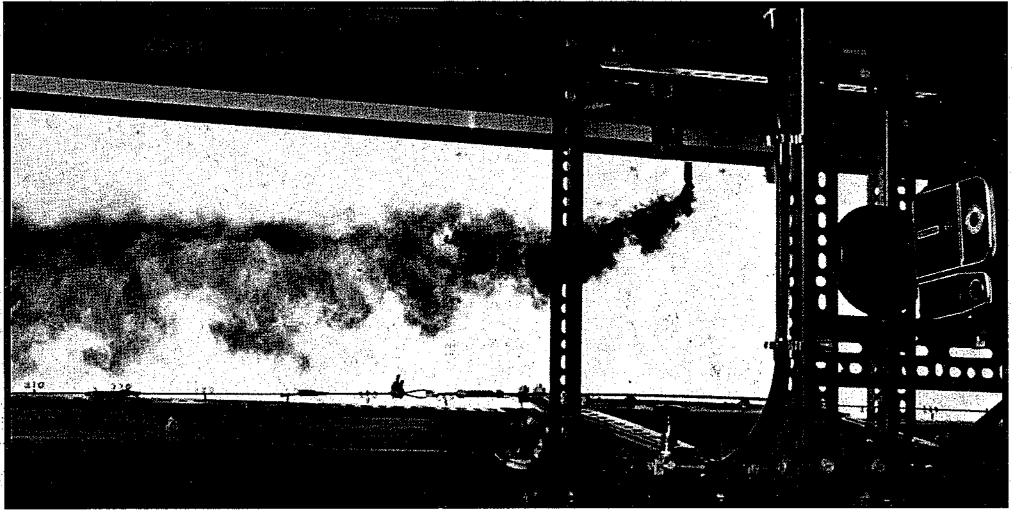
BACK BOX

An alternative to taller chimneys?



Dyed salty water pours into a tank of fresh water to simulate (upside down) a smoke plume.

Tall chimneys are meant to get smoke up and away from principally ground-dwelling creatures, such as Man.

Thanks to hot air being lighter than cold, smoke plumes are buoyant, and drift upwards—unless, of course, they encounter a strong inversion layer. Here, a layer of warm air sits on top of a cooler layer. The result: the plume runs out of buoyancy and smoke is trapped below it. Up goes the smog index.

In an attempt to penetrate the inversion layer, taller and taller chimneys have become the order of the day. But of course there are always times when the layer appears at a height above the effective range of even the tallest chimney.

Dr Peter Manins of the CSIRO Division of Atmospheric Physics suggests an alternative approach. Instead of sending the smoke plume higher by using a taller chimney, he considers that we could increase the buoyancy of the plume.

This is done by adding more heat to the exhaust stream. Typically, the simplest way of supplying heat is to partially by-pass the heat exchangers normally present on large installations.

Of course, some heat energy is then wasted instead of being recovered, but this is probably less wasteful of resources than building a huge chimney. Only on days when the inversion layer was troublesomely low would we need to resort to this strategy, and losing some heat is usually preferable to closing down the plant or operating below capacity.

Dr Manins' suggestion comes from a recent paper in which he reports the results of his experiments with a modelling tank and develops a theory to explain the behaviour he observed.

The laboratory model was a tank more than 9 metres long filled with fresh water to simulate the atmosphere. The model worked upside down, in that a 'chimney' pointed downwards into the fresh water and discharged a plume of dyed, very salty water (see the photograph). To mimic an inversion layer, a layer of weakly salty water covered the bottom of the tank. And to simulate the effect of wind, the chimney was moved along the tank on a trolley.

Dr Manins' theoretical study describes the observed plume behaviour very well. Although field studies are few, his model also seems to fairly accurately reflect the behaviour of real chimney plumes. Its main achievement is to be able to tell us what percentage of smoke in a plume will be trapped in an inversion layer. Previously, models could only say whether or not the plume would penetrate the layer.

In reality, and as predicted by Dr Manins' model, some fraction of a smoke plume will nearly always fail to penetrate an inversion. This is because material near the edge of a plume will have less buoyancy than that near the centre.

The model also predicts that increasing the buoyancy of a plume will only marginally increase the height to which it will rise. However, what it will do is greatly decrease the amount of smoke trapped in the inversion. For example, doubling the buoyancy reduces the amount trapped from 90% to 35%.

It is on this reasoning that Dr Manins bases his statement that extra heat in the chimney exhaust is as effective as increasing the chimney's height in getting rid of troublesome smoke.

Partial penetration of an elevated inversion layer by chimney plumes. P. C. Manins. *Atmospheric Environment*, 1978, **12** (in press).