Letters

Reducing Automotive Emissions

In his letter of 7 December 1973 (p. 967), Alan C. Nixon asks why the automotive industry, in its attack on emissions, is not focusing more attention on combustion within the combustion chamber rather than "uselessly converting up to 10 percent of our precious gasoline supplies" with catalytic converters. He also asks why General Motors is not pursuing high pressure air injection into each combustion chamber during the power stroke as an approach to the "solution of the air pollution problem."

Automotive industry researchers have, in fact, focused a great deal of attention on the combustion process in engines during their 20-year effort to reduce automotive emissions. An examination of the published technical literature in this field makes that obvious. Combustion research has resulted in an understanding of the sources of hydrocarbons, carbon monoxide, and nitrogen oxides in engine combustion and of the effect of engine parameters on their concentrations. From these studies came the emission controls which, since 1961, have reduced hydrocarbon emissions by 80 percent, carbon monoxide emissions by about 70 percent, and nitrogen oxide emissions by about 40 percent in new cars. Both hydrocarbon and carbon monoxide in the atmosphere have been declining since 1968, and nitrogen oxides have begun to decline this year, as new cars replace cars that lack controls in the car population.

These substantial reductions in emissions were accomplished by controls within the engine—changes in the mixture ratios, spark timing, manifold air injection, surface-to-volume ratio, and compression ratios. They were accomplished at relatively small cost, although penalties were incurred in both fuel efficiency and driveability. Contrary to Nixon's implication, the optimum engine design for low emissions is not that which is best for fuel efficiency. Despite maximum efforts to minimize the effect, a loss in fuel economy of about 10 percent (sales weighted average) was incurred in reducing emissions to their current low levels (*1*). The installation of exhaust catalytic converters on our 1975 model cars promises to permit an increase in fuel economy of approximately 10 percent, restoring the previous loss and at the same time further reducing emissions (*2*). By treating the exhaust pollutants in the converter, we allow the engine to be retuned toward maximum efficiency.

As we have testified before Congress, the production of sulfuric acid in catalytic converters is a matter of concern that should be studied closely; but our results to date indicate that it does not present a significant hazard to the populace.

In the immediate future, the catalytic converter is the best, in fact the only, way to meet government-mandated emission standards on production vehicles in the time frame established by Congress. This does not mean, however, that better ways are not being sought. The automotive industry laboratories (and some university and private research laboratories as well) are urgently pursuing other approaches to a low emission automotive power plant that would be more effective, more energy efficient, less costly, and more convenient. A large amount of this effort consists of basic combustion studies, particularly in the area of "dilute combustion" research, which includes the study of stratified-charge engines and continuous combustion systems, such as the gas turbine combustor (*3*). In this respect, I would solicit contributions from members of the American Chemical Society to the 15th International Combustion Symposium in Tokyo, 25 to 31 August 1974. Kiroku Yamazaki and I are co-organizers of the colloquium "Pollution Control in and by Combustion Systems" at that symposium, and we hope to encourage greater participation by the combustion scientists of the world in this pressing problem. The subject *is* complex, and much less than everything is known about it.

With regard to Nixon's idea for injecting air into the combustion chamber during the power stroke, this approach was investigated extensively by General Motors between 1958 and 1960, and again in 1971, at the AC Spark Plug Division, at the Research Laboratories, and by the Engineering Staff. A number of patents were filed in order to cover the possibility that the studies would have a successful outcome. Relative to a comparable non-injection engine, significant reductions in the emissions of hydrocarbons, carbon monoxide, and nitrogen oxides were obtained under some conditions, while the emissions were unchanged or increased under other conditions. Broad ranges of injection air flow rates and injection timings were studied. Injection early in the expansion stroke gave better results than at the end of expansion. But in none of the studies did it appear that federal emission levels could be reached.

Early injection into the cylinder necessitates the use of air pressures of about 75 to 100 pounds per square inch, and a compressor, a distributor valve, injection valves, and controls must be provided. A considerable amount of power is required to supply the compressed air, and only a fraction of this power can be recovered by complete oxidation of the exhaust combustibles.

Faced with these disadvantages, General Motors proceeded to explore the possibility of injecting air into the exhaust manifold at the exhaust valve, where pressures and power requirements are much lower. This approach resulted in emission reductions comparable to those with cylinder injection and led to the introduction by General Motors of the AIR (air injection reactor) emission control system on 1968 model cars. This system is still in use on a number of 1974 model cars manufactured by General Motors and by its competitors.

Scientists and engineers at General Motors are trying to pursue every promising approach to low emission power plants, but they are constrained to meet federal laws on emissions in an almost impossible time frame and, at the same time, make appropriate trade-offs with energy efficiency, vehicle function (personal mobility), manufacturability, reliability, durability, safety, comfort, convenience, cost, and customer acceptance in a competitive market. The task is extremely complex and difficult, and we can use all the understanding and help we can get. Many members of the American Chemical Society are already involved in this effort. We appreciate the interest now evidenced by their former president.

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References and Notes

1. Another 6 percent was lost during the same period because of weight additions required to meet safety regulations and other factors.
2. Additional fuel economy gains will be realized in 1975 model cars as a result of a change in vehicle product mix.
3. For a report of considerable basic combustion work in the latter area, see W. Cornelius and W. G. Agnew, Eds., *Emissions from Continuous Combustion Systems* (General Motors Symposium Series, Plenum, New York, 1972).

Marathoning

In response to Puretz, Young, and Baron (Letters, 14 Dec. 1973, p. 1082), I can only repeat that there has never been a reported death from coronary heart disease among marathon finishers of any age (*1*). Finishers are defined as those covering the 42.2-kilometer course in less than 4 hours. Only autopsied cases can be considered.

Puretz suggests that Paavo Nurmi might be the first such case, and Baron brings up Pheidippides; however, Nurmi never ran a full 42.2-kilometer course (*2*), and Pheidippides probably did not even exist (*3*).

Nurmi broke world records in races of up to 20 kilometers but refused to run marathon distances in practice for fear that it would slow him down. He was a remarkable middle-distance runner, not a marathoner. Puretz is mistaken about the 1928 Olympic marathon. The winner was a Frenchman, not Nurmi (who was not even entered).

The modern Tarahumara Indians, like the legendary Pheidippides, demonstrate their endurance with races of 160 kilometers and longer. The limiting somatic factor in these "marathons" is skeletal muscle rather than cardiac