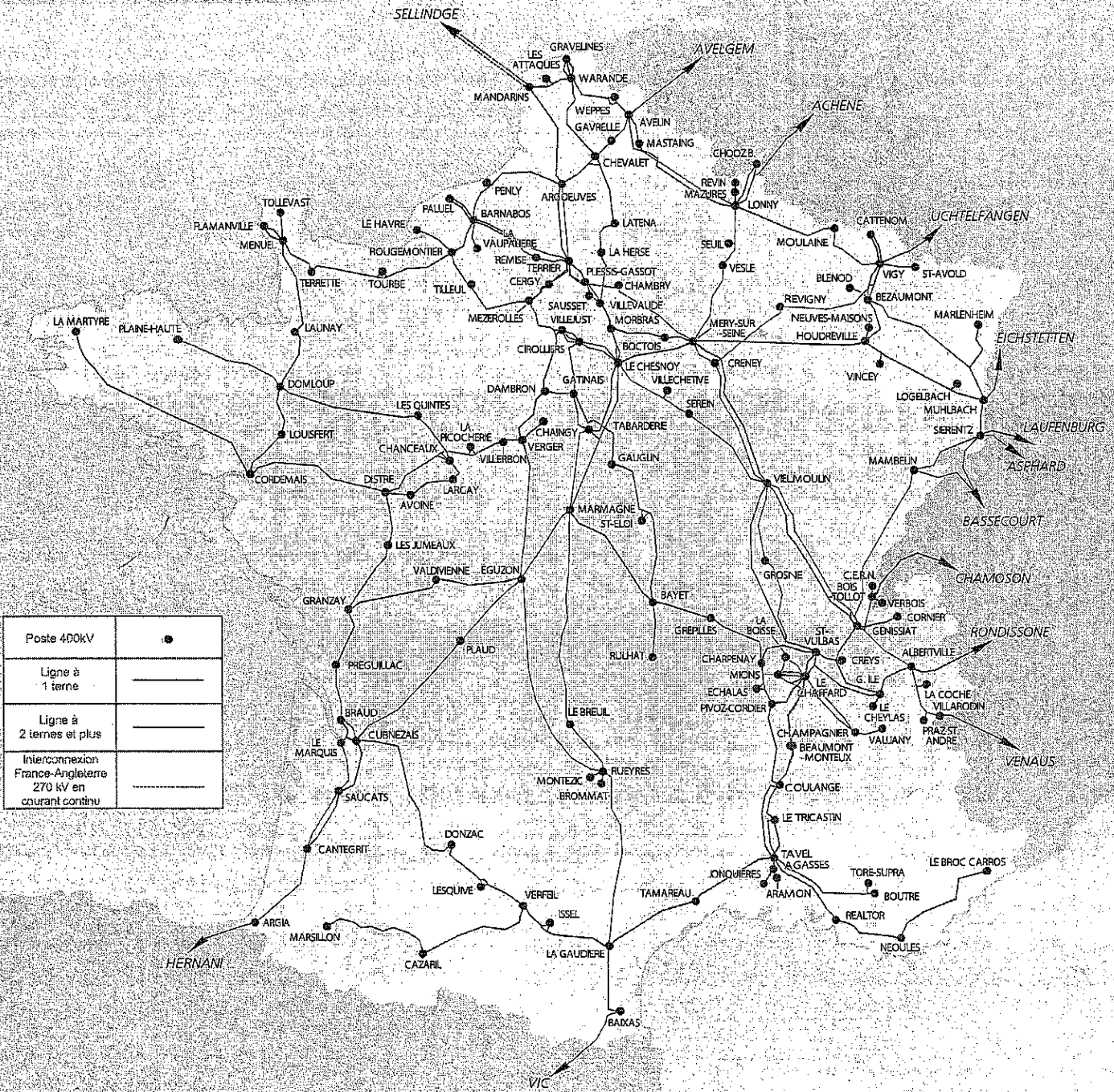




Le Réseau de Transport 400 kV



Poste 400kV	●
Ligne à 1 terre	—
Ligne à 2 terres et plus	—
Interconnexion France-Angleterre 270 kV en courant continu	—



Conception et réalisation :
GESTIONNAIRE DU RÉSEAU DE TRANSPORT
CENTRE NATIONAL D'EXPERTISE RÉSEAUX
SEMIA/DIG
 IMMEUBLE AMPÈRE - LA DÉFENSE 8
 84-40, RUE HENRI-REGNAULT
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 E-mail : rts-cner-semia-accueil@rts-france.com
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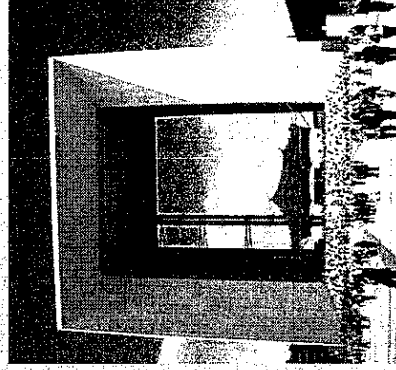
Gestionnaire
du Réseau de Transport d'Electricité

Taipower Visiting

Cables in Tunnels in Urban Areas



台灣電力公司

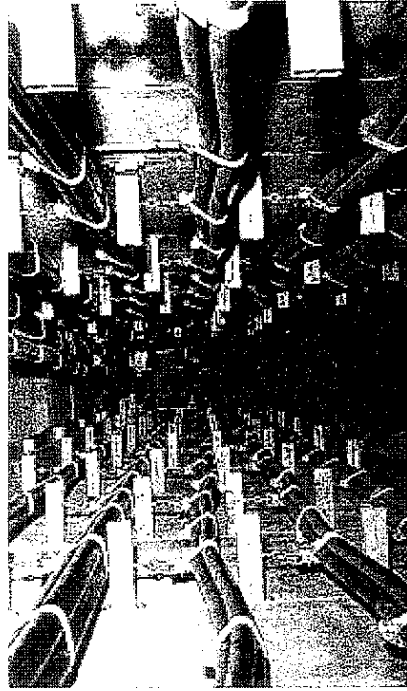


November 19th, 2007

B

Contents

- **RTE Grid: a few statistics**
- **Cables currently installed in France**
- **Transmission network overview: cable installation methods used in France**
 - Ducts in concrete
 - Troughs
 - Weak mortar
 - PEHD ducts
 - Trenchless techniques
- **Cables in tunnels**
 - Installation practices





The French transmission grid

→ RTE: the French Transmission System Operator

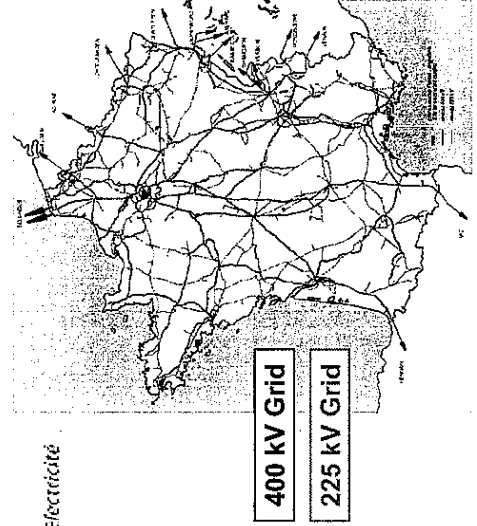
- Four main voltage levels: 400, 225, 90 and 63 kV
- Lines in service (km of circuits, statistics of late 2006)

Voltage level (kV)	400	225	150	90	63	Total
Overhead Lines (km)	21012	25490	1061	15048	33807	96418
Underground Lines (km)	3	902	2	406	1945	3258
Total	21015	26392	1063	15454	35752	99676

Reference: RTE 2006 Annual review report



Gestionnaire
du Réseau de Transport d'Électricité

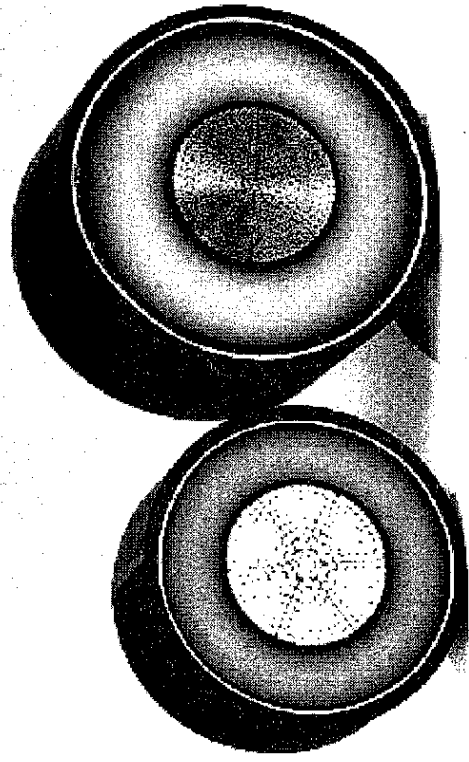




Cables currently installed in France

→ Extruded cables

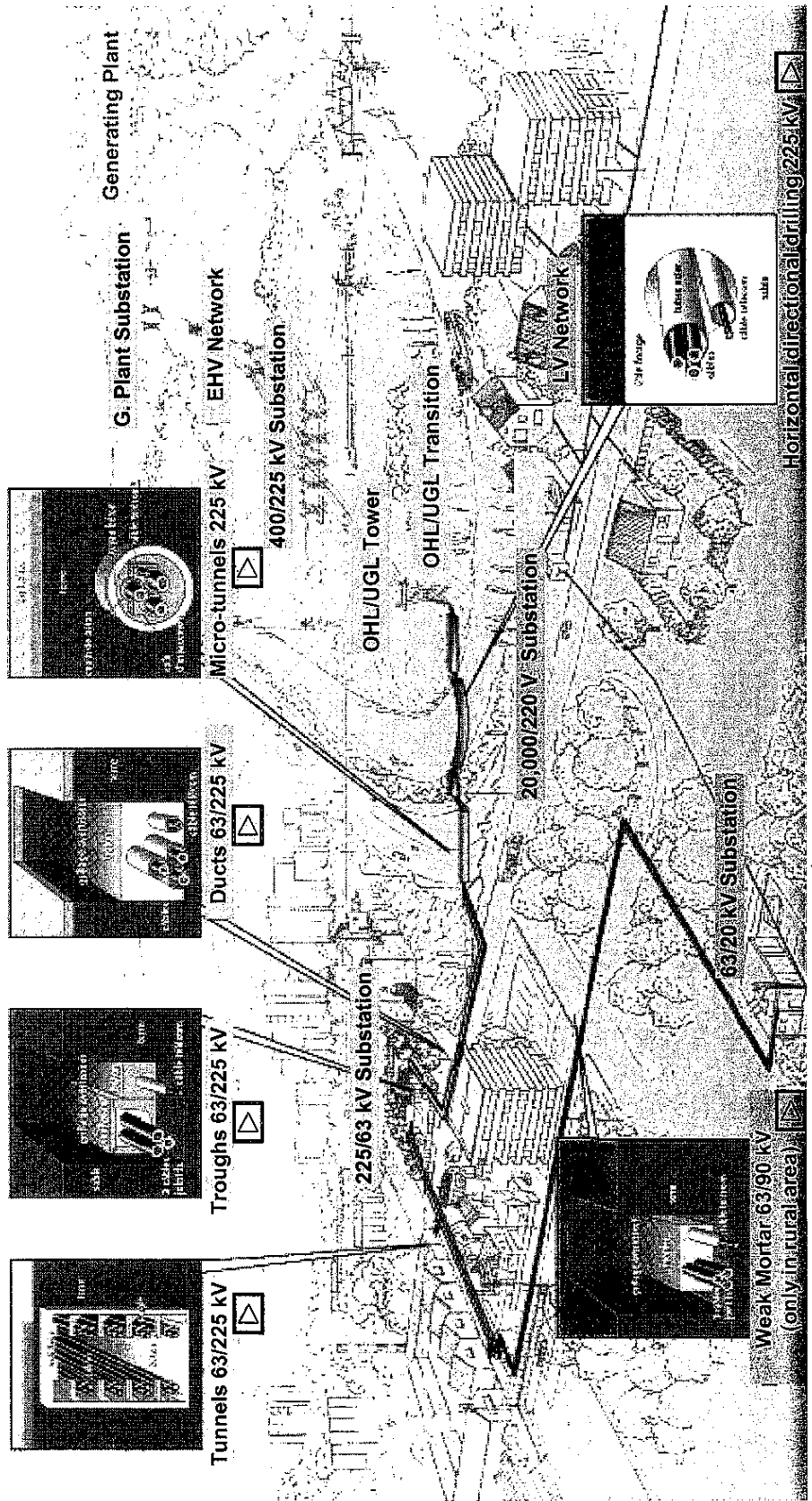
- Aluminium conductors, copper for high current ratings
- XLPE insulation
- Aluminium laminated screens
 - Watertight design
- PEHD oversheath bonded to the metallic screen





Network overview

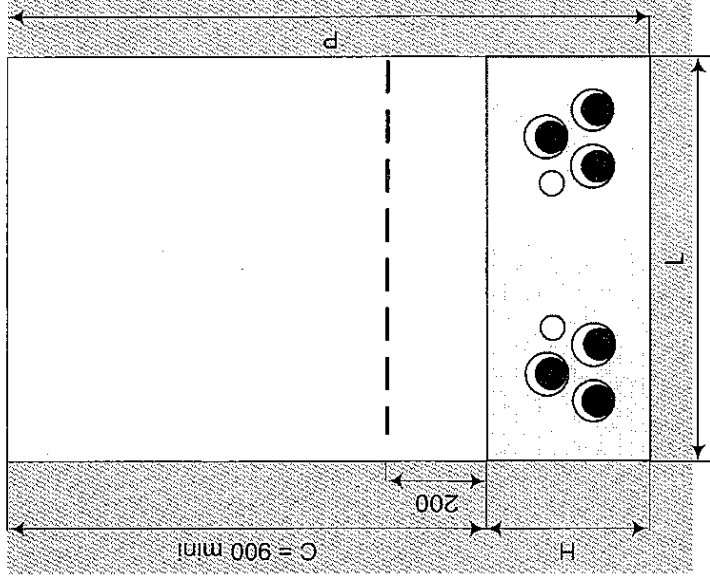
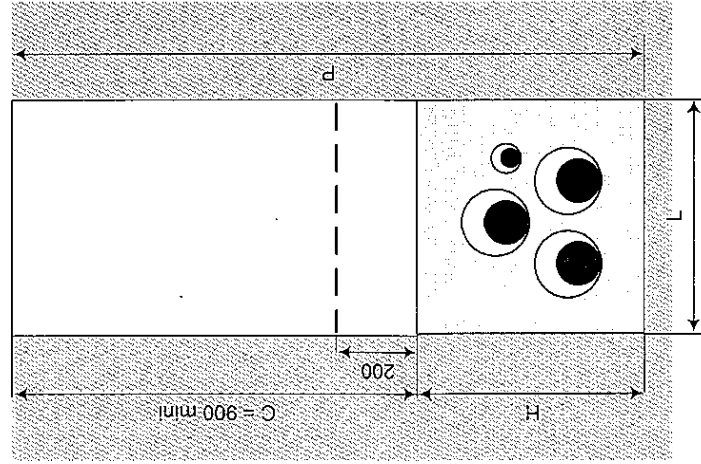
→ Laying methods used for insulated cables



Ducts in concrete

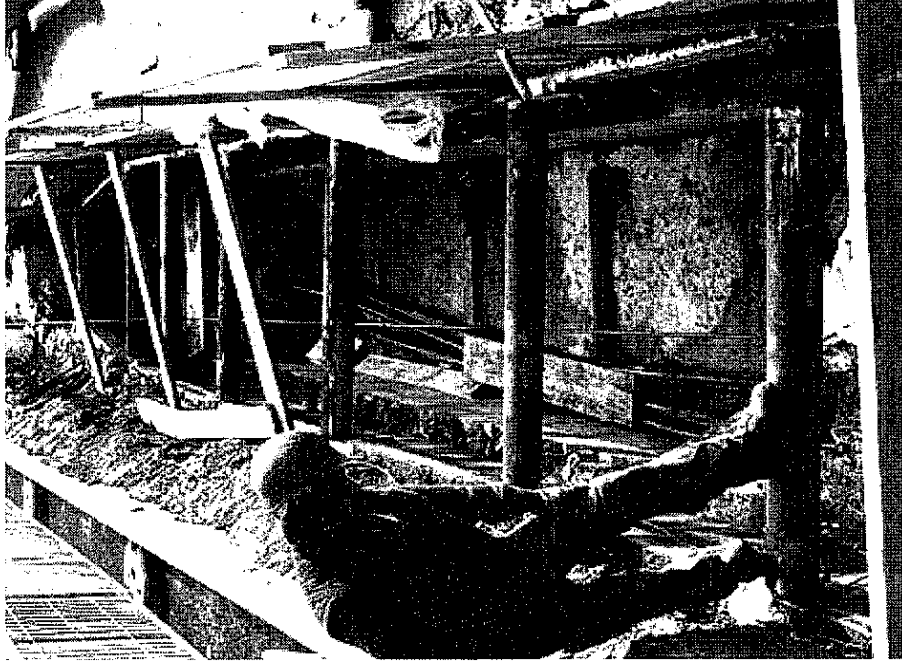
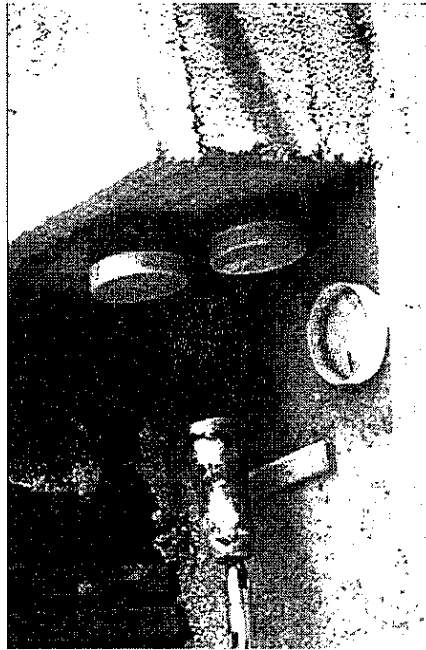
→ PVC ducts in concrete: current trend

- Trench with spacers
- Filled with concrete



Ducts in concrete (2)

→ Pulling cables

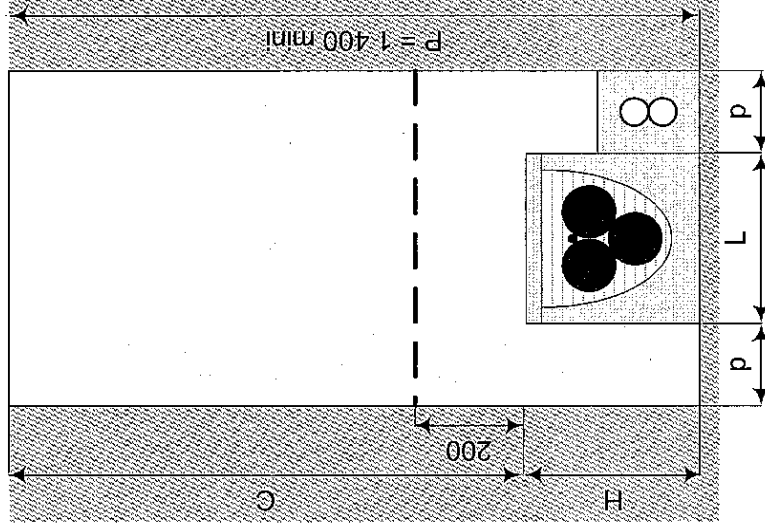
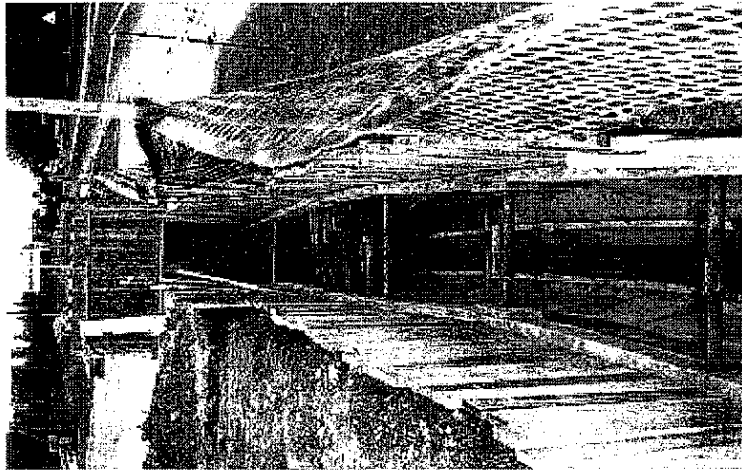


[Back to Network Overview](#)

Troughs

→ Prefabricated troughs in concrete filled with sand

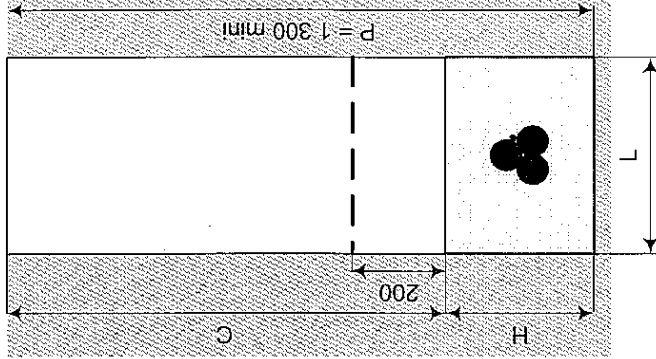
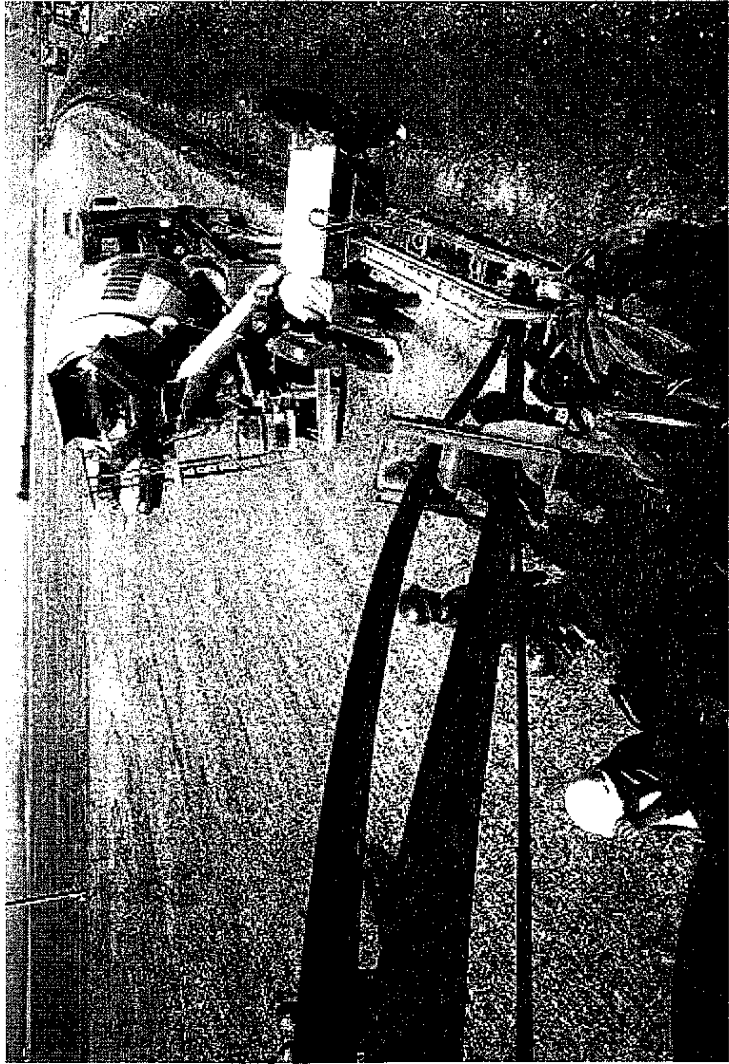
- Existing circuits but not used anymore





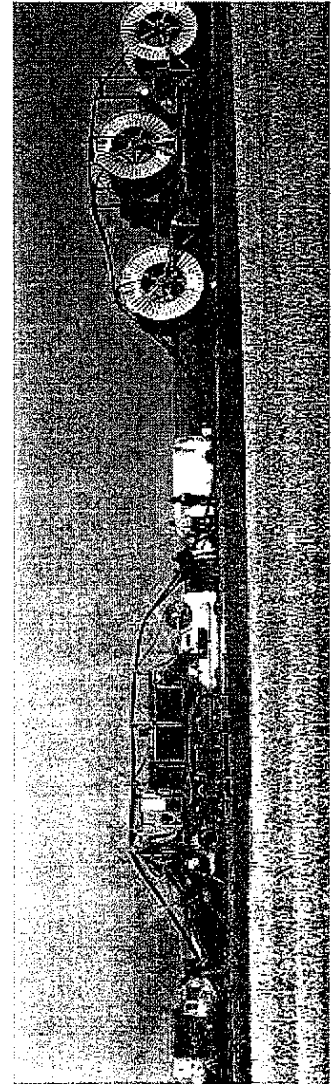
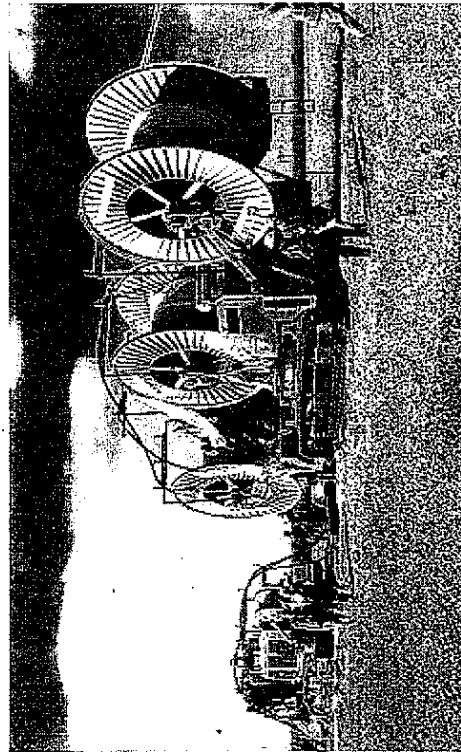
Weak mortar

- Weak mix concrete
- Only in rural area



Weak mortar (2)

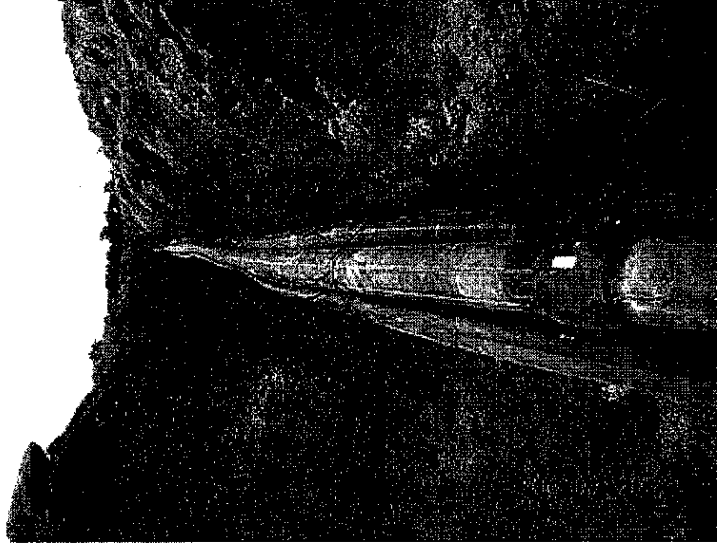
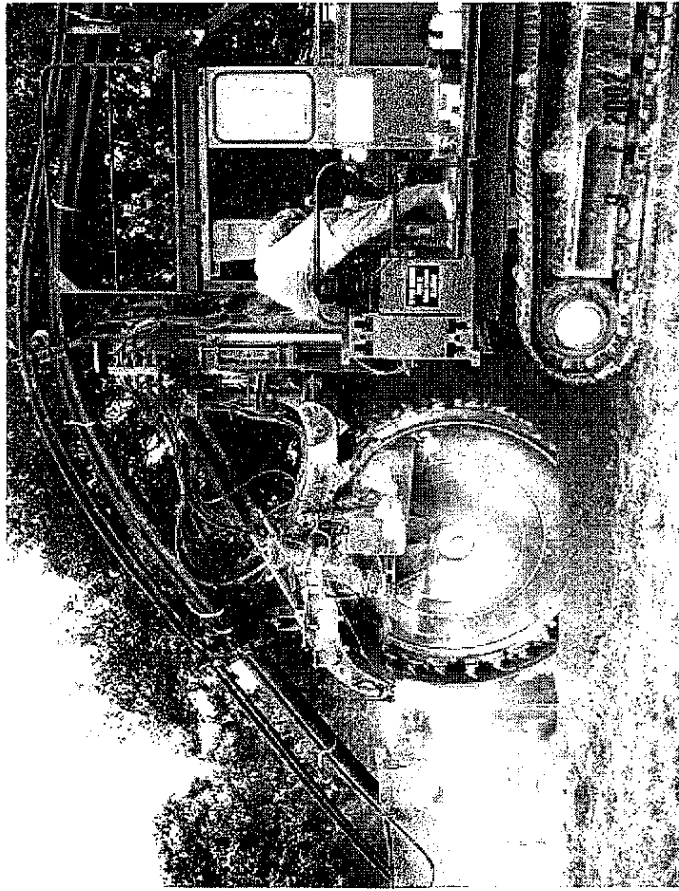
→ Use of mechanical laying





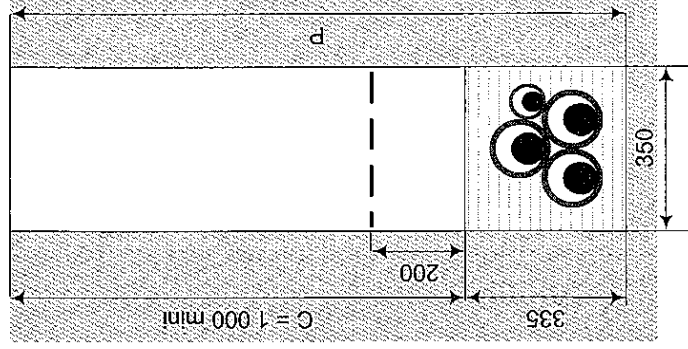
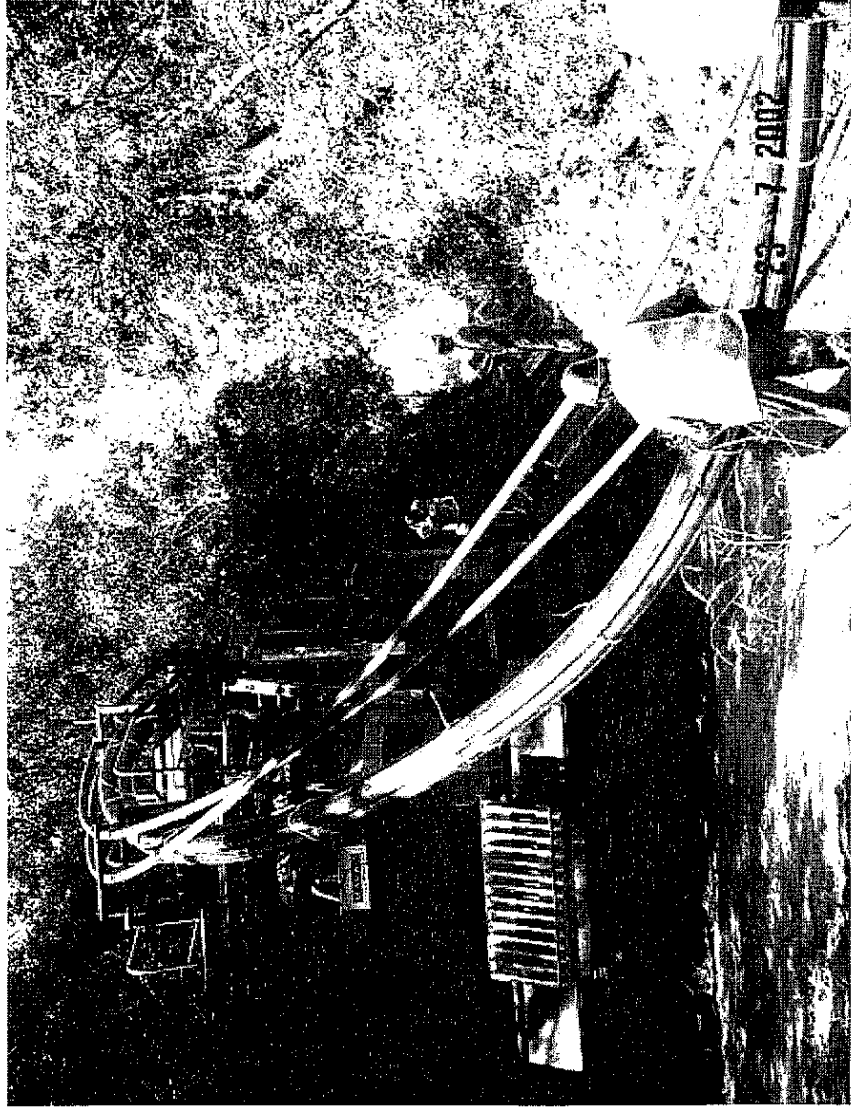
PEHD ducts

- **Ducts directly buried**
- Excellent PEHD behaviour for fault containment
- Only in rural area, combined with mechanical laying



PEHD ducts (2)

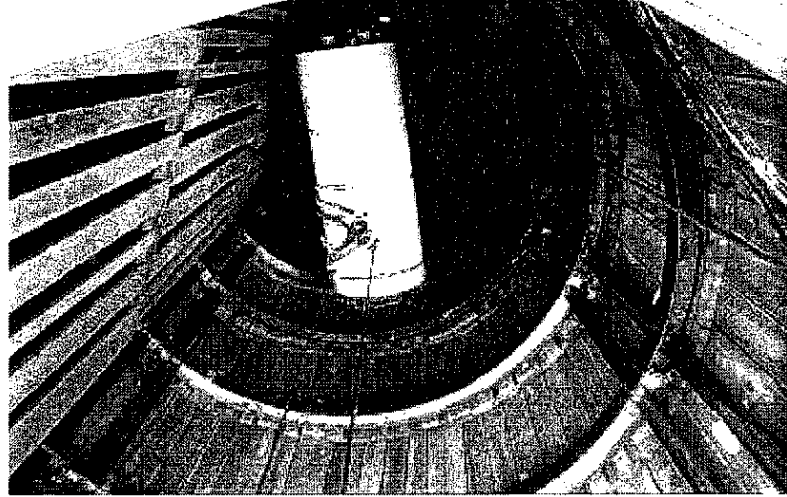
→ Simultaneous laying of several ducts



Micro tunnels

→ Trenchless technique to push prefabricated tubes

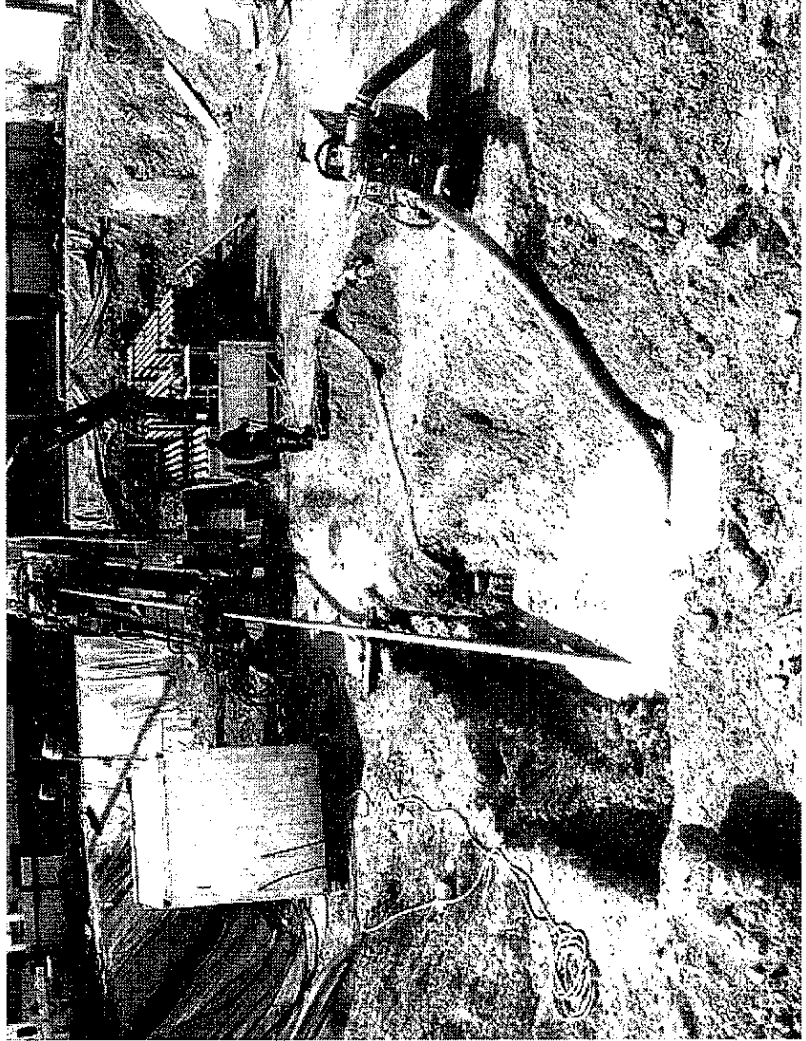
- Short and deep sections
- Access from shafts
- Horizontal drilling
- Equipped with PVC or PEHD ducts
- Eventually filled with fluidised backfill



Horizontal directional drilling

→ Extension of the oil industry technique

- Installation of ducts
- Relevant for river crossing



Tunnels

→ Advantages

- Installation of many circuits in narrow space
 - High current rating
 - Decreasing of mutual heating if the tunnel is ventilated
 - Natural or forced air cooling
- Booking of space for circuits in the future without digging
- Deep civil-work
 - To avoid congested areas
 - No influence in road traffic
- Easy access for eventual maintenance or repair

→ Drawbacks

- Very high cost
 - Preliminary studies
 - Civil works
 - Materials
 - Tunnel boring machine (TBM)
 - Additional equipment
 - Watertightness of walls, drainage
 - Lighting, ventilation
 - Fire detection and extinguishing systems

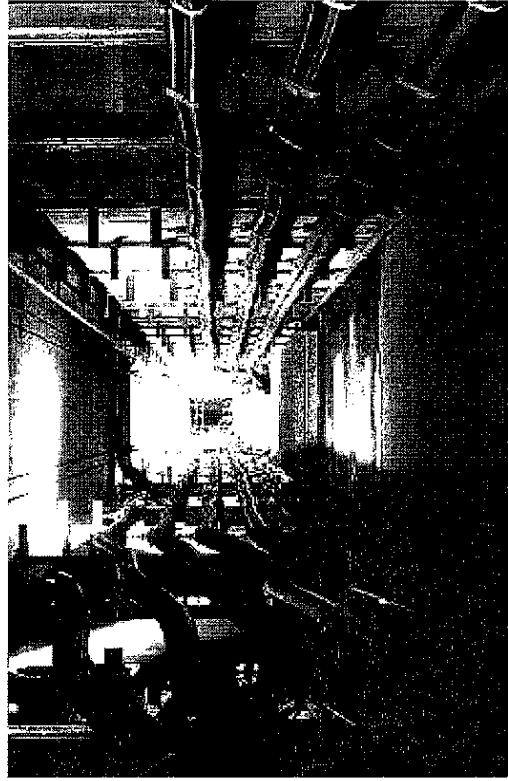
→ Tunnels are not a common practice in France

- Only in urban area
 - Where transmission cables coexist with many distribution cables
 - At substation output with many transmission cables
- Or in mid-urban area
 - Where the access to large substations is impossible with overhead lines

Rectangular tunnel

→ **Rectangular cross section for shallow tunnels**

- Low mechanical stress
 - Low pressure between tunnel top and ground surface
 - No vaulting required



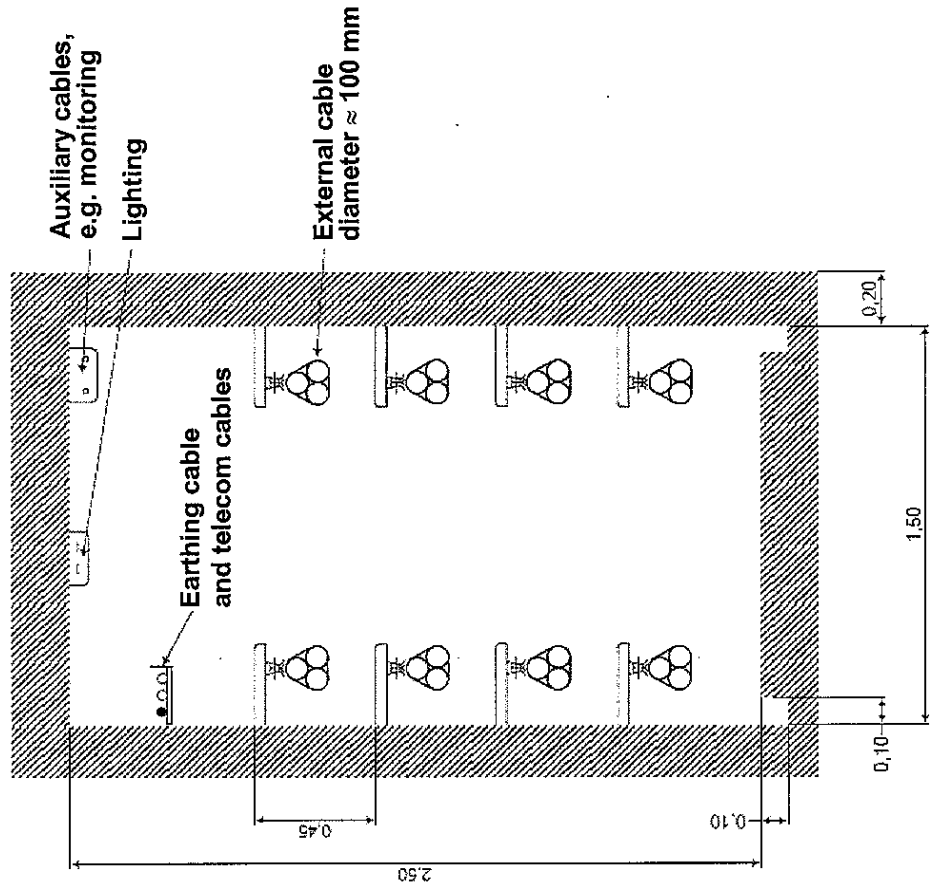
Rectangular tunnel design

→ Characteristics

- Minimal height = 2.0 m
- Minimal width of circulation area = 0.80 m
- Wall thickness and iron framework depending on depth and load

→ Building

- Generally open air technique
- Concrete pouring or prefabricated items



Installation design

→ Cable position

- Must take into account possible evolution of the tunnel (future additional circuits)
- Different circuits must be laid or suspended to distinct items
 - Telecom cables and power cables
 - Cable of different voltage levels
- Heavy cable shall be installed at the lower part of the tunnel

→ Marking

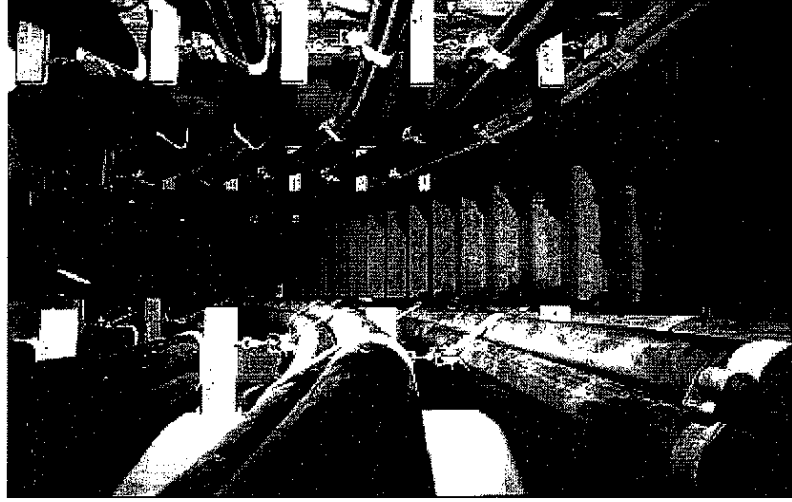
- Cables must be identified unequivocally

→ Damage prevention

- Minimal spaces between circuits
 - To prevent induced phenomena (telecom cables)
 - To prevent electro dynamical stress (short-circuit)
 - Possible dividing wall or protection systems to avoid handy tools damage (other operators)

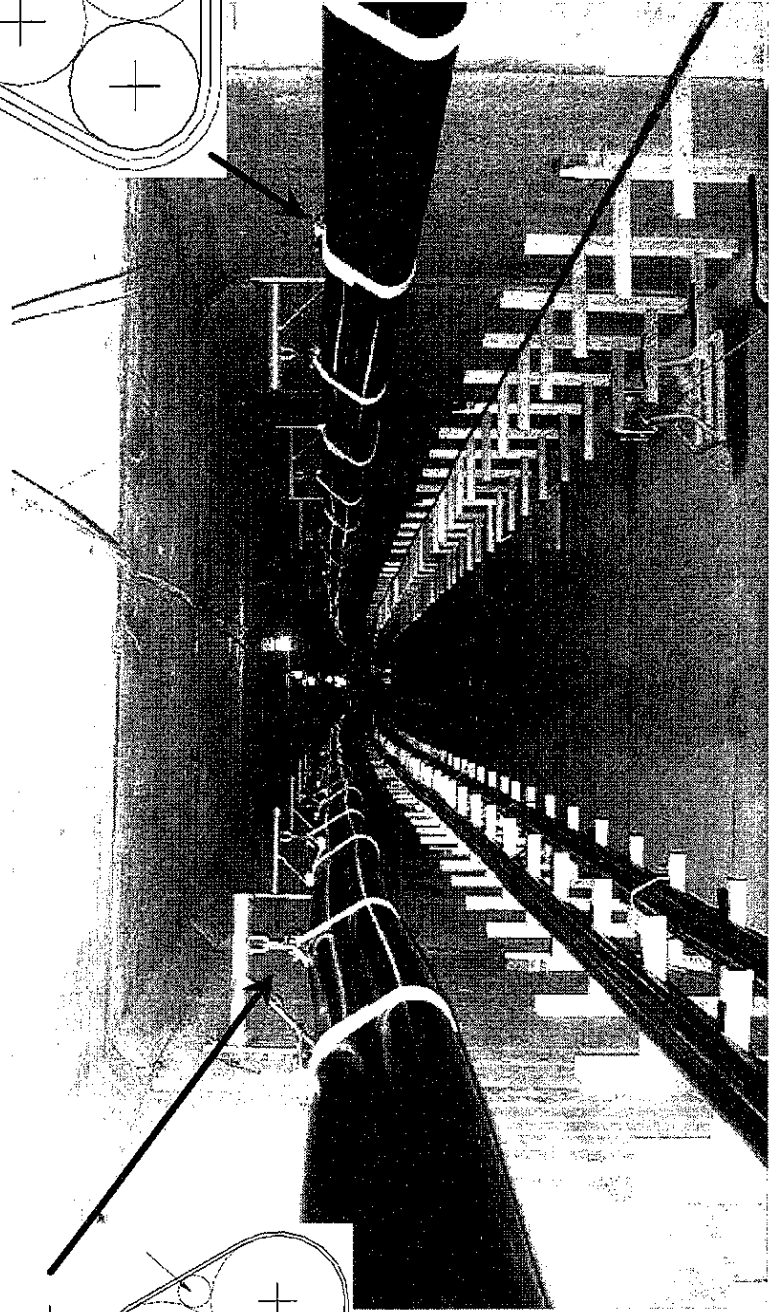
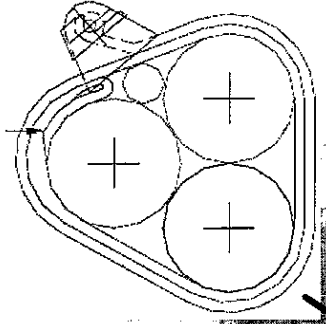
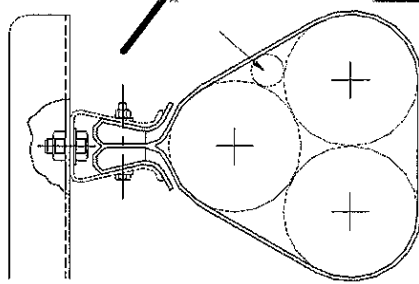
→ Earthing

- Metallic equipment must be grounded to the same earth conductor



Suspension-strap installation

- Suspension to allow vertical snaking
- Straps to withstand electro dynamical stress (short-circuit)



Circular tunnel

→ Depth tunnel excavated with tunnel boring machine

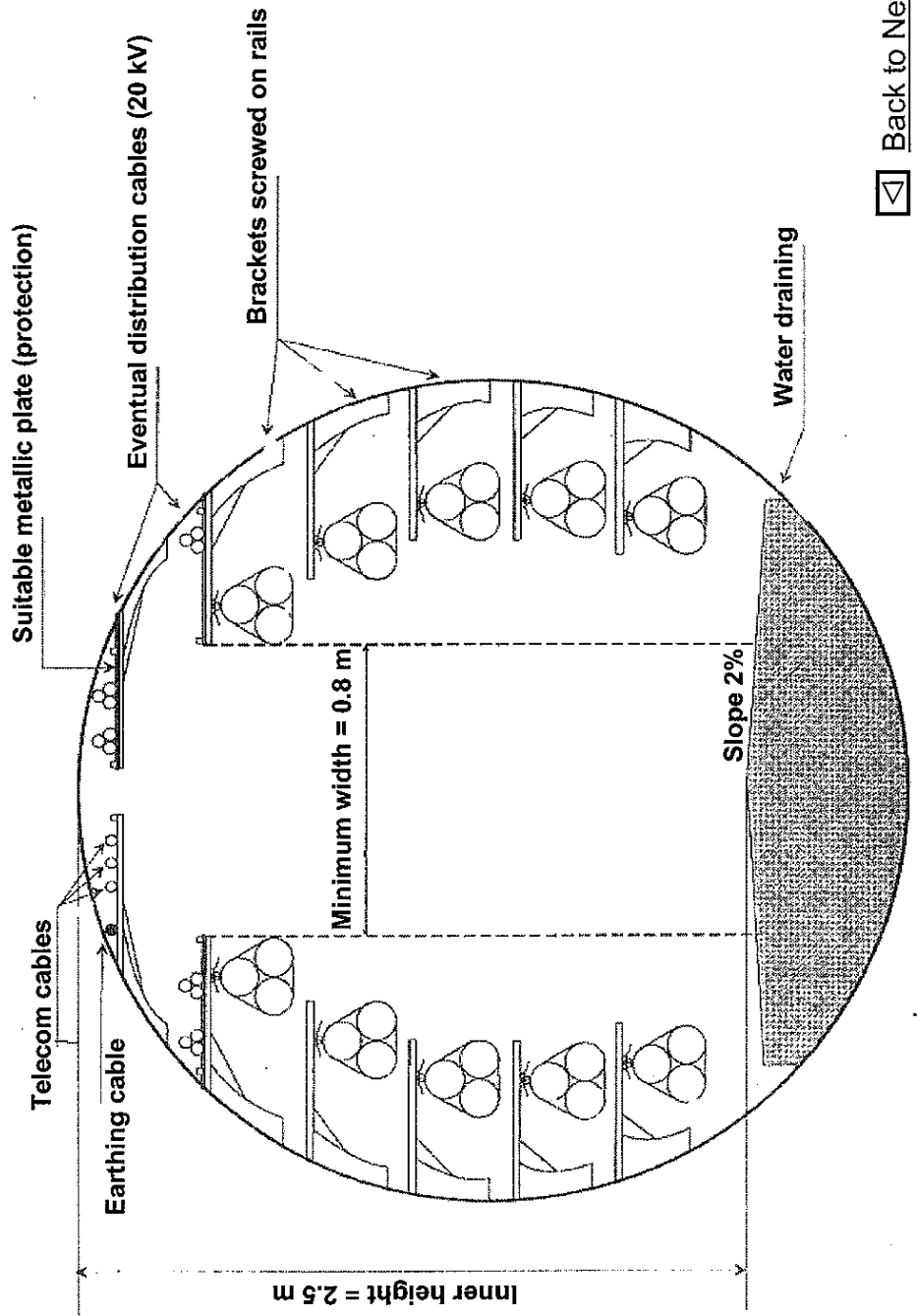
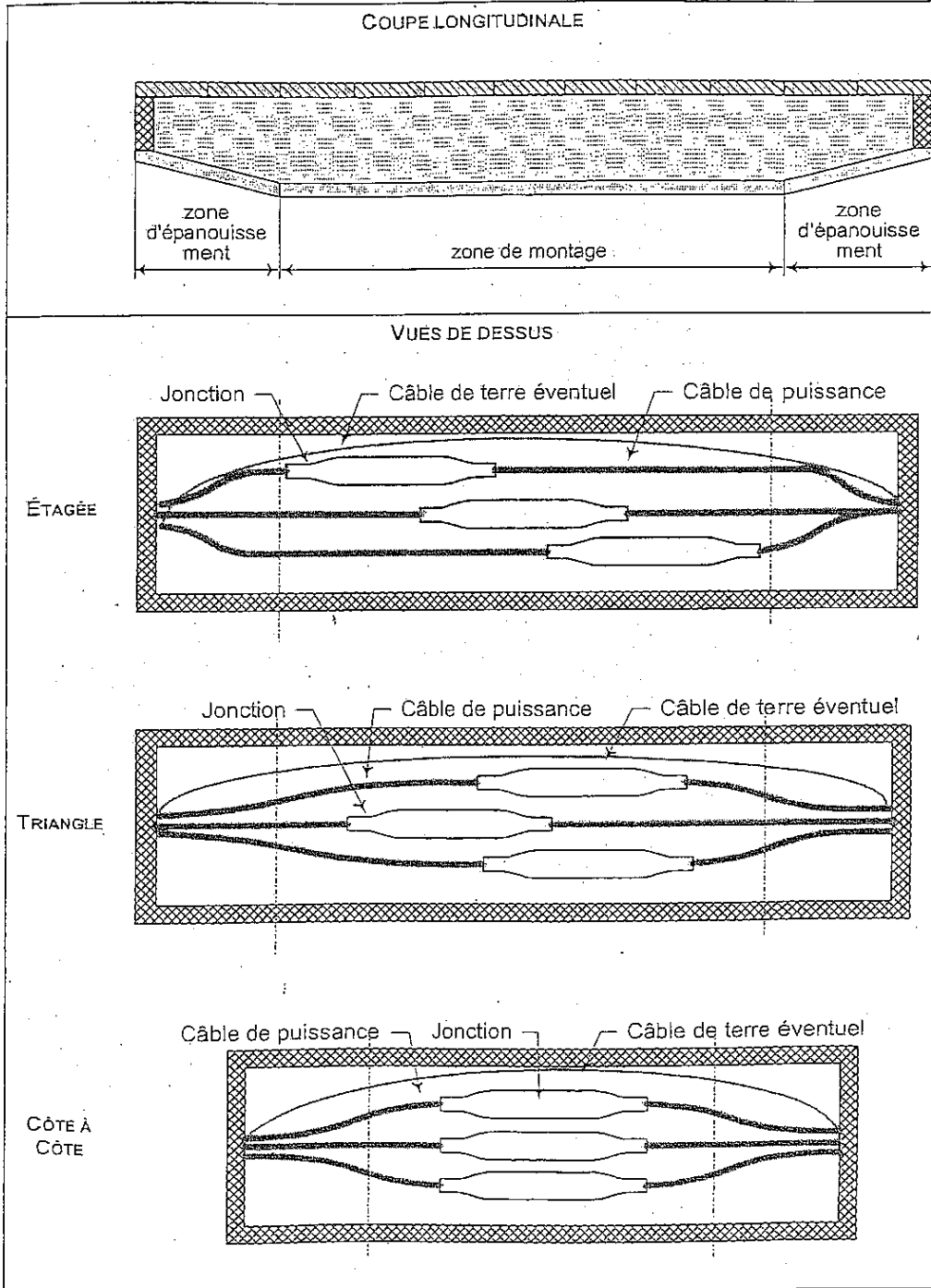


PLANCHE RS52-1
 CHAMBRES DE JONCTIONS DES CÂBLES DE PUISSANCE – DISPOSITIONS



Dalles de couverture
 Sable fin roulé
 Béton armé
 Parpaings pleins allégés 20 x 20 x 50

Plan :	Indice	A					
LS 200094	Date	06/11/2003					

C.A.P.E.C.**Délégation Economique de Taiwan**

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75116 PARIS

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法國鐵路罷工證明

茲證明本(96)年11月16日至27日台灣電力公司輸變電工程處北區施工處工程管理組工管課葉課長明志來法參加經濟部96年度台法技術合作人員訓練計畫、台灣電力公司輸變電工程處電纜設計組機電二課張課長德君來法進行技術研習合作，渠二員在法國考察期間恰逢法國鐵路大罷工，特此證明。

亞洲貿易促進會駐巴黎辦事處