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PAKISTAN'S PROCUREMENT FOR ITS NUCLEAR PROGRAMME - EXAMPLES OF MATERIALS AND EQUIPMENT

1. This document supplements the information contained in BELS/83/0524 - PAKISTAN'S PROCUREMENT NETWORK FOR ITS NUCLEAR PROGRAMME. It gives examples of the types of material and equipment which are sought by the Pakistanis for their nuclear programme through the Procurement Network. Annex A, together with copies of the Figures 1-11, forms the basis of a working document which may be passed to customs authorities.
PLUTONIUM ROUTE

2. The Pakistani's are working to complete the CHASMA reprocessing plant which was started by the French in 1976. We believe that they still lack a fuel element chopping machine and that attempts will be made to procure this through the Network.

GAS CENTRIFUGE URANIUM ENRICHMENT PLANT

3. The Network is still regularly being tasked by the Khan Research Laboratories (KRL) to obtain equipment and components for the gas centrifuge plant at Kahuta. The sketch of a simplified gas centrifuge in Fig 1 shows the relationship of the main components which are discussed below.

4. Rotating Components. Fig 2 shows an exploded view of the rotating components of the centrifuge, and Figs 3-7 show individual components and the materials from which they are made. The materials used for rotor construction are:

- a. Aluminium Alloy. AISI 7075 and equivalents in seamless tubing and other forms have been sought through the Network.
- b. Maraging Steel. This is a steel alloy of very high tensile strength which is particularly suitable for gas centrifuge rotating components, ie rotors, bellows, baffles and end caps. Attempts have been made to obtain maraging steel from European and Japanese sources sometimes using the Network's intermediary ASSAMA Electrical and Engineering Establishment in Sharjah UAE. Bulk orders, up to 60 tonnes, have been for rough machined tubing (known as 'starting stock' or 'preforms') of various sizes suitable for centrifuge rotors and bellows eg OD 110 mm/ID 100 mm approx, OD 160 mm/ID 140 mm approx. Grades specified have varied, eg 350 grade, 300 grade, but we consider it important to prevent the export of all grades of maraging steel in either finished component or starting stock form unless the order is supported by a bona-fide end user certificate.

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5. Forgings for Gas Centrifuges. In addition to rotating components the Network has attempted to obtain other forgings in stainless steel (eg AISI 316) and aluminium alloy (eg AISI 7075-T6) in final and semi-finished forms quoting various disguised end uses. Dimensions, specifications and the large quantities demanded have revealed their true function as components for gas centrifuges. A typical example of a stainless steel forging is shown in Fig 8, the export of which was successfully frustrated in 2 countries.

6. Other Centrifuge Components. Drawings have also been passed by the Network to European engineering companies either with a view to having components made or as examples of workpieces to be produced on machine tools which the Pakistanis intended to order for indigenous production of centrifuge components. Examples are:

- Top Baffle
- Bottom Damper Housing
- Top End Cap
- Bottom End Cap
- Magnet Covers
- Bearing Support Springs
- Waste and Product Scoop Tubes

Enquiries have also been made for ring magnets (OD 53 mm, thickness 8 mm) and bottom bearing balls and spindles.

7. Static Frequency Inverters. Some inverters (ie frequency changers), suitable for controlling the speed of gas centrifuges, were obtained from a UK manufacturer in the 1970's through the Special Works Organisation (SWO) at Rawalpindi. Subsequently export controls were placed on inverters 'capable of multi-phase electrical output of between 600-2000 Hz and parts, components and sub-assemblies thereof.' Arising from this KRL began indigenous production of inverters, but to achieve this, and to maintain them in operation, there is continuing demand through the Network for a wide range of electronic components some of which, such as certain types of thyristors, are subject to UK export controls.

NUCLEAR EXPLOSIVE DEVICE DEVELOPMENT AND PRODUCTION

8. In late 1981 incontrovertible evidence became available that KRL was engaged in the development and production of nuclear explosive devices of the implosion type. Orders for some of their major components were placed, through KRL's procurement agents, on several European companies who were asked to provide them in finished form to close dimensional tolerances or as semi-finished forgings and castings.

9. The major components of implosion type devices are characterised by their spherical shape, the metallic items and the conventional explosive charge being in the form of concentric hollow shells. An example is shown in Figure 9, whilst Fig 10 shows the approximate form of a plate, a number of which are located around the outer face of the explosive charge.

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10. Metal Hemispheres and Dished Plates. The shells and plates have been requested in both aluminium alloy and steel with radii and thickness varying respectively from around 200 mm - 1000 mm and a few millimetres to several tens of millimetres. Material specifications and tolerances have also varied widely. Some have been requested as rough forgings and others in completed form to high levels of machining accuracy and surface finish. The dished plates, shown in Fig 10, were requested as aluminium forgings for subsequent machining to contours specified in coordinate tables.
11. Conventional Ordnance. Attempts have also been made to obtain high quality detonators and a power supply system for firing them. We believe that further components of conventional ordnance and associated control equipment could well be sought by the Network for nuclear implosion devices.
12. High Speed Cameras and Flash X-Ray Equipment. High speed cameras, flash x-ray equipment (15-20 MeV source, 4000 rads per pulse at 1 metre) and other diagnostic equipment for monitoring very fast transient events have also been sought by several Pakistani authorities connected with nuclear device development.
13. Neutron Generators. There have been recent attempts through the Network to obtain neutron generators from European sources. An example of a neutron generator is shown in Fig 11. Neutron generator tubes are sought by the New Labs group working on the implosion device. Although it is likely that they only require the tubes, they are prepared to purchase whole systems, including electronic control and head units, in order to acquire them. The UK controls export of "Neutron-generator systems, including tubes, designed for operation without an external vacuum system and utilising electrostatic acceleration to induce a tritium-deuterium nuclear reaction," and we urge you to be on the lookout for attempts by the Pakistan Procurement Network to obtain these devices.

MACHINE TOOLS AND EQUIPMENT

14. Frustration by supplier countries of components required for the unsafeguarded elements of Pakistan's nuclear programme had led increasingly to the purchase of the necessary machine tools and other manufacturing equipment for their indigenous production. Most of the tools and equipment are multi-purpose and, despite their known end use, are not generally subject to export control. Exceptions, however, in the UK and certain other countries who have agreed to control them, are tools and equipments or parts of them, including certain jigs and fixtures, which are designed specifically for the manufacture of the above mentioned components. These items cover a very wide range and are difficult to identify since they include, eg, at one end of the scale, fixtures such as specially designed expanding mandrels for holding centrifuge rotor tubes during the machining processes, and at the other complete flow-forming machines having drive motors exceeding 80 horsepower.

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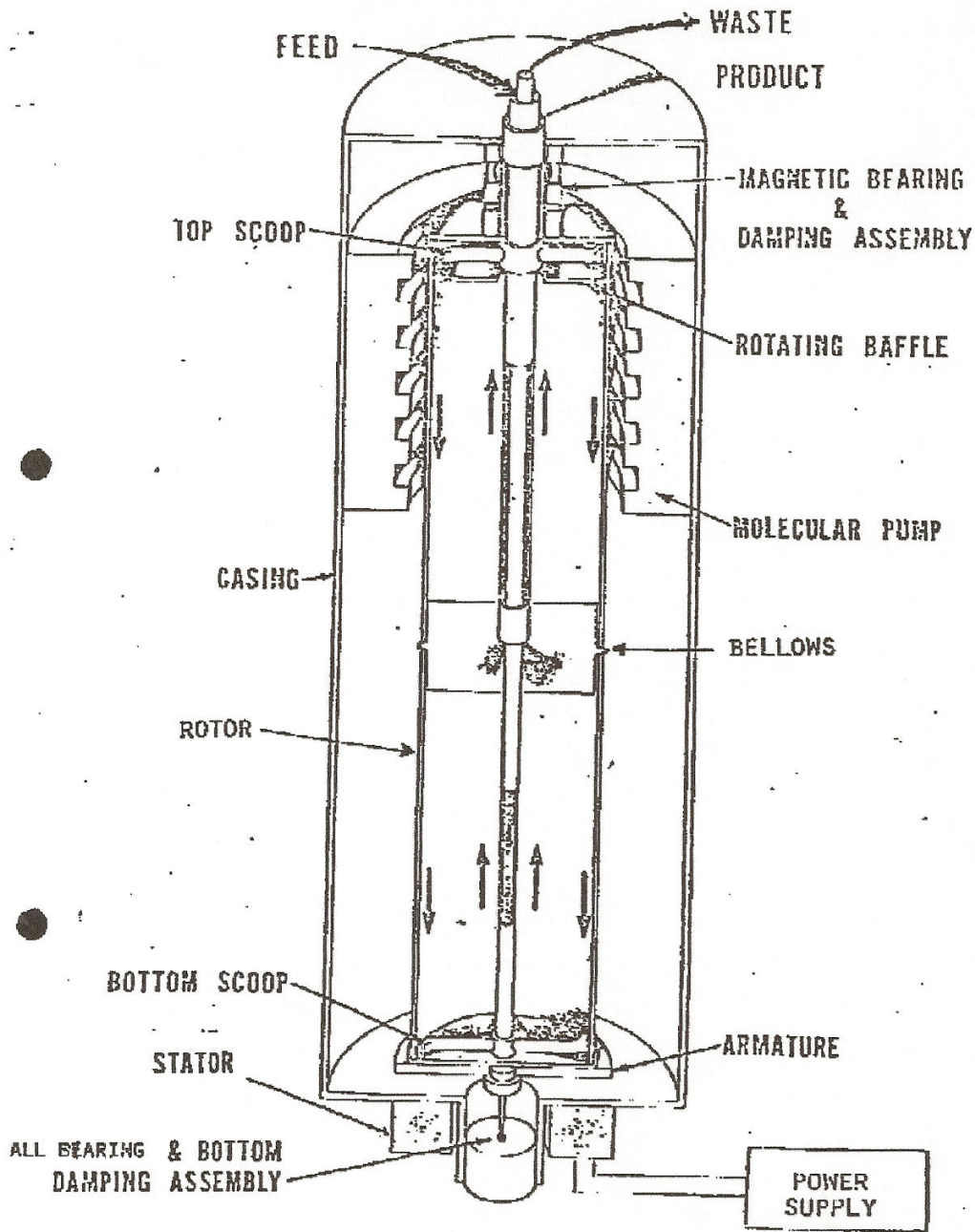
15. You will appreciate from the foregoing that industrial and commercial companies could well become the target of the Pakistani authorities for provision of materials in bulk or semi-manufactured form, for equipment or components required for their nuclear weapons projects. Approaches are likely to be made through the world wide procurement network quoting disguised end uses and destination addresses. Types of company, irrespective of size, most subject to approach would be:

- a. Manufacturers and suppliers of special non-ferrous alloys and steels in stock forms or as purpose-made forgings;
- b. Precision engineers providing high specification machined parts to order;
- c. Manufacturers and suppliers of conventional explosives and associated devices;
- d. Manufacturers and suppliers of electronic control and nucleonic equipment;
- e. Manufacturers and suppliers of precision machine tools and accessories including computer numerical control (CNC);
- f. Manufacturers and suppliers of high speed photography and x-ray equipment.

16. It is of course recognised that many of the materials and equipments which the Pakistani authorities seek are difficult to identify especially by unsuspecting suppliers who frequently do not know - because they have not been told or have been given a false description - the true end use. Experience has revealed however that attempts to evade controls can be frustrated if the potential suppliers are made aware that they may become targets of deception. Considerable success has been achieved by:

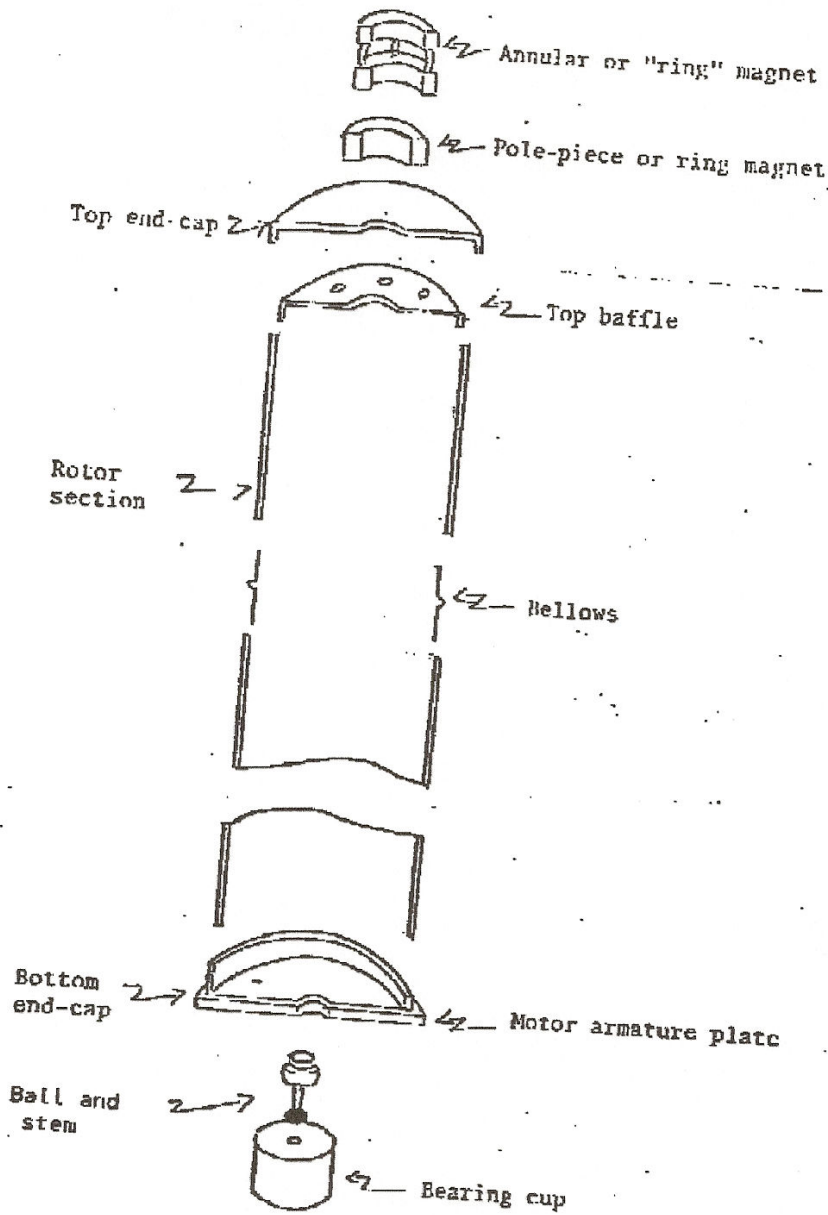
- a. Forewarning companies of the likelihood of approach by Pakistani authorities or by agencies of their Network, and seeking their cooperation in keeping the relevant authorities informed;
- b. Cross-referencing by Customs Authorities of all materials and equipments which could have a nuclear end use to addresses of customers and intermediaries used by the Network;

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FIG 1 - SIMPLIFIED GAS CENTRIFUGE



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FIG 2 - ROTATING COMPONENTS OF A GAS CENTRIFUGE

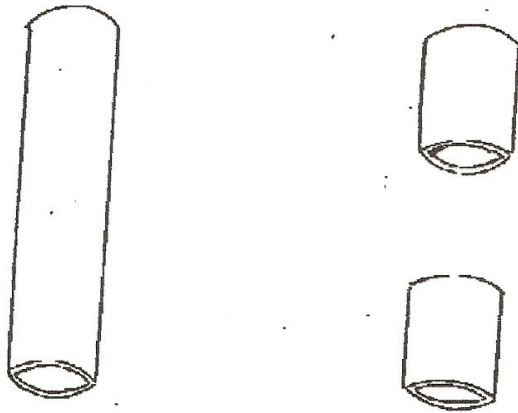


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Fig 3

GAS CENTRIFUGE ROTATING COMPONENTS:
Rotor Tubes/Rotor Tube Sections



- Thin cylinders manufactured from high strength to density ratio materials:
 - Maraging steel (Grade 300 or over)
 - High strength aluminum alloys (AA 7076, HD-89, etc.)
- Typical dimensions (finished or semi-finished forms):
 - Wall thickness - 1/4 inch or less
 - Diameter - 3 inches - 16 inches
 - Length/diameter ratio: 4 or more

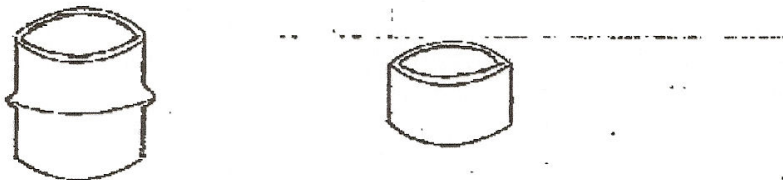
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Fig 4

GAS CENTRIFUGE COMPONENT:

- Rings or Bellows



- Components specially designed or prepared to give localized support to the rotor tube or to join together a number of rotor tubes and manufactured from one of the high strength to density ratio materials:

Maraging steel (Grade 300 or over)

High strength aluminum alloys (AA-7076, HD-89)

- Typical dimensions (finished forms):

Wall thickness - 3 mm or less

Diameter - 3 in. to 16 in.

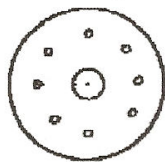
Length/diameter ratio - c.a. 1/3

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Fig 5

GAS CENTRIFUGE ROTATING COMPONENT:
Baffle



Top View



Sectional View

- Components specially designed or prepared to isolate the take-off chamber from the main separation chamber and, in some cases, to create the UF_6 gas circulation within the rotor tube: manufactured from one of the high strength to density ratio materials:

Maraging steel (Grade 300 or over)

High strength aluminum alloys (AA-7076, HD-89)

- Typical forms:

Disk shaped components

Diameter: 3 in. to 16 in.

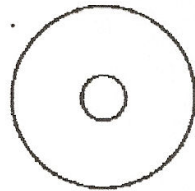
Peripheral lip: 1/2 to 2 in.

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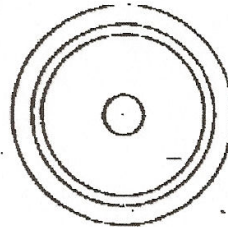
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Fig 6

GAS CENTRIFUGE ROTATING COMPONENTS:
TOP AND BOTTOM END-CAPS



Top Cap



Bottom Cap

- Components specially designed or prepared to contain UF_6 within the rotor tube, and in some cases to support an element of the upper bearing (top cap) or to carry the rotating element of the motor and part of the lower bearing (bottom cap); normally manufactured from high strength to density ratio materials:

Maraging steel (Grade 300 or over)

High strength aluminum alloys (AA 7076, HD-89, etc.)

- Typical forms:

Disk shaped components

Diameter 3 in. to 16 in.

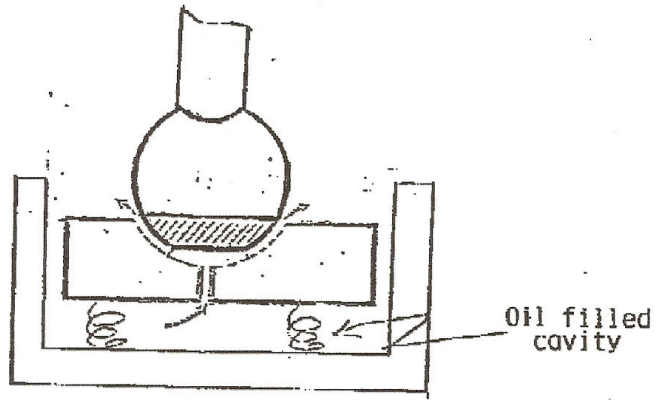
Peripheral lip: 1/2 in. to 2 in.

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Fig 7

GAS CENTRIFUGE COMPONENTS:
BEARING/DAMPER



Bearing/Damper:

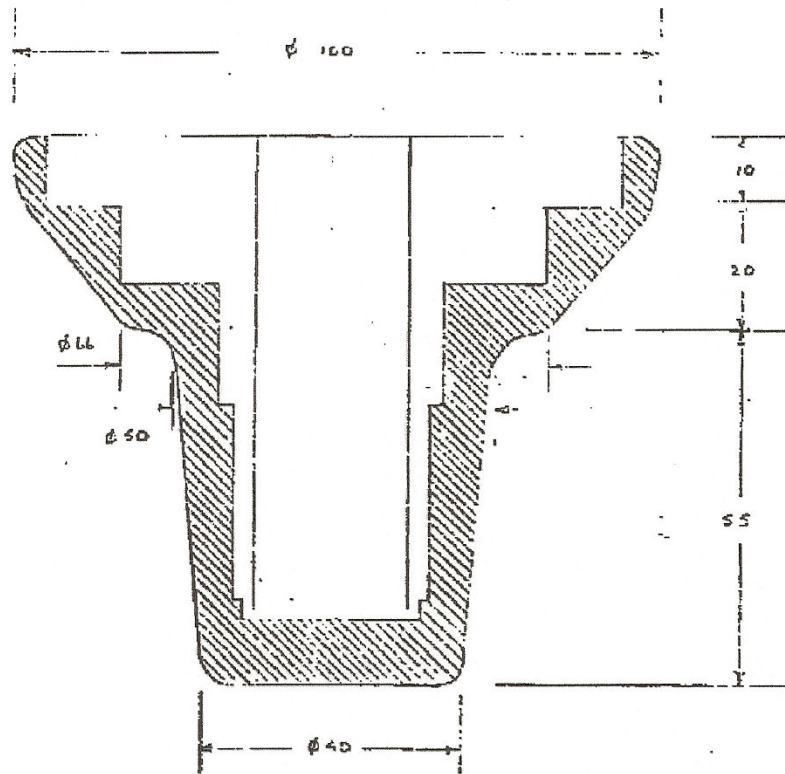
Specially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper using oil as the damping medium.

Typical Bearing Dimensions:

Ball diameter: 1/4 in. to 3/8 in.

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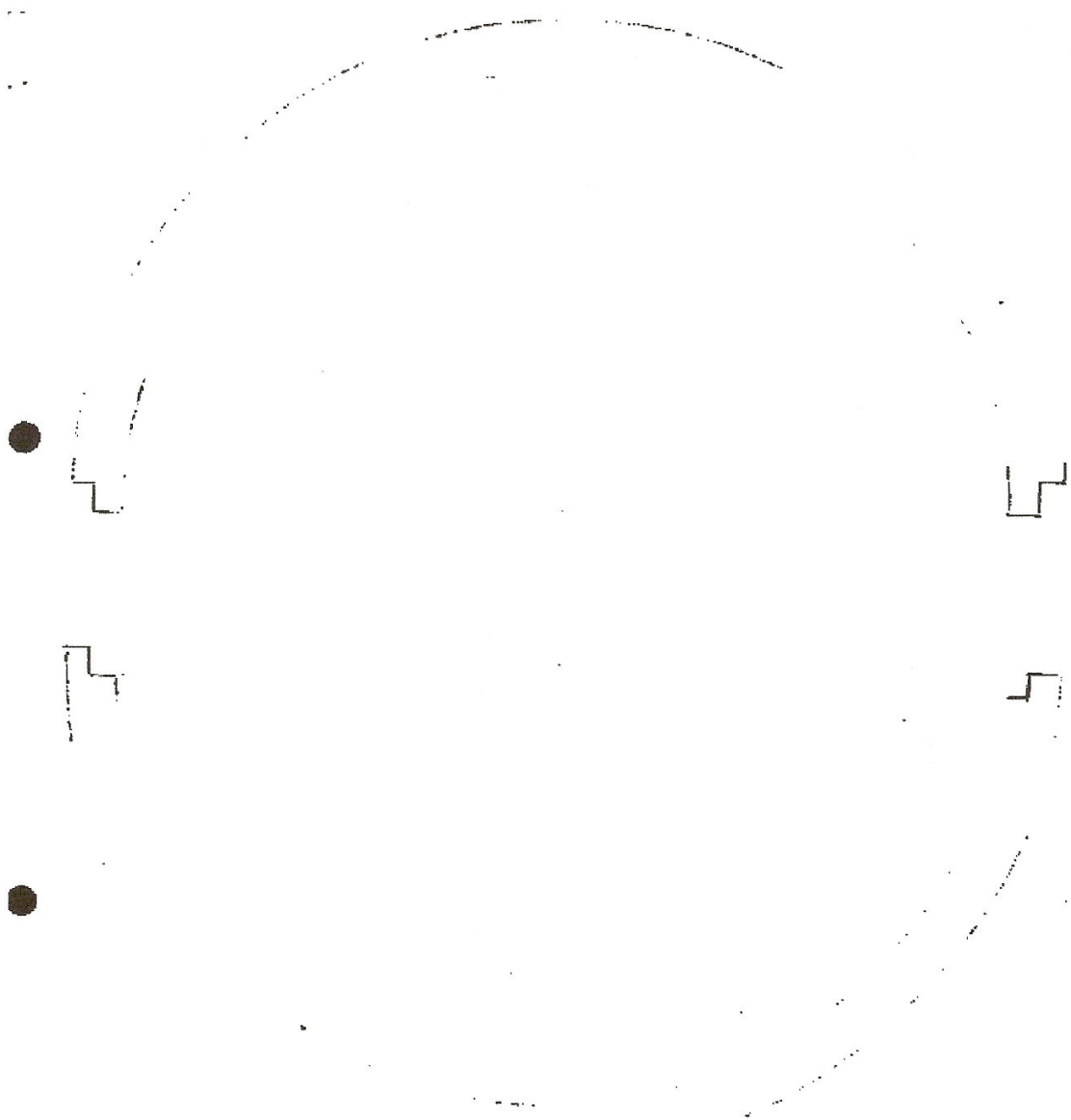
MATERIAL TO BE REMOVED
TO LEAVE FEED OPERATING BUSH

STAINLESS STEEL "PLUG" WITH BUSH SUPERIMPOSED

Fig 8

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EXAMPLE OF SPHERICAL SHELL

Outside dia. approx 425 mm

Inside dia. approx 400 mm

Material steel

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Fig 9

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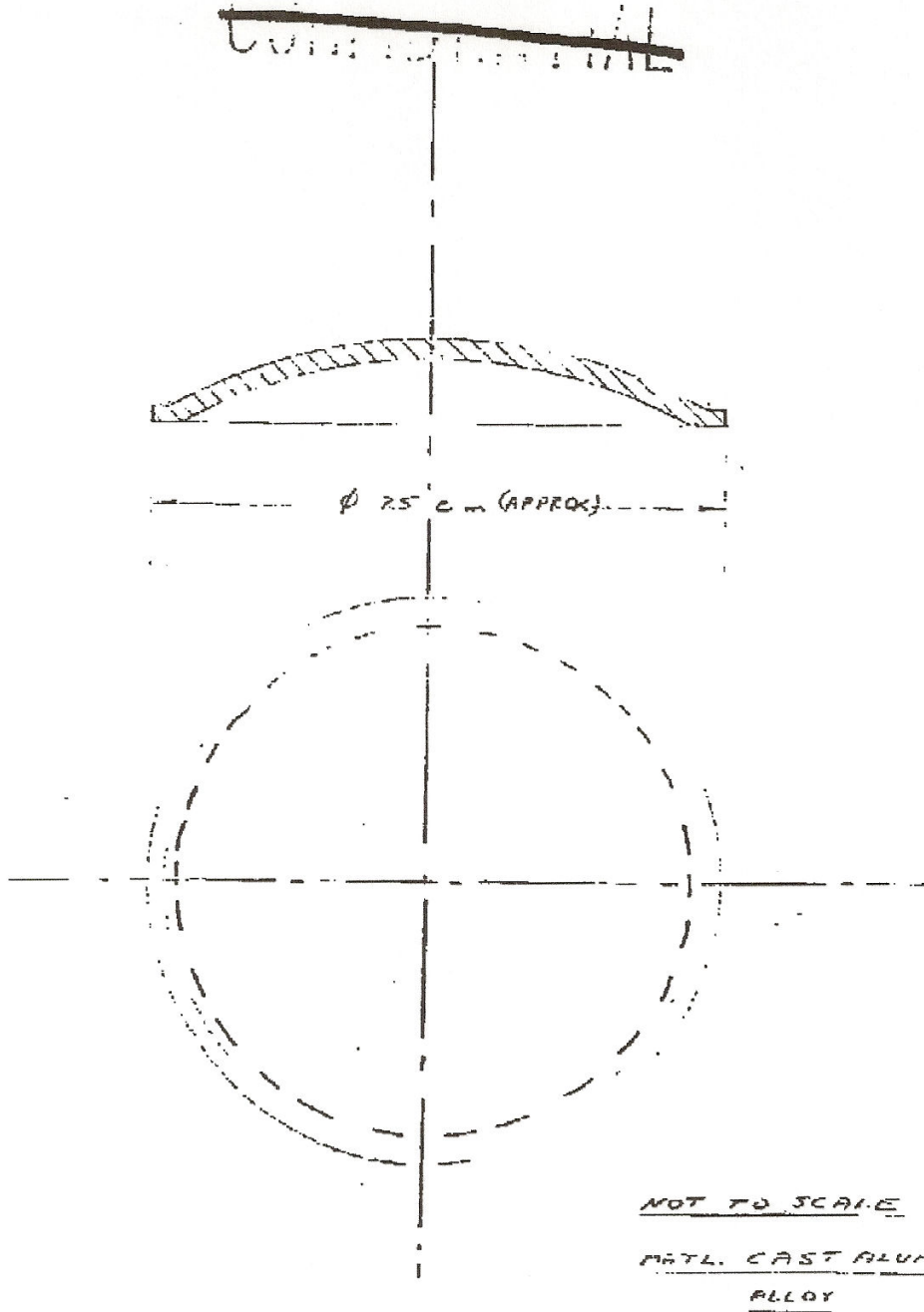
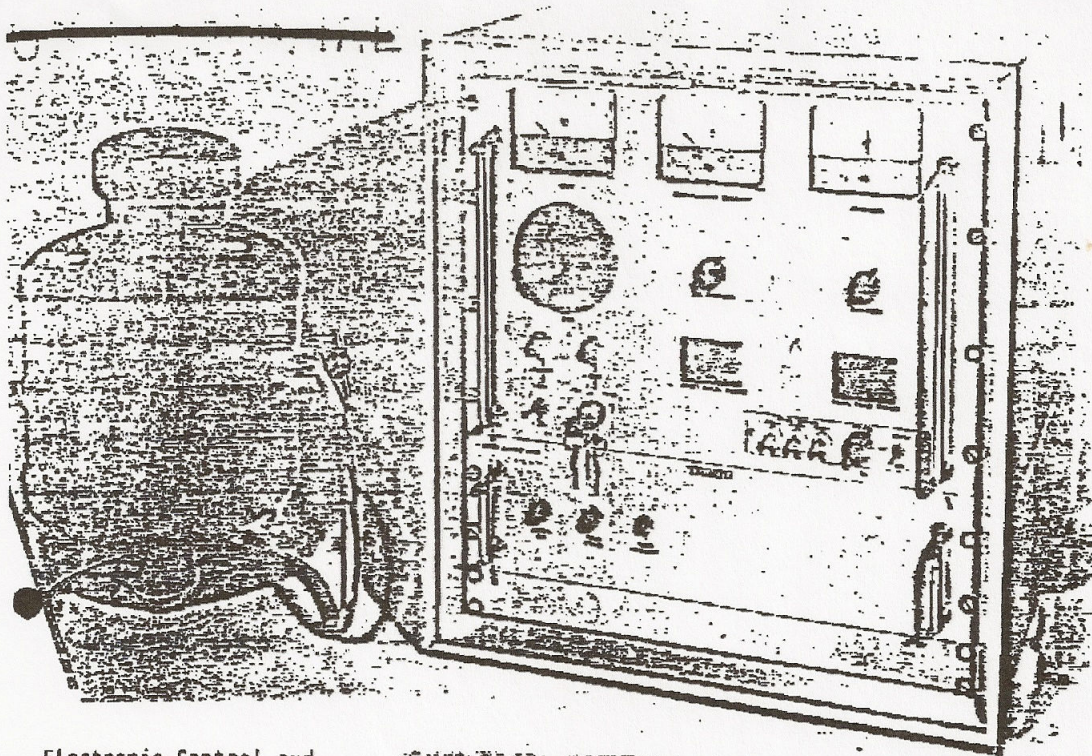
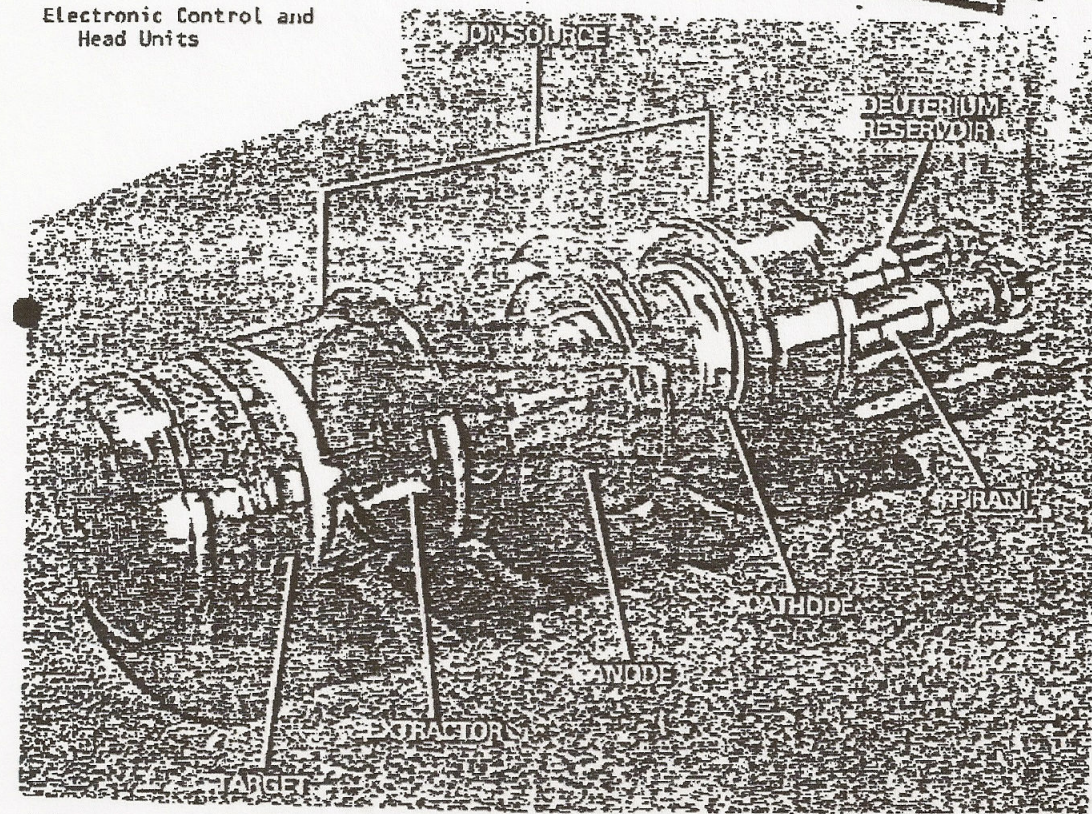


Fig 10 - ALUMINIUM DISHED PLATE

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Electronic Control and Head Units



Tube

~~CONFIDENTIAL~~ Fig 11 - TYPICAL NEUTRON GENERATOR

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PAKISTAN'S PROCUREMENT FOR ITS NUCLEAR PROGRAMME

ANNEX A - SUGGESTED EXTRACT FOR USE BY CUSTOMS AUTHORITIES

Network
Fair
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CASE
* EXPORT
BUT
STILL
POTENTIAL
PROGRAM.

1. It is known that Pakistan is actively engaged in the construction of gas centrifuge plants required for the production of nuclear weapons grade highly enriched uranium and in the development and construction of nuclear explosive devices. To facilitate this, Pakistan have at their disposal an effective and widespread network for the procurement overseas of equipment, components, materials and services required for these programmes. Not surprisingly, the end uses, and destinations, of goods acquired through this Procurement Network are usually disguised.

2. In the interests of nuclear weapons non-proliferation it is important they we act to frustrate the export of such materials, destined for Pakistan, through our outlets.

3. There follows:

- a. A list of supply addresses known to be used by Pakistan for its nuclear programme;
- b. An illustrated list of examples of materials and equipment which Pakistan has sought from overseas for its nuclear programme.

ADDRESSEES

Special Works Organisation (SWO)
169 Kitson Road
Westridge
Rawalpindi

Civil Works Organisation (CWO)
PO Box 368
Rawalpindi

The Directorate of Training
PO Box 1345
House No 18
Park Road
F8/2
Islamabad

The Directorate of Industrial Automation
(also Institute of Industrial Automation)
PO Box 1384 and PO Box 502
House No 12
Street 30
F8/1
Islamabad

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The Directorate of Technical Equipment
PO Box 1153 and 1331
House No 2
Street 32
F8/1
Islamabad

Quaid-I-Azam University
PO Box 502
Islamabad

Ahmed International Equipment Co Ltd
Fort View
Preedy Street
Karachi

Asian Chemical Industries
K-123
SITE
Mauripur Road
Karachi

Astro International

Azam Trading Corporation
26 Bihar MHS
Karachi

Bestfriend
Lahore

Bibojee Services Ltd
3rd Floor
Nelsons Chambers
11 Chundrigar Road
Karachi

Chemech Engineering Ltd
Islamabad

Combi International
House 8
Street 33
F7/1
Islamabad

Electro-Nuclear Corporation
1st Floor
16 Kazi Chambers
Bahadurahab Zafar Road
Karachi

Fab-erector
Rawalpindi

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Farooq Enterprises
135-23 Kashmir Road
Kurzshid Place
Rawalpindi

Farooq Silk Mills
311 and 314 Mohammadi House
Chundrigar Road
Karachi

Arshad, Amjad and Abid Ltd
Arshad International
A F Industries

PO Box 502
Rawalpindi

S-34 SITE
Mauripur Road
Karachi

Haji Ahmad Bros
1/35 Al-Yusuf Chambers
Shahrah Liaquat
Karachi

Ahmad JAFFAR & Co Ltd
38 Harley Street
Rawalpindi

K N Chemicals
PO Box 1286
Islamabad

Manstock Engineering Co
100 Farid Chambers
Abdulla Haroon Road
Karachi

N A Enterprises Trading Co
Karachi

National Engineering Services (NESPAK)
State Life Building
1 The Mall
Rawalpindi

Northern Traders Ltd
26 Napier Road
Karachi

Pakistan Chemical Company
House 24
Street 27
FB/1
Islamabad

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Pakland Corporation
Mohbooh Chambers
Abdullah Haroon Road
Karachi



Pervaiz Commercial Trading Co Ltd
Lahore

Punjab Fertiliser Company
PO Box 716
Rawalpindi

S J Enterprises Ltd
15 Block 14
Super Market
F6/3
Islamabad

S J Enterprises Ltd
37-B School Road
F8/3
Islamabad

S J Enterprises Ltd
124 Cotton Exchange Building
Chundrigar Road
Karachi

S J Enterprises Ltd
10 Wahbat Road
Lahore

Salateen Syndicate Ltd
Eastern Bank Building
Chundrigar Road
Karachi

Salcem and Sons Ltd
Pak Chambers
7 West Wharf Road
Karachi

Saleem and Sons Ltd
2 Bazar Road
G6/4
Islamabad

Saleem and Sons Ltd
15-c/1 Gulberg III
Lahore

Samina Ltd
Karachi

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Sayyadain Ltd
Karachi

Shah Nawaz Ltd

Sibtain Bros
43-48 Ghafur Chambers
Victoria Road
Karachi

Technical Fabricators

M Wasiullah & Co
731 Mohammadi House
Chundriqar Road
Karachi

Zclin Ltd
M A Jinnah Road
Karachi

Bin Belalilah Enterprises
PO Box 11213
Dubai

Khalid Jassim General Trading Establishment
PO Box 10591
Deira
Dubai

Boodai Trading Company
Khalif Al Arabi Street
PO Box 1287
Safat
Kuwait

Ansaha Electric Establishment
PO Box 6956
Sharjah
UAE

MATERIALS AND EQUIPMENT

PLUTONIUM PRODUCTION

Fuel element chopping machine

HIGH ENRICHED URANIUM PRODUCTION

a. Gas Centrifuge Components Figs 1-7

Rotors
Bellows
Top and bottom end caps
Baffles

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Bottom damper housing
Bottom bearing needles and balls
Bearing support springs
ring magnets
Magnet covers
Waste and production scoop tubes

b. Materials for Gas Centrifuge Production

Aluminium alloy (AISI 7075 and equivalents)
Maraging steel (all grades)

Usually sought in form of 'starting stock' or 'preform'. Typically rough machined tubing suitable for rotors and bellows. Sizes to watch for OD 110 mm/ID 100 mm approx, OD 160 mm/ID 140 mm approx,

Forgings in stainless steel (AISI 316 or 304)
aluminium alloy (AISI 7075)

Watch for shapes and sizes which could be semi-manufactured for centrifuge components - frequently (but not necessarily) sought in large numbers - hundreds, thousands.

c. Equipment for Gas Centrifuge Production

Tools and equipments, or accessories, designed specifically for the manufacture of centrifuge components, eg:

Expanding mandrels for holding centrifuge rotors during machining process

Flow forming machines having drive motors exceeding 80 horsepower (59 kw)

d. Equipment and Components for Centrifuge Plant Control

Frequency changers (inverters) capable of multi-phase electrical output of between 600-2000 Hz and parts, components and sub-assemblies thereof.

NUCLEAR EXPLOSIVE DEVICE DEVELOPMENT AND PRODUCTION

a. Metal Hemispheres and Dished Plates Figs 9-10

Hemispherical shells
Dished plates which, in quantity, can be fabricated into hollow spherical form.

Materials may be aluminium alloy or steel.
Radii vary and examples have been between 200-1000 mm.
Thicknesses have varied between a few millimetres and tens of millimetres.

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b. Conventional Ordnance

Detonators

Detonator circuit power supplies and control equipment

c. Neutron Generators Fig 11

Neutron generator systems

Neutron generator tubes

d. Diagnostic Equipment

High Speed cameras

Flash x-ray equipment (output voltage greater than 500 kv)

ACTION TO BE TAKEN

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