on carbon monoxide of 1.5% (the average exhaust emits perhaps 3%), for reason of its own toxicity and its rising concentration in Los Angeles air, not because it contributes to photochemical smog. By 1970 the state will reduce these limits still further, to 180 ppm and 1% respectively. But even now, for reasons that we will discuss shortly, the Los Angeles County Air Pollution Control District—the trail-blazing agency in photochemical pollution control—would like to see the hydrocarbon limit reduced to below 100 ppm.

Such differences in opinion on the part of different control agencies is of course not frivolous in intent. It reflects uncertainty about precisely what should be controlled, and by how much. But at each such turn in the road to inevitable controls, a good deal of prior research on control techniques gets bypassed. And at the spectre of a patchwork of differing, locally determined control limits a national industry, like the auto industry in particular, gets understandably upset. To more clearly understand the basis for some of these difficulties we need a closer look at the nature of the smog which now afflicts all urban regions that are highly populated with automobile traffic.

Fig. 5. High wintertime concentrations of SO_2 in air over (British) cities and surrounding regions come from burning of sulfur-bearing coals and add to ordinary cardio-respiratory hazards of winter weather, especially for the elderly. The map makes clear that pollution is not just a downtown problem; nor is the SO_2 problem exclusively a British one. Abatement efforts center on switching to low-sulfur fuels and eliminating SO_2 from flue gases.

Sun-stewed auto exhaust→smog

Photochemical smog's chief immediate and obvious symptoms are eye irritation, damage to sensitive plants (as far as 100 miles from urban centers), accelerated cracking of rubber, and decreased visibility due to the formation of a haze of solid and liquid particles which are collectively described as aerosols. The first three symptoms are caused by the products of a complex of reactions that start, as we said, with hydrocarbons and oxides of nitrogen. In the course of the reactions some highly reactive intermediates and ozone are formed. These help polymerize the organic compounds in the mixture, according to Prof. A. J. Haagen-Smit of CalTech who pioneered work in this field, and lead to the formation of additional, non-volatile, oxidation and polymerization products which add to haze and eye irritants from other sources of pollution.

This kind of pollution is characterized by the same extreme dilution of reactive constituents and intermediate and final reaction products that characterize all air pollution. An ozone concentration of 0.3 ppm for instance is 10 times its normal background concentrations at ground levels. Haagen-Smit points out that this extreme dilution is one reason why it takes many years to unravel even relatively simple atmospheric reactions such as the photodecomposition of acetone. In ordinary laboratory work, "slow" and "fast" reactions are characterized against a backdrop of reactant concentrations that average about 10%. But in atmospheric reactions concentrations are only on the order of one-millionth as much. Under these conditions reactions which would proceed in thousandths of a second at ordinary laboratory concentrations take an hour in the atmosphere.

This is important: It is essentially what permits the highly potent ozone to survive attack by reducing agents such as SO_2 in the atmospheric mixture. Ozone thus can go on to participate in reactions at several stages in the photochemical chain. The immense slowdown in reaction rates also gives ozone and various, highly reactive, free radicals that are formed a far better chance to survive long enough to play significant roles, not only in the over-all reactions but in some of the observed symptoms as well.

The still far from completely elucidated chain of daily reactions leading to smog is set in motion by the photochemical dissociation of nitrogen dioxide. It is a yellow-brown gas that most effectively absorbs pho-