Letters

Automotive Emissions

I would like to know why the automotive industry and the responsible agencies of the government are not attacking the root cause of the reason for the contribution of automobiles to air pollution by focusing more attention on the problem of combustion *within* the combustion chamber. Rather, they seem to prefer to "solve" the problem by hanging a chemical plant on the exhaust system of the automotive engine, thus uselessly converting up to 10 percent of our precious gasoline supplies to carbon dioxide and water and also converting sulfur dioxide to sulfuric acid (see News and Comment, 26 Oct., p. 368) to the probable discomfiture of the populace.

According to Antoni Oppenheim of the University of California, Berkeley, there is very little work being done on the fundamentals of combustion. The results of such work could be applied not only to this problem but also to making improvements in rocket and turbine engines. (There seems to be a general feeling among purse string holders that everything is known about this complex subject.)

In pondering the problem of automotive air pollution, I thought I had stumbled on a simple and brilliant solution—inject air under sufficiently high pressure into each combustion chamber at about 70° after top dead center during the power stroke, thus converting the original fuel-rich mixture into an oxygen-rich mixture that would burn up all the hydrocarbon and convert carbon monoxide to carbon dioxide. Nitrogen oxides would also be reduced, since starting with a rich mixture keeps the peak temperature lower. All of the power would be obtained from the gasoline because it would be burned up during the power stroke, and a good portion of the power used to compress the injected air would also be recovered. The air could even be injected through a hollow spark plug, thus simplifying the adaption of the system to existing automobiles and trucks.

I consulted with experts and scoured the journal literature, but I could find no reference to this approach. However, when I had a patent search made, I discovered five patents assigned to General Motors in the early 1960's that covered most of the elements of my proposed system, with some data indicating that automotive emissions could be practically eliminated.

Why has General Motors chosen not to pursue this eminently reasonable approach to the solution of the air pollution problem?

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Energy Conservation

In "Energy conservation through effective utilization" (13 July, p. 128), Charles A. Berg, using data from the Stanford Research Institute (*1*), breaks down the total national energy consumption into residential building services (19.2 percent), commercial building services (14.4 percent), industrial processes (41.2 percent), and transportation (25.2 percent). While I applaud his effort and think this type of analysis is necessary, such a listing invites comparison of the four categories, which is inappropriate. The building services and transportation categories are charged with only operational costs, while the category, industrial processes, includes its own operational and manufacturing costs and, in addition, manufacturing costs for the other categories. This lumping of energy costs could lead to serious policy errors in the future.

For example, Berg suggests that improved insulation and draft control in both residential and commercial buildings would result in a considerable energy savings. This seems reasonable; however, what would be the additional energy cost for the manufacture of storm windows and other insulation materials? The estimate of a 40 percent saving, had 1972 Federal Housing Administration standards for heat loss been applied to all buildings, is certainly high, because the manufacturing cost of these additional materials is not considered.

To improve utilization efficiency, the total cost—manufacture, repair, and operation—must be the basis for comparison. If comparisons are made on an operational basis alone, we may be presented with a bill for the "hidden" energy costs sometime in the future. Aren't many of our ecological problems today the result of such "hidden" costs?

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References

1. Stanford Research Institute, *Patterns of Energy Consumption in the United States* (Menlo Park, Calif., November 1971; prepared for the Office of Science and Technology, Washington, D.C., January 1972), p. 6.

In his discussion of solar energy absorbers Berg confuses cost of manufacture with price to the consumer. Cost is a crucial factor in the implementation of a viable solar energy program; without an efficient, low-cost device to collect solar energy, all the current speculation on its use becomes meaningless.

As far as I know, Fafco Incorporated is the only company in this country actively manufacturing, marketing, installing, and servicing flat plate collectors for absorbing solar energy. We are not aware of anyone who can produce a collector for domestic water heating for $18 per square meter (which is $1.67 per square foot), let alone "reduce this cost to $15 per square meter" as Berg suggests.

Even if this low manufacturing cost were possible, it should not be confused with the price to the consumer. A flat plate collector would have to sell to the consumer for approximately three times the manufacturer's cost to allow for his profit, the distributor's profit, and the retailer's profit. The cost of installation and service would be extra. Also, Berg's analysis of the cost of meaningfully implementing solar energy in this country seems to overlook the other essential components of a domestic solar water heater, storage capability and controls, both of which are items of major expense in addition to installation.

We are encouraged by the current

resurgence of interest in solar energy, as it has a real place in the national energy picture. At the same time, it is vital that we be realistic about the problems so as to best channel our resources toward a solution.

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Berg treats, among other factors, the optimum use of heat in industry. In many industrial processes, such as the drying of paint, the curing of adhesives, or the vulcanization of rubber, energy is supplied grossly in the form of heat, whereas the basic goal is change at the molecular level. A more subtle and efficient approach is to bring about interaction directly at the molecular level using electrons, ions, or photons. For example, electron processors can be used to dry suitably formulated paints instantaneously with no significant increase in temperature and using much less power than with the more traditional ovens. There is generally no effluent problem, as the material being processed is almost 100 percent solid, whereas many thermal drying processes involve evaporation of the solvent. A major limitation to the application of the process is betrayed by the phrase "suitably formulated," although the radiation chemist has already produced many useful products, and a number of companies are already using electron beam processing. Another area where electrons can radically reduce power requirements is in product sterilization, which is often accomplished by the application of heat. The science of electron, or radiation, sterilization is fairly well understood, at least pragmatically, and lethal doses can be delivered to bacteria with a relatively small expenditure of energy.

Intense electron beam bombardment can also be used for the efficient application of heat, for example, when metal strip has to be heated to annealing temperatures. Here, electron beam bombardment generates the heat directly in the product, and the problem of efficient heat transfer in a large oven is removed. One disadvantage in such an application of electron beam technology is that the product must be treated in a vacuum, which requires transfer of the product through a vacuum seal or lock. This complication does not apply when the electron beam is used for radiation chemistry, as in the applications mentioned initially. For such applications, much lower beam power levels than for heating are sufficient. These lower levels permit the transmission of electrons through a thin metal membrane without overheating the metal, and thus the beam can pass through a "window" in the vacuum vessel in which it is generated to treat a product in the atmosphere.

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Berg's analysis of some of the "externalities" involved in the purchase of returnable glass milk bottles and analogous items deserves approbation. It is gratifying to see someone recognizing in a widely distributed scientific journal that there are reasons other than ignorance, laziness, or sheer perversity which keep households from being run on ideal ecological principles. Writers who coin phrases like "everything is connected to everything else" and "there is no such thing as a free lunch" choose to completely ignore the effect of the new environmental asceticism on child-rearing practices and the status of women. It is obvious that technology frees many women both to have interests outside the home and to treat their children as human beings rather than as obstacles to getting the housework done; it is at least conceivable that disposable diapers permit a more relaxed attitude toward toilet training, and that detergents, clothes dryers, and no-iron synthetic fabrics give children more chances to play without worrying about getting dirty. Perhaps it is even better for Father to be at home in the evening drinking Coke out of a throw-away bottle than for him to be in the tavern drinking beer out of a glass (*1*). Except in the context of their contribution to overpopulation, women and children are scarcely mentioned in either textbooks or popular writings on ecology. Apparently ecologists tend to share the assumption that once a woman has brought forth her allotted one or two children, she will naturally be home alone with them for 8 to 12 hours a day, and therefore she will have plenty of time to hang clothes on the line or fold diapers or remove plastic wrappings from cookies in the supermarket or shell peas or put eggshells and orange peels on the family compost heap. She will not have an infant who cries 14 hours a day or a toddler who gets bored with staying

inside, and certainly she will not be spending part of her children's preschool years trying to keep up with a profession.

Shortsightedness in this regard is not, to be sure, limited to ecologists. On the other side of the coin, child psychologists and feminist writers, despite their manifold philosophical differences, converge in a fairly uncritical admiration of technology. It seems to be taken for granted that modern society will always be able to provide enough gadgets to give women plenty of time to devote to breastfeeding or writing or teaching a 3 year old to read or political organizing or whatever. To me, it seems rather evident that equality for women and decent treatment for children cannot be made contingent on a maintenance or expansion of the contemporary American middle-class standard of living.

It would, I think, be profitable for anyone who, like me, is attempting a synthesis of Spock and Commoner and Friedan to read some contemporary accounts of what life with children and without technology was really like. According to Quentin Bell, the nephew of Virginia Woolf, an early 20th-century household in which the wife pursued serious intellectual interests required at least one servant per family member (*2*). In Victorian days, even the wife of a poor curate with six children could be expected to employ a 12-year-old servant girl to help with the heaviest drudgery (*3*). Our pioneer ancestresses may have gotten along without help, but even the gentlest and most considerate of them practiced a strict, often severe, arbitrary and puritanical discipline (*4*); and they had to be inured to a high level of infant mortality and crippling illness or injury which they could do very little to prevent.

It seems that the principles of ecology bear very much the same relationship to liberal ideals that Darwinism did to religious faith. I feel, at present, like echoing the cry of the 19th-century Darwinian John Fiske: "If the world's long-cherished beliefs are to fall, in God's name let them fall, but save us from the intellectual hypocrisy that goes about pretending we are none the poorer!" (*5*).

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References

1. B. Commoner, *The Closing Circle* (Knopf, New York, 1971).
2. Q. Bell, *Virginia Woolf* (Harcourt Brace Jovanovich, New York, 1972).
3. G. Eliot, *Scenes of Clerical Life* (Houghton Mifflin, Boston, 1907).
4. L. I. Wilder, *Little House in the Big Woods* (Harper, New York, 1932).
5. P. A. Carter, *The Spiritual Crisis of the Gilded Age* (Northern Illinois Univ. Press, De Kalb, 1971).

Blair raises an important question which I did not explicitly address. The data necessary to evaluate all trade-offs between the energy required to produce energy-saving devices (storm windows, insulation, heat exchangers, and so forth) and the energy savings realizable through their use are not all available. Nevertheless, the limited data now available indicate that use of energy-saving devices is readily justifiable. For example, architects and engineers who have studied energy use in construction find that for each unit of energy required to erect a large office building (including indirect energy use for extraction of natural materials, manufacturing, transportation, and ultimate erection of the building) approximately one unit of energy will be consumed annually to provide services in the building throughout its useful life. Thus, the energy required for building services during the life of a building looms large in importance compared with the indirect "hidden" energy consumption attributable to construction. This is, of course, reflected by the fact that direct consumption of fuel for building services is nearly as great as the consumption of fuel by *all* industrial processes, of which the production of building materials is but one component.

Moreover, the marginal benefits of installing additional energy conservation equipment appear highly favorable. For example, a unit of building insulation (fiberglass, mineral wool, and so forth) that requires one unit of energy to produce can, when properly installed in a building, yield energy savings as high as 25 units of energy per year.

A general rule which is useful in this matter is that the energy required to produce any material or device is but one component of the total cost of bringing the device to market, and is accordingly reflected in the price which the consumer pays for the device. Where economic justification for installing the device is based solely upon the savings to the consumer of

costs of the energy which the device conserves, there is a very high probability that use of the device will yield significant net savings of energy in the economy as a whole. While one can conceive of circumstances in which this rule might not hold, the limited data presently available have not revealed such an example. It would be both interesting and useful to gather more data on the trade-offs between energy of manufacture and energy conserved by conservation equipment, and to develop a better systematic understanding of these trade-offs. However, it is not necessary to wait upon the development of this information in order to justify implementing presently available conservation devices. The indirect (or "hidden") energy expenditures associated with production of these devices appear to be rather small compared with the energy they can save.

It is unclear to me why Ford interprets the costs of solar hot water heat that I cited as representing simply the manufacturer's cost of fabrication. Nevertheless, the data upon which the cost estimates I offered are as follows. Tybout and Löf (*1*) gave a brief survey of solar energy equipment available on the international market (*1*, p. 285). They noted that very simple plastic solar hot water heaters could be obtained commercially in Japan for the U.S. equivalent of $1 per square foot (or $10.75 per square meter) of collector surface area. Further, a professional colleague who recently traveled to Japan examined these devices at my request.

The devices work by batch processing. They are simple, in some respects even crude, and yet they are apparently quite effective. If one were pressed to implement solar-assisted hot water heating immediately, one could import these devices (or copy them), equip them with elementary controls to ingest and discharge batches of water, and install them on existing residences, using the existing hot water tanks for storage. Bearing in mind that conventional domestic hot water heating now operates essentially by batch processing, one can assume that inconvenience to the householder who would adopt solar equipment could be minimized by thoughtful design. Because of the low retail price of these units, it would not seem unreasonable to assume that suitably modified units could be offered to householders at a price in the neighborhood of $18 per square meter.

In addition, Tybout and Löf considered the manufacture of more advanced solar collectors of the type suitable for both space heating and water heating. They noted that the full economies of scale have not been approached in the production of these devices, and estimated that a long-run marginal cost of $2 per square foot (or $21.50 per square meter) of collector surface (installed) for space heating might be expected. If one can assume that equipment suppliers will follow marginal cost pricing, this implies a price to the consumer of $21.50 per square meter for installed collectors. This cost to the consumer is somewhat greater than the figure used in my article, but the collectors to which it applies provide superior performance and probably would not have to be quite as large as those which I considered. It should be reemphasized that existing residences already have hot water storage tanks, and newly constructed units will be equipped with hot water tanks; thus the *extra* cost (to the consumer) of using solar heat for hot water is the installed price of the collector and its controls.

I have received several letters from firms which offer solar energy equipment. In view of the growing interest in solar energy, it might be appropriate to establish a directory of sources of such equipment.

Denholm's comments are most interesting. The general field of tailoring the type of energy supplied to a process to meet the thermodynamic requirements of the process is one in which substantial gains in efficiency can be made. It is reassuring to learn of efforts along these lines.

I am grateful to Bretsky for her comments. I offered the example to which she refers only to point out that certain conservation measures entail broad social implications which extend well beyond the technical aspects of efficient fuel use. Bretsky's examples illustrate this point most effectively, and I look forward to a more complete exposition of her investigations.

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References

1. R. A. Tybout and G. O. G. Löf, *Nat. Resour. J.* **10**, 268 (1970).