transmissions where the clutch packs are immersed in oil and therefore do not give rise to airborne contamination. The friction materials used are, in any case, made from sintered metals or paper based facings in which the fibre is largely cellulose. This feature is made possible by the low operating temperatures, due in turn, to the fact that the materials are immersed in oil.

Clutches for heavy duty manual shift gear boxes are, in the U.S.A., being superseded at a significant rate by the spider clutch. This is a type of clutch in which the friction material, instead of being in the form of a thin annulus, consists of a number of buttons rather like disc brake pads, and these again could be made from asbestos-free material such as sintered metals or cermets (ceramic–metallic compositions).

Summarizing the situation at the present time therefore, it can be seen that there is a drift towards the use of smaller quantities of asbestos in friction materials as a result of a number of purely performance considerations and design changes, *that is*, reduced amounts of asbestos in some disc brakes, and replacement by other materials in automatic transmissions and some dry clutches.

OTHER FACTORS AFFECTING EXPOSURE TO ASBESTOS

There are, however, several other factors which enter the equation when considering the exposure to asbestos during brake and clutch maintenance, which is the subject of this meeting.

The first is that the durability of friction materials is increasing, as is the temperature at which they will operate satisfactorily. I mention these facts not only because they tend to offset the adverse effect of increase in vehicle miles per year, but because they affect the whole chemistry of asbestos in friction materials. The second important point is that the type of asbestos used in friction materials is chrysotile or white asbestos, and is different from blue asbestos or crocidolite, not only in colour, but in chemical composition and also in chemical decomposition. The third important point is that under the influence of heat alone, chrysotile asbestos decomposes by loss of water of crystallization at a temperature of around 600°C. The process is rather slow, taking well over an hour to convert 50 per cent of the asbestos to its degradation products. These form a series of iron magnesium silicate materials known as olivine, the end member of which is forsterite. The olivine series of minerals are quite unlike asbestos, both physically and chemically, being non-fibrous, and in fact, widely occurring as the major part of many common rocks (basic and ultramafic igneous). One would not expect that a significant amount of asbestos would be converted to olivine during braking except under conditions of very severe duty such as a fade test, but in fact it is exceedingly difficult to detect asbestos in friction material wear products. It has only on rare occasions been possible to detect asbestos in wear products by X-ray diffraction methods, and one has to resort to electron diffraction, selecting occasional individual small fibres to show its existence. This rather surprising fact has been known for several years and current theory suggests that it is accounted for by very high temperatures which are said to exist at the points of real contact between the lining and drum or disc, even at bulk temperatures as low as 100°C.

Whether this explanation is correct or not, it remains a fact that very little asbestos survives in the wear products after brakes or clutches have been used under normal