KAON Factory Alignment

George S. Clark and David G. Martin*
TRIUMF, 4004 Wesbrook Mall, Vancouver, Canada

TRIUMF is Canada's national subatomic research facility. Located in Vancouver, Canada, the TRIUMF cyclotron has been providing 100 micro-ampere of 520 MeV proton beams since 1974. From October 1989 to March 1990 TRIDMF conducted a $llM pre-construction engineering design and impact study[1] of upgrading TRIUMF into a KAON Factory. This proposal calls for construction of three storage rings and two fast cycling synchrotrons producing 100 micro-ampere beams of 30 GeV protons. The estimated cost is $693M (Cdn).

Foreign participation in the funding of the KAON Factory is expected to be based on the HERA Model. Governments wishing to participate would provide manufactured components and manpower. Discussions with European, Japanese, and American governments suggest that international participation could total $200M (Cdn)[2].

Figure 1 shows the KAON Factory site plan. The accelerator rings are mounted in tunnels at least 8 meters below ground. The Booster Tunnel houses the Accumulator storage ring and the Booster Synchroton. The Accumulator is 2.2 meters above the Booster. The circumference of the small rings is 215 meters. The Main Ring Tunnel houses the Collector storage ring, the Driver Synchrotron, and the Extender stretcher ring. The Collector ring is mounted 1.2 meters above the Driver ring, while the Extender ring is offset horizontally from the Driver by about 3.5 meters. In part of the Main Ring Tunnel the B-C Transfer line is supported above the Collector Ring. The Collector and Driver ring circumference is 1075 meters, the Extender ring is slightly longer at 1099 meters. Figure 2 shows a cross section through the Main Ring Tunnel.

Over 1800 magnets form the rings and transfer lines. The alignment tolerance is 0.1 to 0.2 mm relative to adjacent magnets, and 1 to 2 mm absolute. A surface survey network and two in-tunnel networks are proposed to achieve this tolerance.

The surface network shown in Figure 3 contains 13 monuments. Seven of the monuments will be mounted on concrete filled steel piles driven up to 10 meters into the ground. The

---

*now at the European Synchrotron Radiation Facility, Grenoble, France.

other six the monuments will be erected on the surface above tunnel floor monuments using optical plummets and vertical shafts. These six monuments, two in the Booster Tunnel and four in the Main Tunnel, will be shared between the surface and in-tunnel networks. The monument locations will be determined by trilateration using a KERN ME-5000 measuring all distances in both directions. Simulations show that the monument position uncertainty should not exceed 0.8 mm.

Removable rigid steel tripods, bolted to the floor in the tunnel walkway will form the base of the in-tunnel network. The crowded nature of the tunnels preclude using the magnets themselves as the base of the network. The tight radii of curvature of the tunnels severely limit the use of classical survey instruments such as the nylon wire offset device.

We expect the tripods to relocate with a standard error of about 0.3 mm. The in-tunnel network will be measured in sections between the floor monuments shared with the surface network. Each traverse will be adjusted by least squares holding the shared monuments as known points. The steel tripods will then be used in the positioning, alignment, and smoothing of the magnets.

The measurement scheme for the main tunnel network is outlined in figure 4. Simulations[3] of the in-tunnel network predict the maximum standard error in position of the tripods to be 0.45 mm. The simulations assumed the following equipment and standard errors:

angles	Wild T3000	2.7 seconds
distances	Wild DI2000	0.5 mm

Combining the standard error of the surface network, optical plummet error (1:200,000), and the relocating error in the tripods results in a absolute tripod position standard error of 0.9 mm.

Figure 5 shows the quadrupole alignment scheme. Simulations for the Driver and Collector rings show that the relative radial error between adjacent quadrupoles does not exceed 0.06 mm. and that relative longitudinal errors do not exceed 0.14 mm.

Plans call for a laser tracking system to measure the location of a magnet's external targets with respect to the pole faces. The external targets will likely be based on the CERN tooling ball (alesage). Many of the external targets will have to be side mounted and removable because of the small vertical space between the rings.

Current plans are to construct the 5 rings over 5 or 6 years. The precision alignment budget totals about $11 M (Cdn) and includes a core group of up to 11 people during the construction and installation phase. A great deal more planing must be done before any installation can start.

The pre-construction study is complete and was delivered to the Canadian Government on May 24th. Given the strong local and international support for the TRIUMF KAON Factory proposal, we anticipate a positive decision in the Fall of this year.

References

[l] *KAON Factory, Engineering Design and Impact Study,* TRIUMF May 1990.

[2] J. Elliot et al, *Report of the Steering Committee, KAON Factory Engineering Design and Impact Study,* TRIUMF, Feb. 1990.

[3] D.G. Martin and G.S. Clark, *The Survey and Alignment of the KAON Factory Project,* TRIUMF Design Note TRI-DN-K103, Dec. 1989

Figure Captions

Figure 1: TRIUMF KAON Factory Site Plan

Figure 2: Driver Tunnel Cross Section

Figure 3: The surface geodetic network

Figure 4: The measurement scheme for the in-tunnel network

Figure 5: The measurement scheme for positioning and smoothing the magnets

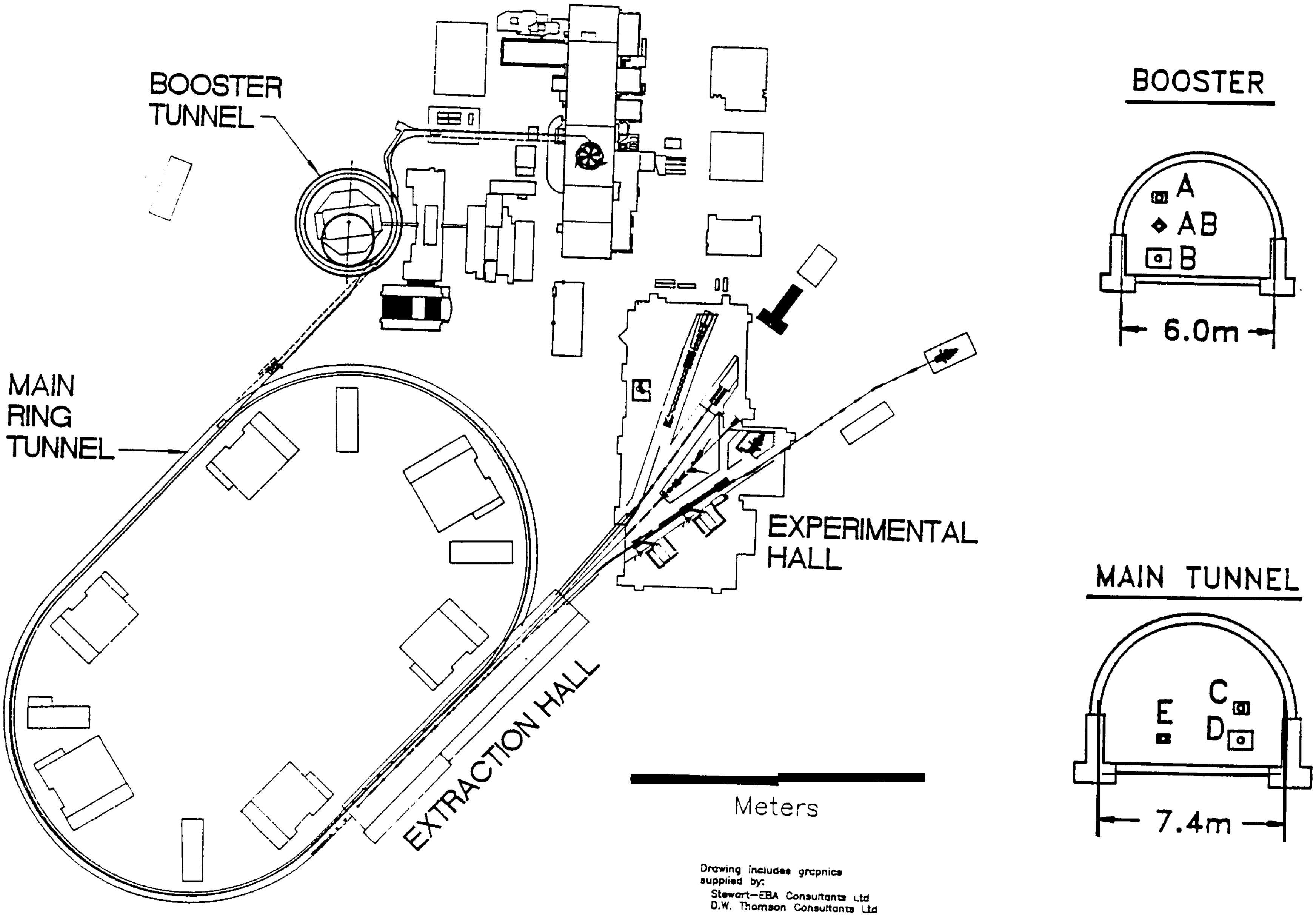
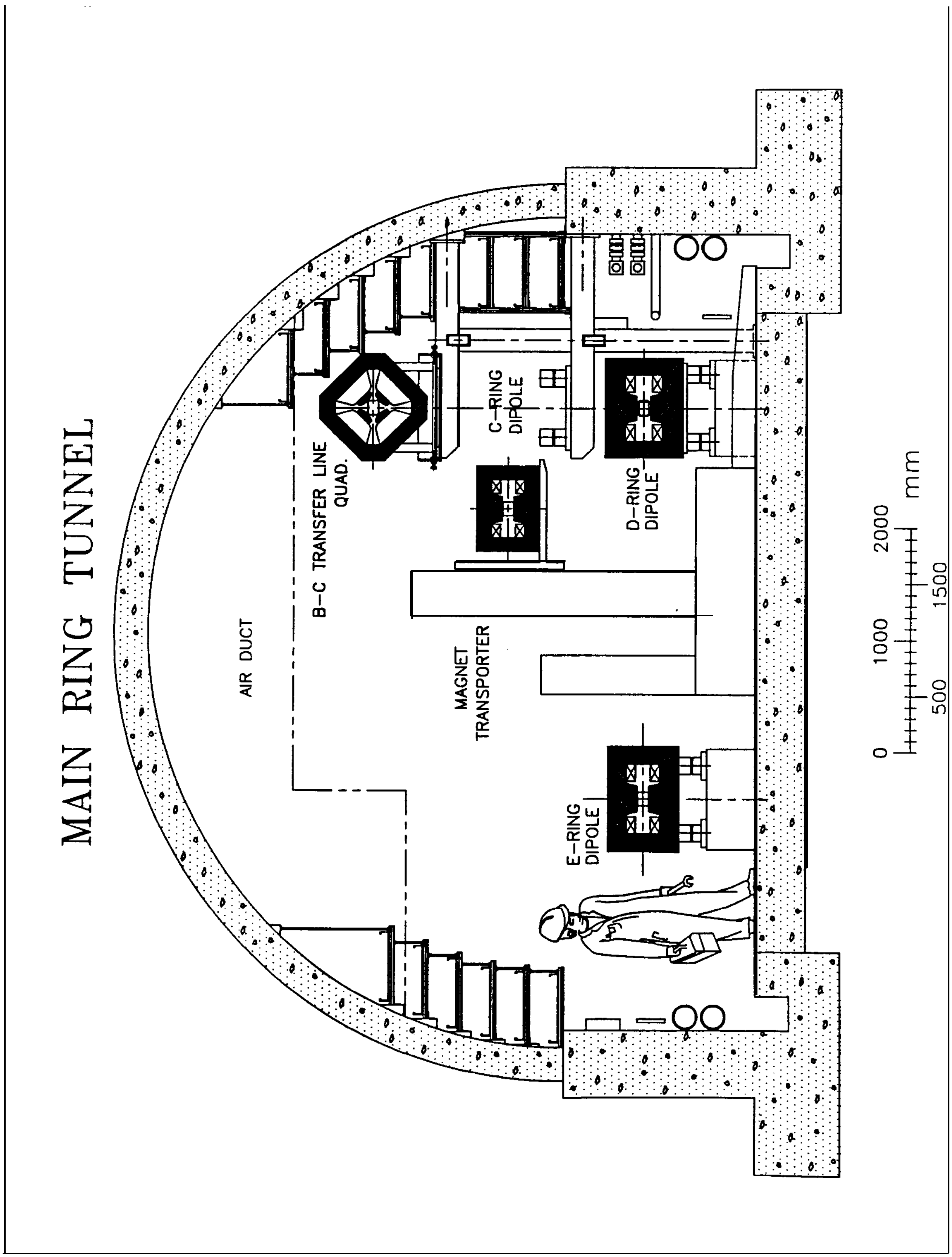

BOOSTER TUNNEL
MAIN RING TUNNEL
EXPERIMENTAL HALL
EXTRACTION HALL
Meters
Drawing includes graphics supplied by:
Stewart-EBA Consultants Ltd
D.W. Thomson Consultants Ltd
BOOSTER
A
AB
B
6.0m
MAIN TUNNEL
C
D
E
7.4m

Figure 1

Figure 2


MAIN RING TUNNEL
AIR DUCT
B-C TRANSFER LINE
QUAD.
C-RING
DIPOLE
MAGNET
TRANSPORTER
D-RING
DIPOLE
E-RING
DIPOLE
0
500
1000
1500
2000
mm

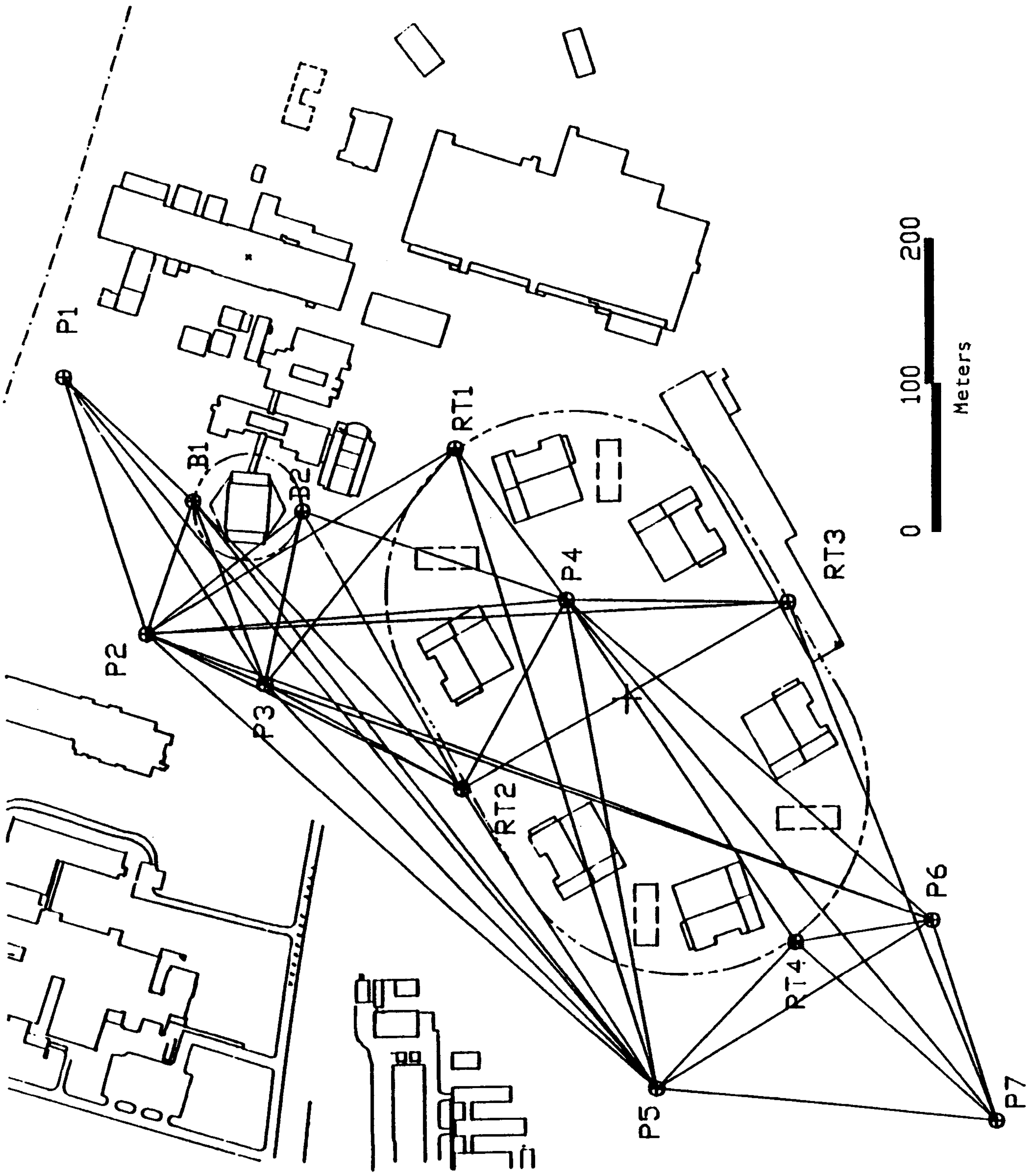


Figure 3: The surface geodelic network.

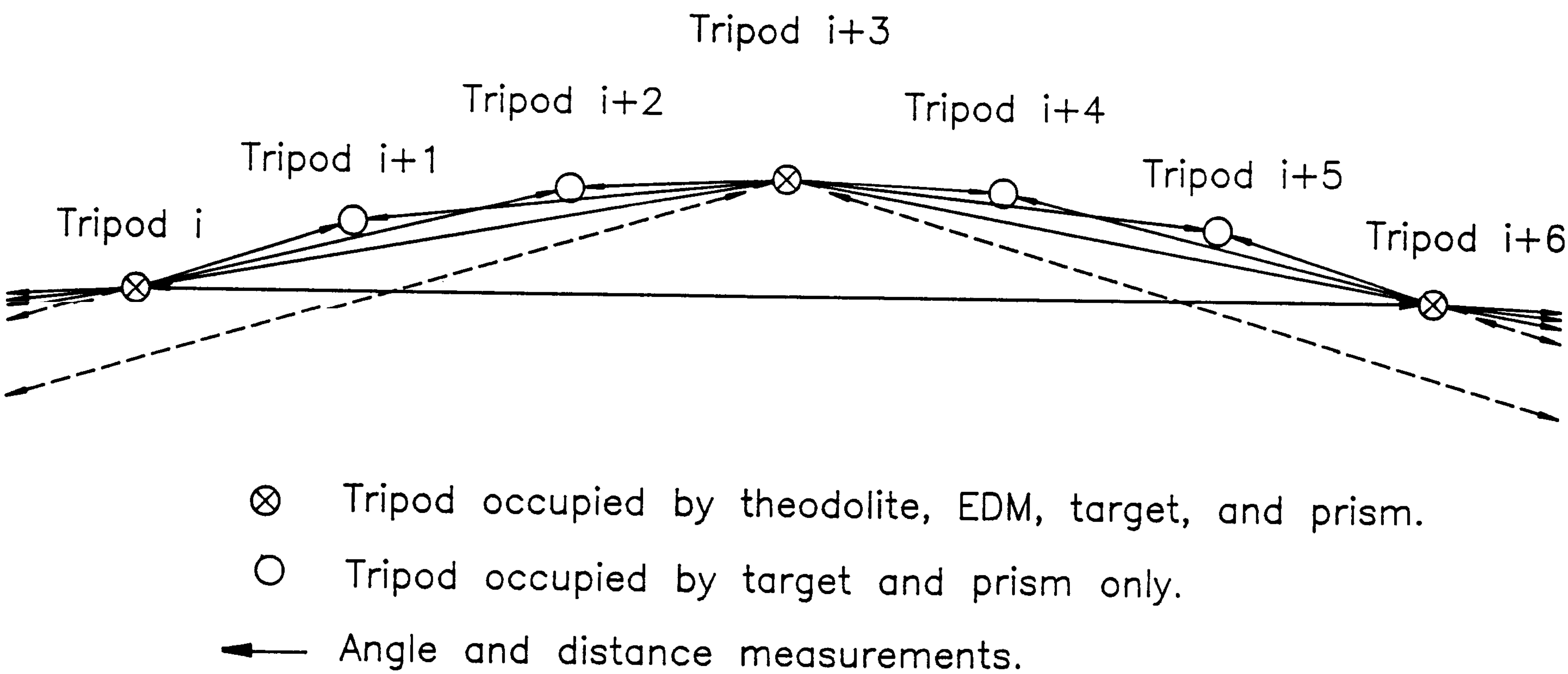
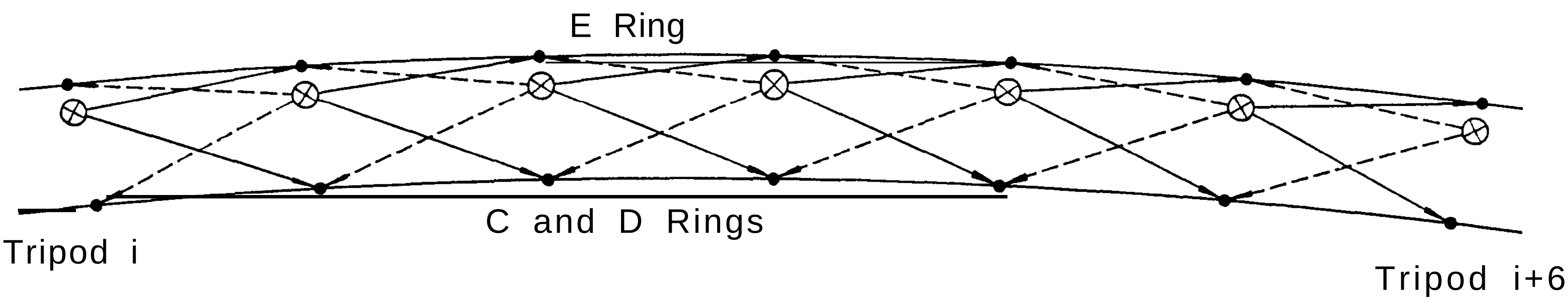

Tripod i+3
Tripod i+2
Tripod i+4
Tripod i+1
Tripod i+5
Tripod i
Tripod i+6
Tripod occupied by theodolite, EDM, target, and prism.
Tripod occupied by target and prism only.
Angle and distance measurements.

Figure 4


E Ring
C and D Rings
Tripod i
Tripod i+6

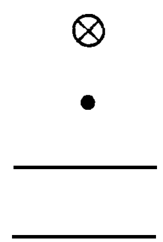

Tripod occupied by theodolite and EDM.
Quadrupole (and other machine components).
Angie and distance measurement.
Angle measurement only.

Figure 5