The resistance R (in Ω) of a 1·2 m × 1·2 m plate is given approximately by the formula:

$$R = \frac{\rho}{2{\cdot}75}$$

For conventional sizes, the resistance is approximately inversely proportional to the linear dimensions, not the surface area, that is a 0·9 m × 0·9 m plate would have a resistance approximately 25 percent higher than a 1·2 × 1·2 m plate. The current loading capacity of a 1·2 m × 1·2 m plate is of the order of 1 600 A for 2 s and 1 300 A for 3 s.

Plate electrodes shall be buried such that its top edge is at a depth not less than 1 5 m from the surface of the ground. However, the depth at which plates are set should be such as to ensure that the surrounding soil is always damp. Where the underlying stratum is solid, for example chalk or sandstone and near the surface, the top of the plate should be approximately level with the top of the solid stratum.

9.2.2 *Pipes or Rods* — The resistance of a pipe or rod electrode is given by:

$$R = \frac{100\ \rho}{2\ \pi\ l} \log_e \frac{4l}{d} \text{ ohms}$$

where

l = length of rod or pipe (in cm),

d = diameter of rod or pipe in cm, and

ρ = resistivity of the soil (in Ω.m) (assumed uniform).

The curves of Fig. 11 are calculated from this equation for electrodes of 13, 25 and 100 mm diameter respectively in a soil of 100Ω.m respectively. Change of diameter has a relatively minor effect and size of pipe is generally governed by resistance to bending or splitting. It is apparent that the resistance diminishes rapidly with the first few feet of driving, but less so at depths greater than 2 to 3 m in soil of uniform resistivity.

A number of rods or pipes may be connected in parallel and the resistance is then practically proportional to the reciprocal of the number employed so long as each is situated outside the resistance area of any other. In practice, this is satisfied by a mutual separation equal to the driven depth. Little is to be gained by separation beyond twice the driven depth. A substantial gain is effected even at 2 m separation.

Pipes may be of cast iron of not less than 100 mm diameter, 2·5 to 3 m long and 13 mm thick. Such pipes cannot be driven satisfactorily and may, therefore, be more expensive to instal than plates for the same effective area. Alternatively, mild steel water-pipes of 38 to 50 mm diameter are sometimes employed. These can be driven but are less durable than copper rods.

Driven rods generally consist of round copper, steel-cored copper or galvanized steel (*see* **9.2.8**) 13, 16 or 19 mm in diameter from 1 220 to 2 440 mm in length.

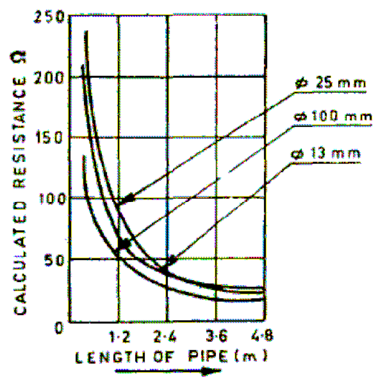

Fig. 11 Effect of Length of Pipe Electrode on Calculated Resistance for Soil Resistivity of 100 Ω m (Assumed Uniform)

Cruciform and star shaped sections are also available and are more rigid while being driven, but the apparent additional surface does not confer a noticeable advantage in current-carrying capacity or reduction of resistance. In circumstances where it is convenient to do so, the addition of radial strips will be advantageous.

Such rods may be coupled together to give longer lengths. Except in special conditions, a number of rods in parallel are to be preferred to a single long rod. Deeply driven rods are, however, effective where the soil resistivity decreases with depth or where substrata of low resistivity occur at depths greater than those with rods, for economic reasons, are normally driven. In such cases the decrease of resistance with depth of driving may be very considerable as is shown by the measurements plotted in Fig. 12 for a number of sites; for curves A_1 and A_2, it was known from previously sunk boreholes that the soil down to a depth between 6 and 9 m consisted of ballast, sand and gravel below which occurred London clay. The rapid reduction in resistance, when the electrodes penetrated the latter, was very marked. The mean resistivity up to a depth of 8 m in one case was 150Ωm; at 11 m the mean value for the whole depth was 20 Ω m moving to the low resistivity of the clay stratum. Similarly for curve C, the transition from gravely soil to clayey at a depth of about 1·5 m was very effective. In the case of curve B, however, no such marked effect occurred, although there was a gradual