heat and corrosion resistance. In recent years, the uses of carbon fibre in the fields of structural and functional materials have been developed rapidly and it appears to play an important role in the national economy

and the people's livelihood, so that the research and development of carbon and its composites is required for realizing the science and technology modernization.

The development objectives for this project are as follows:

1. Research capabilities will be built up for developing various types of carbon fibre of high quality and developing prepregs and composites, so that research achievements on new technology and products can be performed for improving and directing pilot production.

2. A technical team to successfully develop carbon fibre and composites will be established through systematic training.

B. Immediate objectives

1. Additional laboratories will be set up for developing precursors, carbon fibres, prepregs and composites and for determining related properties.

2. Processes will be optimized for improving quality of carbon fibre (for example, overcoming brittleness, broken filaments, variations in strength and so on) and increasing the varieties of prepregs available for manufacturing composite components.

3. Technical personnel engaged in this project would be trained systematically.

C. Background and Justification

In China, carbon fibre has been under development since the 1960's. At present, carbon fibres with strength of 2.5-3.0 GPa can be produced in the laboratory. Greater emphasis has been placed on research work on composites, and articles for industrial, transport, medical and recreational uses have been made on small scale. But problems remain, concerning processing technology, product properties, quality control, and economy. Therefore, it is necessary to accept technical assistance and exchange to solve these problems.

To conduct this project, there are two Recipient departments: Beijing Institute of Chemical Technology and Beijing Institute of Aeronautical Materials; the former will carry out the work on precursor and carbon fibre and the latter on composites.

The Research Institute of Polymer Materials in Beijing Institute of Chemical Technology has developed carbon fibre using a carbonizing equipment of 5 tons. The Research Institute, which is working in cooperation with Liaoyuan special Fibre Factory for developing carbon fibre, is equipped with facilities for property measurements and has organized a technical team for carrying out research work on fibre processing and structural characterization. The Beijing Institute of Chemical Technology, a university of industrial technology, is comprised of departments of chemical engineering, Polymer science, mechanical engineering, chemical industrial automation and management engineering, etc., so there is enough capability to perform research work through internal cooperation.

The development of composites has been in progress for more than ten years in the Institute of Aeronautical Materials, where there are laboratories for fabricating composites, property determination and non-destructive testing, etc.. Research work on preparation of prepreg and autoclave moulding of composites has been carried on and standards for testing materials have been established by 50 scientists and engineers of various specialities.

It is believed that through the activities of this project, much greater progresses on the development of carbon fibre and its composites will be made.

D. Outputs

1. Development of knowledge and capability to fabricate carbon fiber and advanced composites from raw material produced in the

1. Building and remodelling of laboratories for precursor, carbon fibre, prepregs and composites, and of other offices in both, the Research Institute of polymer Materials in the Beijing Institute of Chemical Technology and the Beijing Institute of Aeronautical Materials.

2. Establishment and modification of the following equipment facilities to perform process optimization within three years after starting the project:

- 2-1. Experimental equipment for wet spinning (mainly nitric acid method);
- 2-2. Experimental equipment for carbonization and surface treatment;
- 2-3. Experimental equipment for preparing prepregs;
- 2-4. Experimental equipment for composite fabrication and machining;

3. Establishment of the following special research groups for:

- 3-1. Surface treatment of carbon fibre;
- 3-2. Property and structural characterization of carbon fibre;
- 3-3. Preparation of prepregs;
- 3-4. Fabrication of composite structural components;

4. Establishment and training of personnel for research and development work.

E. Activities

1. Invitation of foreign experts for consulting-22 m/m in total, which is detailed in Table 1.

Table 1. The plan for inviting foreign experts

Item	Mission and Speciality	Number of experts	Starting time	Duration (months)
I	II	III	IV	V
01	Consultin for the project acument	2	Before impletment of the project	0.5 (each)
02	Chief consultant	1	1 1st year 1 2nd year 1 3rd year	2 2 2
03	Precursor Chemistry	1	2st	0.5

(continued)

I	II	III	IV	V
04	Stabilization of PAN	1	1st	0.5
05	Carbonization Technology	1	1st	0.5
06	Testing General, including X-ray	1	1st	0.5
07	Testing Special (TEM, electronic)	1	2nd	0.5
08	Spinning Technology	1	1st	0.5
09	Surface Treatment	1	1st	0.5
10	Fibre-Matrix Interaction	1	2nd	0.5
11	Test Runs-Experimental Spinning	1	2nd	0.5
12	Test Runs-Fibre Line	1	2nd	0.5
13	Correlation Between Fabrication, Testing and Design	1	1st	0.5
		1	2nd	0.5
		1	3rd	0.5
14	Resin and Prepreg Technology	1	1st	0.5
15	Prepreg Technology	1	1st	0.5
16	Wet Winding	1	2nd	0.5
17	Autoclave Processes	1	1st	0.5
18	Molding Techniques	1	2nd	0.5
19	Thermoplastic Processing	1	2nd	0.5
20	Static Mechanical Testing	1	1st	0.5
21	Dynamic Mechanical Testing	1	1st	0.5
22	Special Test Techniques	1	2nd	0.5
23	Non-Destructive Testing	1	2nd	0.5
24	Composites Design	1	1st	0.5
25	Review Implementation of the Project	1	1st	2/3
			2nd	2/3
			3rd	2/3
Total			22	m/m

2. Study tour: 20 m/m altogether, the plan of which is shown in Table 2.

Table 2. The plan of study tour

Item	Purpose	Country	No. of persons	Duration (week)
01	equipments and technology for manufacturing carbon fibre	Japan, America, Brizal, Wet German	7	6
02	equipments and technology for manufacturing prepregs and composites	England, France, America, Japan, West German	7	6

3. Fellowships: 57 m/m altogether

Table 3. The plan of fellowships

Item	Purpose	No. of persons	Starting time	Duration (month)
01	Carbon fibre technology	2	the first half of the second year	3(each)
02	Preoxidization technology	1	the first half of the second year	2
03	Surface treatment of carbon fibre	1	the second half of the second year	3
04	Precursor technology	2	the second half of the second year	2(each)
05	Active carbon fibre	1	the second half of the second year	3
06	Structure and property of carbon fibre	1	the first half of the second year	3
07	Prepreg technology	2	the first half of the second year	2(each)
08	Moulding and design of composites	2	the first half of the second year	3(each)
09	Moulding and design of composites	2	the second half of the second year	3(each)
10	Property measurement	2	the first half of the second year	2(each)
11	Nondestructive testing	2	the first half of the second year	2(each)
12	Moulding of composites	1	the second half of the second year	3
13	Operating of the equipments	3		3(each)

F. Inputs

1. Government inputs: RMB ¥ 6,900,000, including:

- 1-1. Charges for purchasing instruments and equipment;
- 1-2. Charges for civil engineering;
- 1-3. Charges for purchasing accessories;
- 1-4. Charges for project personnel and training home;
- 1-5. Charges for common materials;
- 1-6. Charges for translation and traffic during experts' stay in China.

2. UNDP inputs: US \$ ^{2,650,000} 2,820,000, where Government share \$1,820,000 is included, are used for following items:

- 2-1. experts' service;
- 2-2. study tours;
- 2-3. fellowships for training;
- 2-4. procurement of equipment;
- 2-5. ~~some~~ raw materials;
- 2-6. unpredictables.

G. Work plan

1. The first year

1-1. The chief consultant will be invited to China to advise and cooperate making work plan, proposing the experts, to be invited, training places and equipment and instruments to be purchased, etc.;

1-2. Two specialized study tour groups will be sent to learn the newest state of the art in the specific field of the project to revise the project plan and equipment to be purchased, if necessary;

1-3. Laboratories for research and development will be built and remodelled by both Recipient Departments;

1-4. Instruments and equipment to be purchased will be ordered;

1-5. The activities of consulting and training will be initiated in accordance with the annual plan in the Tables 1 and 3.

1-6. Research work on carbon fibre, preregs, and composites will be started using available equipment.

1-7. Preparations will be made for special research groups on specific research such as surface treatment of carbon fibre, property and structural characterization of carbon fibre, fabrication of preregs, and moulding and machining of composites.

2. The second year

2-1. The new equipment will be installed and used in the on-going research work as it is received;

2-2. The activities of consulting and training will be continued in accordance with the annual plan;

2-3. Setting up laboratories for special research as pointed out in section 1-7 and carrying out the respective research work.

3. The third year

3-1. Processing optimization experiments will be continued to obtain products and articles of good quality;

3-2. The installation and adjustment of the equipment for fabricating precursor will be finished;

3-3. The activities of consulting will be continued in accordance with the annual plan;

3-4. The research work on special subjects (see paragraph 2-3) will be completed;

3-5. A final report of the project will be written and submitted for evaluation by UNDP.

H Institutional Framework

1. The Ministry of Foreign Economic Relations and Trade as a equivalent partner to the UNDP will be in charge of supervising implementation and coordination of the project.

2. The Government Implementing Agency is the Ministry of Chemical Industry.

3. The Recipient Departments are the Research Institute of Polymer Materials in Beijing Institute of Chemical Technology and Beijing Institute of Aeronautical Materials.

4. UNIDO as a Cooperating Agency will be in cooperation with Chinese Government in accordance with the "Service Agreement".

5. The project in practice will be implemented by both Recipient Departments:

5-1. One chief director and one deputy director are in charge of this project;

5-2. Personnel

5-2-1. The personnel in the period of the first year and the second year:

There will be fifteen engineers or scientists and fifteen technicians involved in each Recipient Department.

5-2-2. The personnel in the third year:

There will be forty five persons involved in the research of carbon fibre and fifty in composites.

5-3. The places for implementing the project:

5-3-1. Research Institute of polymer Materials Beijing Institute of Chemical Technology Beijing

5-3-2. Institute of Aeronautical Materials
Beijing

I. Future UNDP Assistance

In order to extend the base for research and development of additional types of carbon fibres and composites, future UNDP assistance will be required in areas such as:

1. Establishment of experimental equipment for developing new PAN copolymer precursor to obtain new "generation" type PAN-based carbon fibre.
2. Establishment of experimental equipment for developing active carbon fibre for absorption purposes, including a laboratory for making surface chemistry measurements.
3. Initiation of research work on pitch based carbon fibres.
4. Development of the hybrid composites.
5. Development of moulding techniques for carbon fibre reinforced thermoplastics.
6. Development of pultrusion processes for carbon fibre composites.

PART III. Review, Evaluation and Report

A. Monitoring reviews:

The project will be subjected to periodic review in accordance with the policies and procedures specified by UNDP for monitoring and review of the project implementation.

B. Evaluation

The project will be subjected to evaluation in accordance with the policies and procedures established for this purpose by UNDP. The organization, terms of reference and timing of the evaluation will be decided by consultation among the Government, UNDP and UNIDO.

C. Progress and final reports

The sixth month progress reports and the final report of the project will be prepared by the project director.

PART IV. Budget and Procurement

A. Budget

1. Government inputs: RMB ¥ 6,900,000

Table 4. The distribution of the Government inputs

No.	Item	1'st year	2'nd year	3'rd year	total
01	Instruments and equipments*	2,690,000	300,000		2,990,000
02	Civil engineering	1,180,000	1,340,000	130,000	2,650,000
03	Accessaries	100,000	100,000		200,000
04	Personnel	120,000	120,000	160,000	400,000
05	Materials	200,000	200,000	200,000	600,000
06	Unpredictables	20,000	20,000	20,000	60,000
	Total	4,310,000	2,080,000	510,000	6,900,000

* where some of budget for instrument is in kind.

2. UNDP inputs: US \$ 2,820,000

Table 5. The distribution of UNDP inputs

No.	Item	1'st year	2'nd year	3'rd year	total
01	Experts' service, 22 m/m	57,500	68,400	62,100	198,000
02	Study tour, 20 m/m	96,000			96,000
03	Fellowships, 57 m/m		136,800		136,800
04	Equipments and instruments	1,000,000	1,150,000		2,150,000
05	Materials	25,000	25,000		50,000
06	Others		19,200		19,200
	Total	1,188,500	1,399,400	62,100	2,650,000

B. The list of instruments and equipments for purchasing

Table 6. The instruments and equipments to be purchased

No.	Apparatus	Quantity	Price (\$)
01	PAN Wet Spinning equipment (Bench and experimental scales)	2	200,000
02	Stabilization, carbonization and surface treatment complete experi- mental Unit	1	400,000
03	Preimpregnating machine, by hot- melt method and film method	2	400,000
04	Winding machine	1	100,000
05	Automatic press for composites,	1	100,000

(continued)

No.	Apparatus	Quantity	Price (\$)
06	Cutting Machine for prepreg and composites (knife cutter and water jet cutter)	2	150,000
07	NDT instruments for composites (infra-red thermography and ultrasonics)	3	150,000
08	Biaxial tensile test machine	1	70,000
09	Environmental chamber for MTS	1	25,000
10	Tension-torsion test machine	1	100,000
11	Microprocessor central for axial/torsion test machine	1	80,000
12	Single fiber tensile test machine	1	30,000
13	Instrumented pendulum-type impact tester	1	25,000
14	Instrumented drop-weight impact tester	1	70,000
15	Automatic type lay-up machine	1	250,000
	Total	20	2,150,000

