the focal spot of a standard X-ray tube, giving an apparent source 1 mm square perpendicular to the incident beam. The openings of the slits S_1 and S_2 are also 1 mm in the plane of incidence, and the distance S_1–S_2 (which may be identified with the distance a) is typically 0.3 m. The specimen is oriented so as to Bragg reflect asymmetrically, as shown. Softer radiations, *e.g.* Cu $K\alpha$, Co $K\alpha$ or Cr $K\alpha$, are employed and higher-angle Bragg reflections are chosen ($2\theta_B \simeq 90°$ is most convenient). Fig. 2.7.2.1 indicates three possible film orientations, F_1–F_3. (These possibilities apply in most X-ray topographic arrangements.) Choice of orientation is made from the following considerations. If minimum distance b is required over the whole length CD, then position F_1 is most appropriate. If a geometrically undistorted image of CD is needed, then position F_2, in which the film plane is parallel to the specimen surface, satisfies this condition. If a thick emulsion is used, it should receive X-rays at normal incidence, and be in orientation F_3. If high-resolution spectroscopic photographic plates are used, in which the emulsion thickness is $\sim 1\,\mu\text{m}$ only, then considerable obliquity of incidence of the X-rays is tolerable. But these plates have low X-ray absorption efficiency. Nuclear emulsions (particularly Ilford type L4) are much used in X-ray topographic work. Ilford L4 is a high-density emulsion (halide weight fraction 83%) and hence has high X-ray stopping power. The usual minimum emulsion thickness is 25 µm. Such emulsions should be oriented not more than about 2° off perpendicularity to the X-ray beam if resolution loss due to oblique incidence is not to exceed 1 µm (with correspondingly closer limits on obliquity for thicker emulsions). With 1 mm openings of S_1 and S_2, and $a = 0.3$ m, most of the irradiated area of CD will receive an angular range of illumination sufficient to allow both components of the $K\alpha$ doublet to Bragg reflect. In these circumstances, the distance b must be everywhere less than 1–2 mm if image spreading due to superimposition of the α_1 and α_2 images is not to exceed a few micrometres. In order to eliminate this major cause of resolution loss (and, incidentally, gain sensitivity in misorientation measurements), the apertures S_1 and S_2 should be narrowed and/or a increased so that the angular range of incidence on the specimen is less than the difference in Bragg angle of the α_1 and α_2 components for the particular radiation and Bragg angle being used. (This condition applies equally in the transmission specimen techniques, described below.). With a narrower beam, the illuminated length of CD is reduced. This disadvantage may be overcome by mounting the specimen and film together on a linear traverse mechanism so that during the exposure all the length of CD of interest is scanned. In this way, surface-reflection X-ray topographs can be recorded for comparison with, say, etch patterns or cathodoluminescence patterns (Lang, 1974).

2.7.2.2. *Transmission topographs*

The term 'X-ray topograph' was introduced by Ramachandran (1944) who took transmission topographs of cleavage plates of diamond using essentially the arrangement shown in Fig. 2.7.1.2. (In this case, S was a 0.3 mm diameter pinhole placed in front of the window of a W-target X-ray tube so as to form a point source of diverging continuous radiation.) Ramachandran adopted a distance $a = 0.3$ m and ratio a/b of about 12, which produced images of about 25 µm geometrical resolution having the characteristics of Fig. 2.7.1.3(*b*), *i.e.* sensitive to diffraction contrast but not to orientation contrast. For each reflection under study, the film was inclined to the incident beam with that obliquity calculated to produce an undistorted image of the specimen plate. Guinier & Tennevin (1949) studied both diffraction contrast and orientation contrast in continuous-radiation transmission topograph images. Their minimum b/a ratio was set by the need to avoid overlap of Laue images of the crystal produced by different Bragg planes.

Collimated characteristic radiation is used in the methods of 'section topographs' (Lang, 1957) and 'projection topographs' (Lang, 1959*a*), the latter being sometimes called 'traverse topographs'. Fig. 2.7.2.2 explains both techniques. When taking a section topograph, the specimen CD, usually plate shaped, is stationary (disregard the double-headed arrow in the figure). The ribbon-shaped incident beam issuing from the slit P is Bragg reflected by planes normal, or not far from normal, to the major surfaces of the specimen. As drawn, the Bragg planes make an angle α with the normal to the X-ray entrance surface of the specimen, the positive sense of α being taken in the same sense as the deviation $2\theta_B$ of the Bragg-reflected rays. If the crystal is sufficiently perfect for multiple scattering to occur within it (with or without loss of coherence), then the multiply scattered rays associated with the Bragg reflection excited will fill the volume of the triangular prism whose base is ORT, the 'energy-flow triangle' or 'Borrmann triangle', contained between OT and OR whose directions are parallel to the incident wavevector, $\mathbf{K}_0$, and diffracted wavevector, $\mathbf{K}_h$, respectively. Both the $\mathbf{K}_0$ and $\mathbf{K}_h$ beams issuing from the X-ray exit surface of the crystal carry information about the lattice defects within the crystal. However, it is usual to record only the $\mathbf{K}_h$ beam. This falls on the film, F, in a strip extending normal to the plane of incidence, of height equal to the illuminated height of the specimen multiplied by the axial magnification factor $(a+b)/a$, and forms the section topograph image. The screen, Q, prevents the $\mathbf{K}_0$ beam from blackening the film but has a slot allowing the diffracted beam to fall on F. A diffraction-contrast-producing lattice defect cut by OT at I will generate supplementary rays parallel to $\mathbf{K}_h$ and will produce an identifiable image on F at I', the 'direct image' or 'kinematic image' of the defect. The depth of I within CD can be found *via* the measurement of $I'T'/R'T'$. From a series of section topographs taken with a known translation of the specimen between each topograph, a three-dimensional construction of the trajectory of defect I (*e.g.* a dislocation line) within the crystal can be built up. To obtain good definition of the spatial width of the ribbon incident beam cutting the crystal, the distance between P and the crystal is kept small. The minimum practicable opening of P is about 10 µm. If diffraction is occurring from planes perpendicular to the X-ray entrance surface of the specimen, *i.e. symmetrical Laue case* diffraction, the width $R'T'$ of the section topograph image is simply $2t \sin\theta_B$, t being the specimen thickness, and neglecting the contribution from the

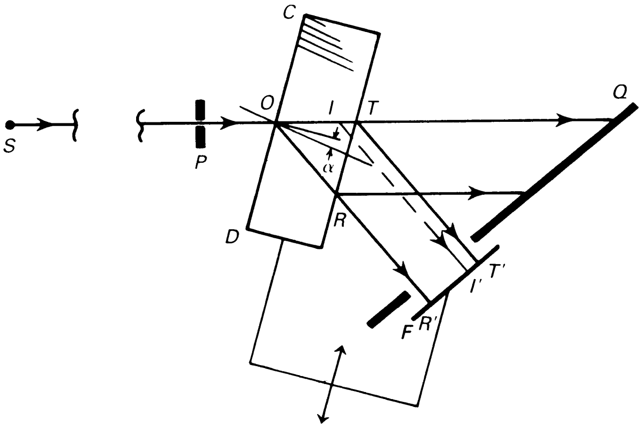

Fig. 2.7.2.2. Arrangements for section topographs and projection topographs.