DOCUMENT RESUME

ED 067 302 SE 014 914

AUTHOR	Bemiss, Clair W.
TITLE	Teachers Environmental Resource Unit: The Automobile.
INSTITUTION	Brevard County School Board, Cocoa, Fla.
SPONS AGENCY	Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE	72
NOTE	63p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Environmental Education; *Environmental Influences; *Instructional Materials; *Motor Vehicles; Pollution; *Resource Units; Teaching Guides; Technology; *Transportation
IDENTIFIERS	ESEA Title III

ABSTRACT

Environmental problems created by the automobile and intensified rapidly over the past three decades are studied in this teacher's guide. The resource unit is intended to provide the teacher with basic information that will aid classroom review of these problems. With efficient and effective transportation as a goal, topics focus on transportation efficiency, the cost of transportation, the automobile, the automobile and the environment, air pollution, land use, water pollution, improving the internal combustion engine, alternatives to the conventional internal combustion engine, and mass transit. A bibliography is included. This work was prepared under an ESEA Title III contract for the project "Broad Spectrum Environmental Education Program." (BL)

TEACHERS ENVIRONMENTAL RESOURCE UNIT: THE AUTOMOBILE

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TEACHERS ENVIRONMENTAL RESOURCE UNIT:

THE AUTOMOBILE

Developed by the

ECONOMIC/MORAL ENVIRONTEAM

as a portion of the

Title III, ESEA Project DOE, #050-72003

"BROAD SPECTRUM ENVIRONMENTAL EDUCATION PROGRAM"

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The work presented or reported herein was performed pursuant to a grant from the United States Office of Education, Department of Health, Education, and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the United States Office of Education, and no official endorsement by the United States Office of Education should be inferred.

INTRODUCTION

In July 1899, Scientific American published the following comment on "motor cars:"

> The improvement in city conditions by the general adoption of the motor car can hardly be overestimated. Streets clean, dustless and odorless, with light rubber-tired vehicles moving swiftly and noiselessly over their smooth expanse, would eliminate a greater part of the nervousness, distraction, and strain of modern metropolitan life.

In October 1970, Business Week took this view of the automobile:

> Watching the endless stream of cars and trucks whizzing by on a busy freeway - or, more typically, lurching and stopping - it... seems... as if all anyone really is doing is consuming transport without purpose or destination... If any more land is to be committed to transportation in the megalopolitan areas, it is going to be at the expense of a lot of things that many people consider more desirable and more urgent - housing, greenbelts, recreation facilities.

The environmental problems created by the automobile have intensified rapidly over the past three decades. This resource unit is intended to provide the teacher with basic information that will aid classroom review of these problems. Our youth must begin to take part in a careful examination of the process of economic and social change that increased awareness of critical environmental needs has brought about. As the unit is written new ideas are being generated and new data is being published. What economic decisions transpire even on a daily basis will add new insight to the information contained in the unit. But we must choose a point to begin.

TABLE OF CONTENTS

Note: This entire unit is printed on 100% recycled paper.

I. OVERVIEW

A. TRANSPORTATION EFFICIENCY

It has become increasingly apparent during the last decade that transportation in the United States is so abundant that most of it isn't used efficiently or effectively. A recent Business Week article summed up the situation like this:

> ...In the 19th century land seemed to be infinitely available, and transportation could grow as fast as the needs of the expanding economy required. Railroads spread out to tap every conceivable population center and reach any farmer who could bring his crops to a railroad siding.
>
> Then, without an appreciable amount of track being picked up, the world's most sophisticated network of highways and superhighways was built. Finally, without any cessation of highway building, the world's most crowded airway and airport system was superimposed on all the rest.[1]

Clearly the most inefficient user of land and air is the automobile. The auto is the number one contributor to air pollution. Most cars were built to carry from four to six passengers, but the national average for passengers per trip is 1.6. Many have begun to criticize the manner in which highways have eaten up valuable land without effectively solving transportation needs. Secretary of the Interior John A. Volpe has pointed out that "a road can create more problems than it solves, if it simply causes massive congestion by pouring automobiles into a downtown bottleneck."[2] According to Helen Leavitt, author of Superhighway - Superhoax, "one-third of the land in fifty-three central cities in the United States has been converted to street use." In

Minneapolis, 50 per cent of the land is devoted to the automobile. In downtown Los Angeles 66 per cent is taken up by parking lots and streets. Commenting on Leavitt's statistics another author stated, "that's like giving half your home over to hallways and shoeracks."[3]

To a lopsided degree the private automobile does most of the passenger transporting in the United States. In 1965, 82 per cent of all workers went to work by car, and most of the rest by bus.[4] Automobiles presently account for 86 per cent of all travel between cities and for more than one-half of all trips of more than one-thousand miles. The airline industry currently accounts for less than 10 per cent of intercity passenger miles while passenger travel on railroads has depreciated to a point where federal funds have been provided in a last ditch effort to revitalize the industry. (Although most freight still moves by rail and barge, trucks monopolize the local distribution of goods.) Annual travel per capita, which came to 400 miles in 1916 and 2,000 miles in 1940, approached 7,000 miles in 1969. According to the latest Environmental Protection Agency figures, the average distance driven by an automobile in a year is 10,600 miles.[5]

In terms of land use efficiency each mode of transportation uses a larger or smaller portion of the earth's surface. The following chart illustrates this point:

Auto: A transportation corridor one highway lane (12 feet) wide can carry a maximum of 3,600 passengers per hour.

Bus: Half-filled buses can carry 60,000 people per hour - seventeen times as many as the car.

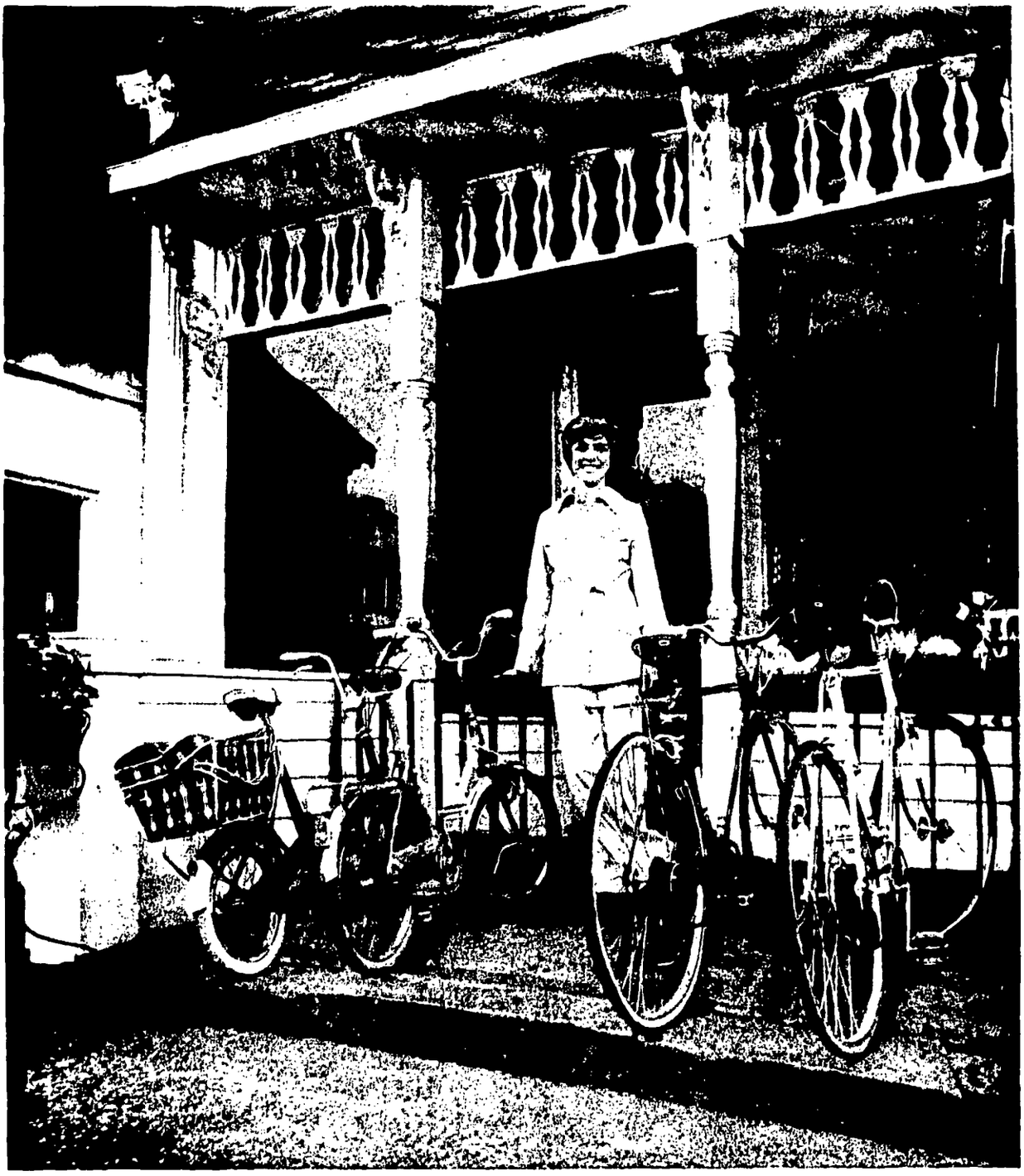
Train: Trains, half-filled, will transport 42,000 passengers per hour - twelve times the number handled by the auto.

Bicycle: A highway lane can comfortably hold two bicycle lanes, allowing passage of 10,600 people per hour - almost three times as many as cars.

Walking: A path the width of a highway lane can accommodate 6,300 walkers per hour - almost twice as many as automobile passengers.[6]

SOURCE: Kenneth P. Cantor, "Warning: The Automobile is Dangerous," The Environmental Handbook, ed. Garrett De Bell, New York, Ballentine Books, Inc., 1970 , p. 200.

The degree of personal freedom and convenience that the automobile provides has seldom been questioned. The complete freedom of private transportation has been considered an "inalienable right," but the ultimate amount of ground space that is available is forcing a reconsideration of this assumption. This year, Russell E. Train, chairman of the White House Office of Environmental Quality, said, "There will have to be changes in traffic patterns, in the freedom to use automobiles in downtown areas."[7] Compulsory car pooling has been recommended as one possible solution to congestion and pollution problems. Some cities, such as New York, have already barred the automobile from certain streets.



Ruth Henderson takes a stand for her country.

Up with bikes. Down with cars. It's more than just talk in Dry Dock Country where Ruth Henderson, of Daly's Dandelion at 61st and 3rd, has installed a bike rack to encourage bikers.

"I hope that our bicycle rack will be an example for everyone to put up bicycle racks," says Mrs. Henderson. "I think it would get more people to bike and that means less cars, less congestion, less pollution and less grim faces. It seems people on bikes smile more."

That's Dry Dock Country for you. Not just some of the best stores, restaurants and theaters, but also concerned citizens, doing something to make New York a better place.

Isn't it great to bank where almost everyone cares?

Dry Dock Country.

3 Great Days with Chevrolet.

(May 25.26.27.)

Remember, buckling your seat and shoulder belts is an idea you can live with.

Impala Custom Coupe *Chevelle Malibu Coupe*

See your Chevy dealer during his 3 Great Days. Get a great buy on any Chevrolet in stock. Immediate delivery.

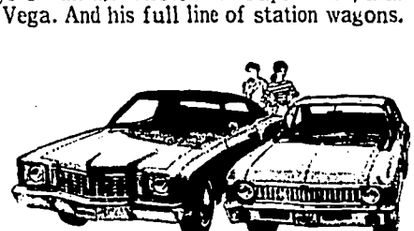
Summer's just around the corner. In fact, for many Americans summer traditionally starts on the Memorial Day weekend.

That's why your Chevrolet dealer is celebrating May 25, 26 and 27 with a special "3 Great Days with Chevrolet" selling event.

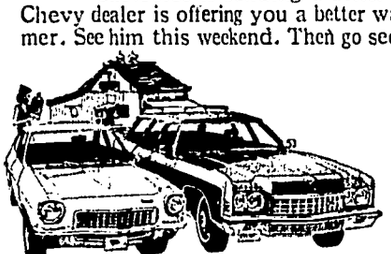
He's offering great buys on all his Chevrolets. Caprice. Impala. Chevelle. Monte Carlo. Nova. Vega. And his full line of station wagons.

Right now his stock of new cars is broad and diversified. So bring in your old car, get a great trade-in allowance and drive home in your Chevrolet.

Chevrolet is building a better way to see the U.S.A. And your Chevy dealer is offering you a better way to get a running start on summer. See him this weekend. Then go see the U.S.A.

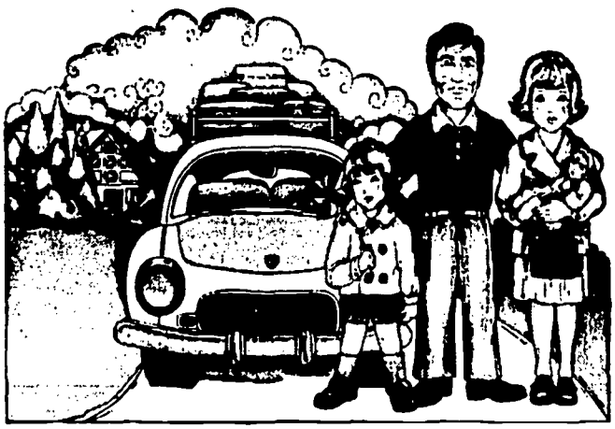


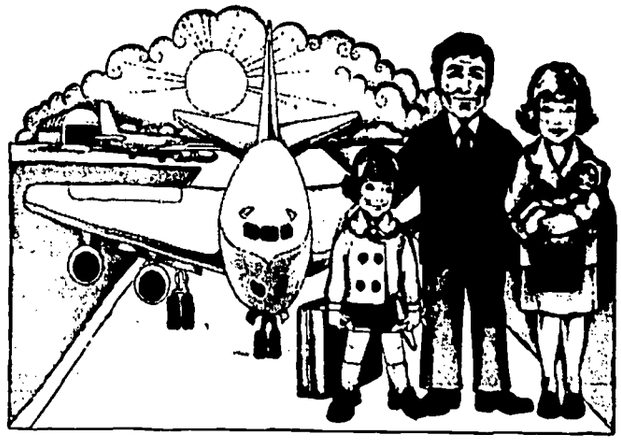
Monte Carlo Coupe *Nova Coupe*



Vega Hatchback Coupe *Kingswood Estate Wagon*

Building a better way to see the U.S.A. Chevrolet





The Wheels of Man vs. The Wings of Man.

In all fairness, there are certain advantages to taking the family car along on your family vacation.

For one thing, you can stop whenever you want to. At the rest rooms. To stretch your cramped legs. To empty the litterbags. And at the rest rooms.

Then too, there's the togetherness of the whole family all cozy and warm in the same 12 square feet of space, for maybe three days going and three days coming back. Not to mention the economy. Based on average figures a family of four can drive to Miami and back for about $447 in motels, gas, food and tolls.*

Those are the advantages. And obviously we wouldn't remind you of them if we didn't believe we could top them. All of them.

We get you there faster, but you'll have to pay less.

For a family of four, you'll pay $330 to fly to Florida for a week. Adults pay $110 each, coach excursion rates, and children under 12 fly half fare, any Tuesday, Wednesday or Thursday.

And your vacation really begins the minute you step on the plane. The kids can stare at the clouds and play with the puzzles in our special magazine. You can read, or snack, or just put your head back and dream about all the terrific things you'll be doing in a couple of hours.

You'll have time for Walt Disney World and Miami.

The three days you would have spent driving, you can spend exploring Walt Disney World, with free admission to the Magic Kingdom and nearly $20 worth of free tickets to attractions for each member of the family. You'll have two nights at a selected motel in Orlando, then you're off to Miami at your choice of eleven selected beachfront hotels and motels, for six shining days and five nights.

The total cost per adult (when two share a room) is from $122.50 to $165 which even includes breakfast and dinners in Miami. And special children's rates are available. (4% Florida tax, 2% Miami Beach tax, and air fare not included.)

You'll have time for a picnic by the sea.

The time you didn't spend getting there is time to look for beach treasures. Time to savor every morsel in the picnic basket the hotel gives you, then share the last crumbs with the seagulls. There's a zoo nearby. A sequarium a nice bike-ride away. And nice bikes to be used, free.

Each adult pays $70 for eight days and seven nights (when 2 share a room) and children under twelve can share it for free, at the Sonesta Beach Hotel in Key Biscayne. (4% Florida tax and air fare not included.)

You'll have time to improve your golf score.

Each day you didn't spend driving down is another 18 holes on the championship golf course at Tarpon Springs. That's for you. The kids have their own miniature golf course as part of the $50,000 recreation area for children.

There's no charge for your first six days of green fees (18 holes a day). Or the golf cart. Or the tennis courts. Or the saunas. Or your Avis subcompact except for gas and insurance. It will take you the 90 miles to Walt Disney World. And your bonus books will get you in and onto nearly twenty dollars' worth of rides for free.

Each adult pays $224.50 for 8 days, 7 nights when two share a room. And children under twelve share the room for free at the Innisbrook Resort and Golf Club. (4% Florida tax and air fare not included.)

You'll have time to laze around the villa.

At Duck Key, you can have breakfast in your pajamas, in your own kitchen, in your own villa. Each marina villa has a parlor, bedroom, and bath as well, so all you need to set up housekeeping is food.

A family of four can share a villa for $241 for 8 days, 7 nights. Or how about a cottage on a waterway with a parlor, two bedrooms, a kitchen, and of course your own dock. A family of four can share a hotel for $321 a week.

At the Indies Inn Hotel in Duck Key, you'll have 36 holes of golf free, and the kids will be welcome guests at Flipper's playground. Parents and two children share a deluxe double room for $210 a week. (4% Florida tax and air fare not included.)

You'll have time to enjoy each other.

And it will be good time too. Because little people won't be bored from sitting too long. And big people won't feel badly about saying "Don't bother the driver." And none of the cranky things that occur when people have been driving too long will happen. Nice things will happen. They always do when you have time for them.

All you do is call your travel agent or Eastern at 986-5000 in New York or 621-2121 in New Jersey. Ask about the low mid-week rates and half fares for kids. Check on our daily service to Florida. Eastern has the most non-stops to Miami including L-1011 Whisperliner service and the most nonstops to Orlando and Tampa. Then tell them you want a summer to remember for you and yours. Eastern will make sure you get it.

EASTERN The Wings of Man.

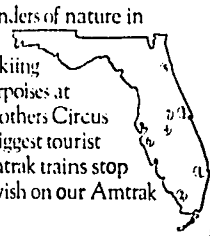
NOW GET A CAR FOR A WEEK ON US ON AMTRAK'S SPECIAL FLORIDA OFFER

Starts April 17

Amtrak's **"Free Wheels"** plan gives you the best of both worlds for a Florida vacation. (For a family or for any three full fares traveling together.) You start with an easy relaxing train trip instead of a long tiring drive. By coach in reserved reclining seats or first class in private-room accommodations. Then when you get to Florida, rested and refreshed, you have a Kinney-Universal rent-a-car reserved for seven whole days to do all the sightseeing you wish. No daily charge. No mileage charge. You pay for the gas. This year enjoy the newest and best Florida vacation ever with Amtrak's "Free Wheels."

All Florida is yours to explore on your "Free Wheels" vacation

1 Miami's fabulous Gold Coast. 2 The wonders of nature in the Everglades. 3 The wonders of space at Cape Kennedy. 4 The spectacular water skiing at Cypress Gardens. 5 The performing porpoises at Marineland of Florida. 6 The Ringling Brothers Circus Museum at Sarasota. 7 The newest and biggest tourist attraction — Walt Disney World. (All Amtrak trains stop nearby.) Go where you want, see all you wish on our Amtrak "Free Wheels" week.



Amtrak's "Free Wheels" Plan. Here's how it works:

1 The purchase of three full round-trip "Free Wheels" fares [illegible] (for instance two full fares and two half fares for children) entitles you to a 1972 Maverick, Hornet or similar [illegible] seven days in Florida. A minimum of [illegible] full fares or the equivalent entitles you to a larger car such as a 1972 Ford T[illegible] [illegible] also for a week.

2 Our "Free Wheels" plan gives you an option of three train fares. You can use our 6-month-limit round-trip coach fare. Our 6-month-limit round-trip first-class fare. Or, lowest of all, our 30-day round-trip Excursion Fare which amounts to only $96.65 per person from New York or Newark.

3 Passengers electing to use our 30-day round-trip Excursion Fare to get their "Free Wheels" car must originate both their southbound and return trips on a Monday, Tuesday, Wednesday or Thursday. Passengers going on our 6-month fare may travel any day in the week.

4 When you purchase your "Free Wheels" train tickets, you will receive coupons entitling you to a car for seven days in Florida. And that car is guaranteed.

The auto renter must be at least 21 years old and have a valid driver's license.

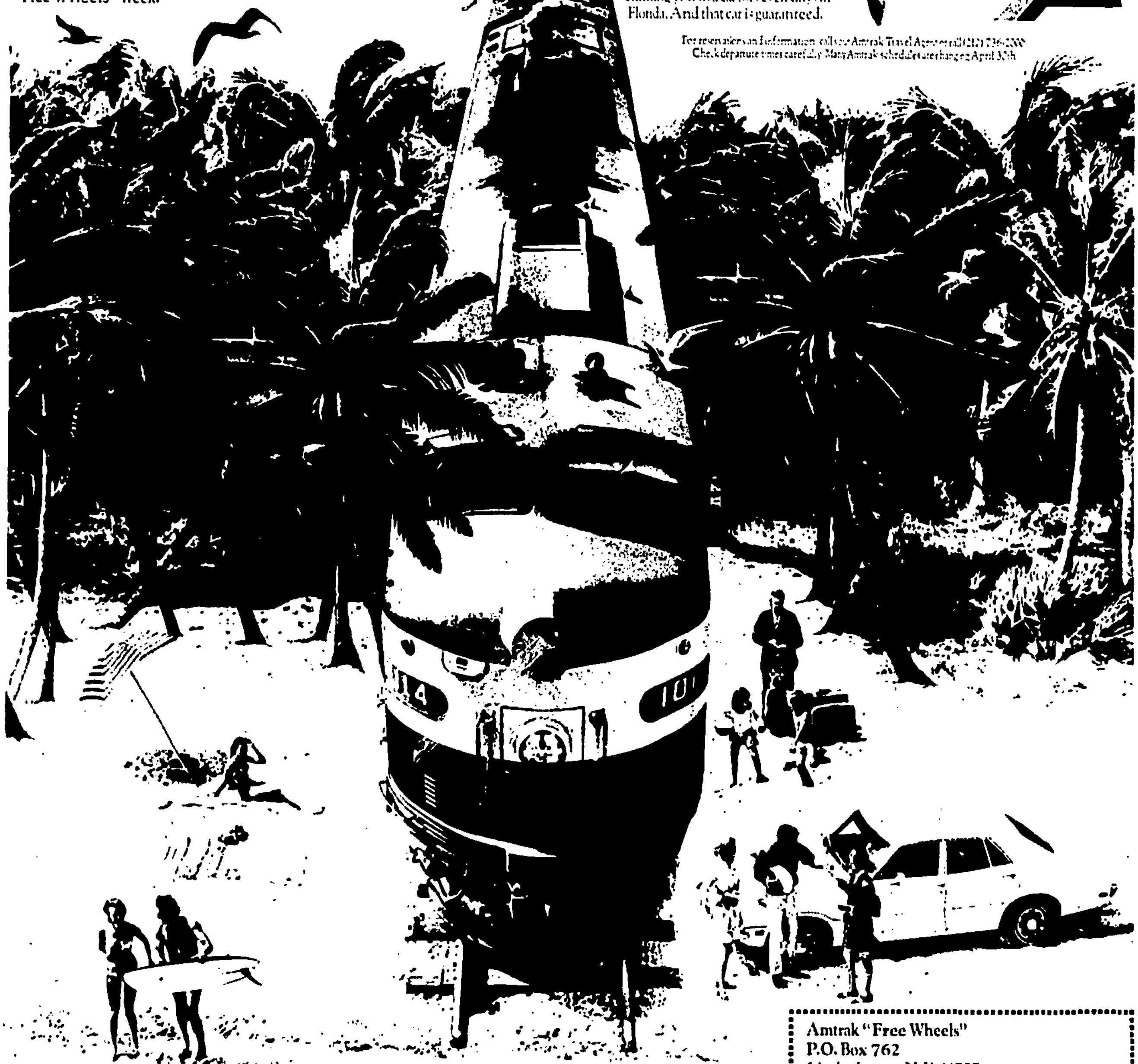
5 During your "Free Wheels" week you can drive your car [illegible] within Florida without mileage charge. All you pay for is the gas you use, a state [illegible] and local tax, and any additional insurance you want above the [illegible] coverage provided with your car.

6 In Florida, cars may be picked up and dropped off at Orlando, Tampa, St. Petersburg, West Palm Beach, Ft. Lauderdale, Hollywood and Miami. They may be picked up at one point and dropped off at another without charge. And, if you wish to keep your car beyond your first week at your own expense, you can make arrangements to do so wherever you pick up your car.

We're making the trains worth traveling again.

Amtrak

For reservations and information call your Amtrak Travel Agent or call (212) 736-[illegible]
Check departure times carefully. Many Amtrak schedules are changing April 30th.



Amtrak "Free Wheels"
P.O. Box 762
Lindenhurst, N.Y. 11757

Please send me details of your "Free Wheels" plan along with information about Florida trains. I plan to go about ______ (date)

Name ______
Street ______
City ______ State ______ Zip ______
Phone ______ NYT1

B. THE COST OF TRANSPORTATION

Transportation in the United States has expanded year after year, accounting in 1970 for about 20 per cent of the Gross National Product, or approximately $200 billion (almost as much as the GNP of Japan). Over the past twenty years the figure has added up to $2.3 trillion.[8] Expenditures include everything from freight bills, passenger tickets on railroads, boats and airplanes, to the purchase of automobiles, trucks, tires, and gasoline.

In 1970, $109 billion was devoted to strictly passenger transportation, with only $13 billion of that sum channeled into public transportation facilities, (buses, airlines, trains, and transit lines).[9] By far the majority of money spent on moving people around goes for highway transportation, and most of this is directly related to the individually owned and operated automobile. Approximately $5 billion was committed to commercial ground transportation in 1970, while $93.5 billion was used to purchase, fuel, insure, repair, park, clean, and build highways for the automobile.

The automobile is the most expensive item that most Americans buy apart from a house. Operating a car entails an average annual cost of $1,400. Evidently convenience and service support a very high price. Those who feel that its convenience still outweighs the environmental problems it has created are backed by some of the powerful lobbies that pressure the U.S. government. These include car manufacturers, tire producers, highway builders, and gasoline companies. Yet, public concern over highway safety and environmental degradation has made it easier for the government to adopt a tougher stance toward the entire industry. One prominent industry spokesman has publicly recognized that "people are

ready for more legislation. We [the industry] should assume this and be aware of it."[10] With the adoption of tough Federal guidelines for abatement of air pollution directly related to the automobile it is no longer a question of whether the government will find it necessary to invervene in the design of automobiles, but how much the public will demand that it do so. The public is then faced with how much it is willing to pay for automobiles with improved emission controls. The industry has used this point to argue against the 1975-76 federal emission control deadlines. Edward N. Cole, president of General Motors recently stated:

> General Motors does not know whether or not it will be able to meet these standards - and others, as well as ourselves, are concerned with whether the additional cost to consumers for such standards, which have questionable data to support them, is justified.[11]

The National Academy of Sciences has estimated that the additional emission control equipment needed to meet 1975 emission standards will add $288 per vehicle to the cost of 1975 models over and above 1973 costs. There will also be increased fuel and maintenance costs.

Some argue that it already costs the nation about $13 billion to contend with environmental and safety problems created by the automobile. Air pollution may cost the nation more than $11 billion a year, and cars cause at least half the pollution. Automobile accidents not covered by insurance have added up to about $6 billion a year, and many point out that free parking on congested city streets represents a subsidy of several billion dollars to car owners. But total cost estimates are difficult, if not impossible to calculate.

As one author commented, "In fact, the automobile has shaped our whole style of life and structure of cities. It is impossible to calculate its total cost to society - or the value of the flexibility and convenience it brings."

C. THE AUTOMOBILE POPULATION

At present rates of production there are two automobiles produced for every baby that is born. By the end of 1972, there will be well over eighty-five million private autos powered by the internal combustion engine on U. S. highways. If both light and heavy-duty gasoline powered trucks are included, the figure is a little more than 100 million according to the Environmental Protection Agency. (There are 2 million automobiles in Russia and a total of 100 million in all the world outside the United States.) The Agency projects that by 1976 the number of gasoline powered vehicles will be close to 114 million (see chart on following page). Other projection figures say that by the end of the century the total number of vehicles in use in the United States may be between 200 and 250 million.[12]

In 1900, 4,192 automobiles were sold. By 1920 the number of sales totaled 1.9 million. Increased demand for cars prompted construction of better roads, which in turn increased demand for cars. World War II stimulated road building in the name of national defense and set the stage for remarkable increases in sales. In 1965 a record 9,300,000 autos were purchased. In 1968, the number was 9,600,000 but this was surpassed in 1971 when 10,200,000 new cars were sold.[13] Current figures indicate that 1972 will be another record year.

Fiscal Year	Numbers of Vehicles in Use (Millions)		
	Autos & Light-Duty Trucks	Heavy-Duty Gasoline Trucks	Total
1967	81.8	5.3	87.1
1968	84.6	5.7	90.3
1969	88.3	5.9	94.2
1970	90.7	6.0	96.7
1971	92.2	6.1	98.3
1972	94.9	6.2	101.1
1973	97.5	6.4	103.9
1974	100.1	6.6	106.7
1975	103.9	6.8	110.7
1976	107.2	7.1	114.3

SOURCE: The Economics of Clean Air, Report of the Administrator of the Environmental Protection Agency to the Congress of the United States, Washington, U.S. Government Printing Office, 1971, p. 3-5.

In 1971 the automobile industry projected unit sale increases averaging 3.5 per cent a year over the next decade (a total market growth of some 40 per cent). At that rate, Detroit can expect to add 11,300,000 new automobiles to the road in 1975 and 13,200,000 in 1980.[14] How these figures will be modified

THERE ARE TWO CARS PRODUCED FOR EVERY BABY BORN

by emission control regulations, changes in engine design, and the attitude of the public remains to be seen. Dan Cordtz, writing for Fortune magazine, comments:

> ...Time-honored formulas may now be overmatched by an array of elements that nobody has learned to qualify or even to anticipate accurately. And so another point has to be made about the standard forcast: it is ventured with less confidence than it used to be.[15]

D. SUBURBIA AND THE FAMILY CARS

The railroads encouraged urbanization by offering fast travel between selected cities. The automobile has encouraged dispersal or suburbanization. In the United States the suburban population is now larger than that in the center of cities or in the countryside. Since most suburbs were not planned with adequate public transportation facilities the automobile has remained the primary source of transportation. The trouble is that just as cities were not built for the automobile, many suburbs were not built for an age in which most families would own two. The following statement is not uncommon:

> You could get along without a car living downtown, but I'd go mad without mine. I'd have to shop at night and give up my teaching in the city if we had only one car. Linda couldn't take music lessons, and Ben and Amanda couldn't have friends outside the immediate neighborhood. Certainly, a second car can be an expensive nuisance, but my station wagon makes it possible for us to do what we want to do.[16]

The traffic from one suburb to another is increasing rapidly. Martin Whol, director of transportation studies for the Urban Institute points out that traffic no longer tends to concentrate on the most centralized metropolitan

areas. In Manhattan, for example, "half the cars going through the Lincoln Tunnel into New York at the morning rush hour simply cross Manhattan and go somewhere else."[17] New jobs and living conditions have made the suburbs attractive, but numerous experts contend that by the 1980's weekend congestion created by leisure alone will be as bad as rush hour congestion during the week. One critic of the automobile stated:

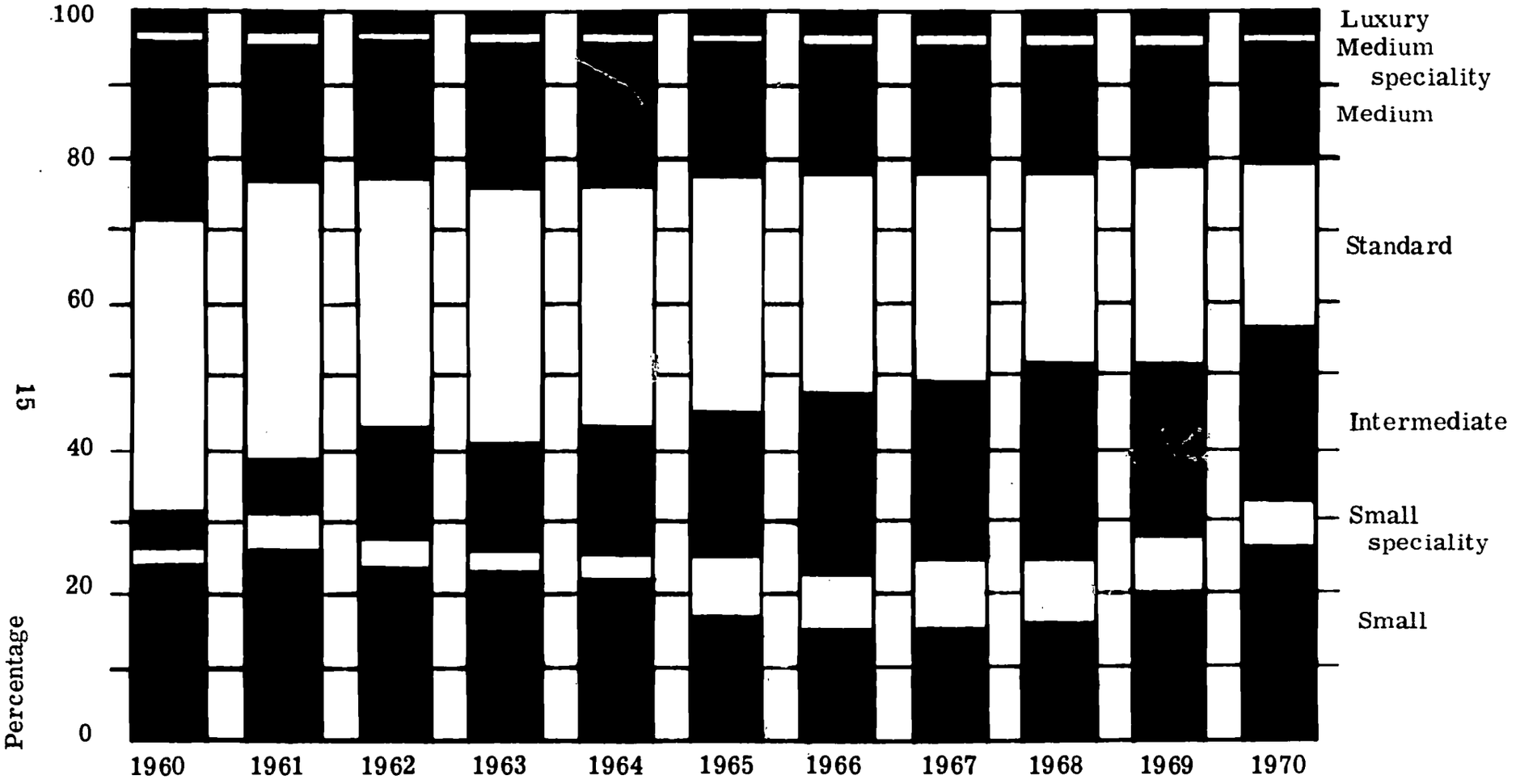
> In using the car to flee from metropolis the motorist finds he has merely transferred congestion to the highway and thereby doubled it. When he reaches his destination, in a distant suburb, he finds that the countryside he sought has disappeared: beyond him, thanks to the motorway, lies only another suburb...[18]

Another made the following observation:

> The suburb and private motor car are locked in an embrace of destruction. We must start thinking about phasing out both of them. Higher density living arrangements, such as cluster developments, leave large areas of open space and agricultural lands untouched... They allow for rational transportation alternatives. Within the human habitat, the foot, the bicycle, perhaps the minibus, for greater distances, the train or bus.[10]

Congestion is intensified by the rising demand for second and third cars. The present trend indicates that suburban living combined with increased personal income means increased multiple car ownership. With the lack of adequate alternatives housewives and teenagers are moving out onto the highway with automobiles purchased to meet their own individual transportation needs. The proportion of households without a car continued to decline during the 1960's, and is now only about 20 per cent, while multiple

AUTOMOBILE SPENDING PATTERNS ARE CHANGING



SOURCE: Dan Cordtz, "Autos: A Hazardous Stretch Ahead," Fortune, April 1971.

car households added more than 9,000,000 to the automobile population. Virtually, all of the growth the automobile industry expects to achieve during the 1970 decade will be concentrated in the suburbs and will be designed primarily to meet the demands of two and three car families. General Motors' projections for new car sales are based on the expectation that 47 per cent of all Americans will live in suburbia by 1980 and that they will have a disposable personal income of over a billion dollars (double the present figure).[20]

In a dispersed population of car owners it is difficult to run buses and trains commercially. The traffic pattern of almost every metropolitan area - not just Los Angeles - has become so random that installing mass transportation facilities has been viewed as too difficult and costly. Attempts are being made however. San Francisco recently cancelled proposed freeway construction in favor of the BART system (Bay Area Rapid Transit) that will go into operation in late 1972. Washington D.C. has begun construction on its Metro system that will provide public transportation between the central city and the suburbs. Many other major metropolitan areas are beginning to initiate similar proposals.

E. ATTITUDES TOWARD THE AUTOMOBILE

Henry Ford II recently made the following comment about automobiles:

> It has been said that the American people have for more than fifty years had a "love affair" with the automobile. I believe that is true and, generally, I think the affair continues. But its persistence is only partly attributable to "cosmetics" - styling changes, performance images and all the rest. It isn't just the car that is the object of America's affections - it's the mobility.[21]

Indeed, the automobile has provided a high degree of personal freedom in the form of door-to-door, no wait, no transfer, private and flexible route service, (the automobile has sometimes been called a "mobile living room") but changing economic, demographic, environmental and social conditions have begun to alter the degree to which the automobile can continue to meet this need. The high position that the private car has held as a possession and symbol of social status has also begun to decline. Some of the interrelated questions that are linked to the changing perception of the automobile and that inhibit accurate industry sales projections are listed below:

(1) What will the future number and size of families be?

(2) How many persons will choose to work and how hard will they be willing to work?

(3) Will the propensity to take the fruits of increased productivity be in the form of increased leisure rather than consumption?

(4) To what extent will Americans embrace an emerging anti-materialist ethic that is opposed to conspicuous consumption?[22]

(5) To what degree will awareness of environmental issues change consumer habits and how soon will the change take place?

One study conducted in the late 1960's indicated that "the car has increasingly become a means for serving important ends, rather than the highly prized possession it once was in the United States and still is in much of Europe."[23] Donald E. Peterson, vice president of car planning and research for Ford's product development group stated in 1970 that "more and more people view the automobile as an unfortunate necessity. As you are viewed more as a necessity, people are less tolerant of your shortcomings."[24] Some describe the change in attitudes as primarily youth oriented:

> Many people - especially better educated, higher income young adults - now view their cars in a more rational, more matter of fact, and less emotional way. They see the car as equipment that gets them, more or less comfortably, from here to there; they are less susceptible to the industry's traditional sales pitch, which has often been directed to status-conscious households and has encouraged them to trade up to the limit of their ability.[25]

The number of "big" car sales has not kept pace in recent years with the number of households that were once considered prime targets for the industry's advertising campaigns. A Ford study completed in 1970 confirmed a "significant negative attitude" toward Detroit, pointed out a credibility gap in advertising claims, and indicated that people are less tolerant of the many "nonfunctional" design changes that are made from year to year. This point has important consequences for the environmental movement. As Sterling Brubaker points out in his book To Live on Earth:

> The environmental movement shares with the consumer protection movement a concern about the quality of goods. We live in a disposable society. Not only do nondurable goods generate much of our solid waste problem; we find also that many of our durable goods are all too disposable. Our worship of fashion and change is one root of the problem. Products are not built to last, minimal attention is given to repairability, and repair may be neglected, all on the assumption that we will want something new. In consequence we have the added environmental burden of needless production and the problem of disposing of discarded merchandise. Our classic example is the automobile industry where at great cost we retool for frequent model changes that rarely incorporate new engineering. Even those consumers who resist the blandishments of Madison Avenue and seek to buy quality find the market ill-equipped to serve them and cannot shop knowledgeably

> among the welter of products where technical information would be necessary to a rational judgment.[26]

Americans are becoming less concerned with automobile "cosmetics," and more concerned with quality, but it appears a large majority still want the mobility cars provide. As explained above, part of the decline in prestige car sales can be attributed to the rising demand for second and third cars, which tend to be small. The American industry has had to hustle to keep up with European and Japanese competition whose imports captured about 15 per cent of the market in 1970. Smaller cars will help to reduce noxious emissions, but it is clear that more long term solutions must be sought to automobile pollution problems.

Changing attitudes toward the automobile may have important psychological consequences. As one article points out, "Psychologists have claimed that humans have a basic need to move about under their own control, to 'locomote' themselves. This need is not basic to humanity, but is peruliar to Americans. Europeans use public transit en masse and in good health. It is more likely that we have just been thoroughly sold on owning and operating our own conveyance."[27] Another author makes the following observation:

> Automobiles insulate man not only from the environment but from human contact as well. They permit only most limited types of interaction, usually competitive, aggressive, and destructive. If people are to be brought together again, given a chance to get acquainted with each other and involved in nature, some fundamental solutions must be found to the problems posed by the automobile.[28]

II. THE AUTOMOBILE AND THE ENVIRONMENT

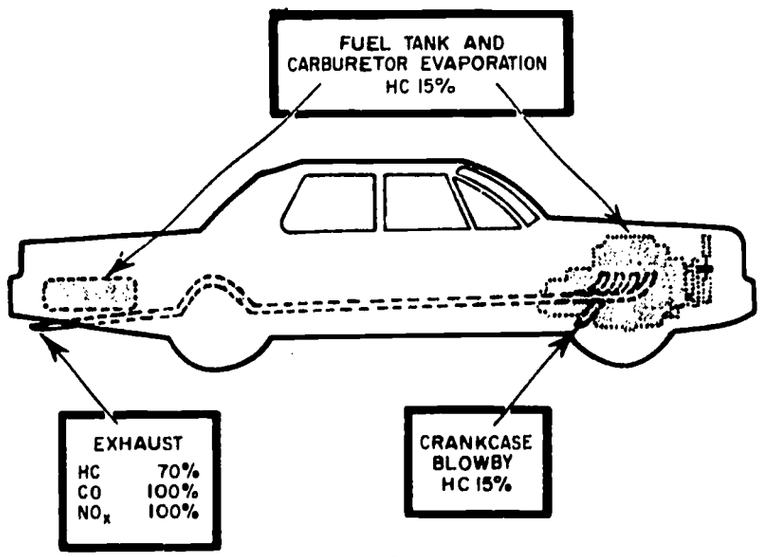
A. AIR POLLUTION

All forms of power production that burn fossil fuels, whether an electric power plant or an internal combustion engine, pollute the air by adding substances that weren't there previously. About 60 per cent of all pollutants added to the air in the United States come from the internal combustion engine. These include hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x), and lead. Sixty per cent is, however, a national average. In major urban areas the level of automobile pollution can be as high as 85 per cent. This is because the number of automobiles is greater and the internal combustion engine performs at its worst in stop and go traffic. Washington D.C., for example, attributes 80 per cent of its air pollution problem to the automobile, while Los Angeles blames the car for 85 per cent of its problem.

The gasoline that the internal combustion engine burns is composed of various size hydrocarbon compounds. Smaller compounds are used in starting the engine, larger ones to keep it going during warm-up, while the largest are utilized at high speed. It is the uneven and incomplete combustion of these compounds that create carbon monoxide and hydrocarbon pollutants. Both are emitted primarily in the exhaust, although hydrocarbons also result from fuel tank and carburetor evaporation as well as crank case blow-by and leakage. Nitrogen oxides are produced as a result of high combustion temperatures. Atmospheric oxygen and nitrogen combine in the engine to form nitrogen oxides that are emitted in the exhaust. The major

technical problem in effectively stopping all automobile pollution results from the fact that increasing combustion efficiency in order to reduce hydrocarbon and carbon monoxide emissions increases the levels of nitrogen oxides formed. Although the technology to promote more complete combustion is available, there does not appear to be an immediate solution to the nitrogen oxide problem.

APPROXIMATE DISTRIBUTION OF EMISSIONS BY SOURCE FOR A VEHICLE NOT EQUIPPED WITH ANY EMISSION CONTROL SYSTEMS



SOURCE: The Economics of Clean Air, Report of the Administrator of the Environmental Protection Agency to the Congress of the United States, Washington, U.S. Government Printing Office, 1971, p. 3-3.

The source of lead pollution from the automobile is the particulate matter emitted in the exhaust. Particulate matter consists of carbonacious material, salts and oxides of iron and lead, and droplets or particles of

hydrocarbon materials. Lead compounds constitute about 80 per cent of the particulate matter.

The level of emissions of carbon monoxide, hydrocarbons, and nitrogen oxides from the automobile and other forms of transportation in 1969 are given by percentage in the following chart:

Source *	CO	HC	NO_x
Motor Vehicles	64.7	45.7	36.6
Other forms of Transportation	9.0	7.2	10.5

SOURCE: Annual Report of the Environmental Protection Agency to the Congress of the United States, In Compliance With Section 202 (b) (4) Public Law 90-148, The Clean Air Act As Amended, July 9, 1971, p. 4-1.

*These figures are averaged over the entire U.S. and compared to all other sources of air pollution.

A brief description of the environmental effects of automobile air pollutants is given below:

1. Carbon Monoxide

Carbon monoxide is a colorless, odorless, and poisonous gas. It dilutes rapidly in the atmosphere, but because it is created by the incomplete burning of almost any substance (including tobacco) it is accompanied by other pollutants and is used as an approximate gauge of air pollution.

Carbon monoxide is absorbed through the lungs, reacts primarily with the hemoglobin of the blood, and robs the body of oxygen. Some doctors contend that prolonged exposure to even low levels of carbon monoxide is dangerous

to heart patients because the heart must work that much harder to supply oxygen to the blood. According to one source:

> Drivers and pedestrians on busy streets often are exposed to from 10 to 100 parts per million. Some studies indicate that 10 parts per million over a period of eight hours may dull mental performance. Researchers at Stanford University have found that CO levels of 50 parts per million for 79 minutes can affect judgment and hearing.[29]

2. Hydrocarbons and Nitrogen Oxides

Hydrocarbons have been linked to cancer by some researchers, but complete information on its health effects is limited. Information on the health effects of nitrogen oxides is also limited, but some research has indicated that children who are exposed to this pollutant more readily develop respiratory problems.

Both hydrocarbons and nitrogen oxides are key elements in the formation of photochemical smog. In the presence of sunlight they are broken apart and release their oxygen atoms. Some of these oxygen atoms combine with other pairs of oxygen atoms to form the unstable gas ozone. Ozone can kill in high concentrations. In small concentrations it irritates the nose and throat. It has also been linked to crop destruction. Hydrocarbons also combine with oxygen molecules to create peroxyacyl nitrates. Peroxyacyl nitrates cause eye irritation and also damage plants. Ozone and peroxyacyl nitrates can also combine to create more smog problems. An essay on air pollution stated the following:

> As long ago as 1949, air pollution in Los Angeles County caused damage to crops amounting to almost half a million dollars. Its most serious effects were on leafy greens such as lettuce

> and spinach. Estimates of the 1961 crop loss in California were eight million dollars, quite a bit of food. There is little available current information on the subject, but we can be sure that today's losses are far above those of nine years ago. Today spinach and a few other vegetables cannot be grown in the Los Angeles basin, and many of those which can are stunted and unhealthy because of the air pollution. A recent survey shows that smog is killing 100,000 acres of Ponderosa and Jeffrey pine trees in the San Bernadino National Forest sixty miles away from Los Angeles proper.[30]

Dr. Harris M. Benedict, a plant physiologist at the Stanford Research Institute in Irvine, California, estimates that the damage to plants from air pollution may cost the United States in the area of $280 million a year. There is little doubt that smog does damage vegetation and is a hazard to health. A good deal of research is now being conducted, especially in California, to find out the exact extent to which this is true.

It is widely recognized today that an inversion layer, like that which exists in Los Angeles, is not needed to "trap" pollutants in the surrounding atmosphere. Any city with a combination of heavy automobile traffic and sunlight can have smog.

3. Lead

Lead is lethal in high concentrations, but specific health effects of exposure over long periods are still largely unknown. Dr. Clair C. Patterson, a scientist at the California Institute of Technology estimates that individuals who live in cities carry fifty to one-hundred times the amount of lead in their bodies as primitive man.[31] Another source states that people with more than 0.5 parts per million of lead in their blood show visible signs of lead poisoning.

These include constipation, headaches, anemia, and emaciation. Paralysis, blindness, insanity and death result from large doses. The same source estimates that the average city dweller in the United States "now has 0.17 parts per million of lead in his blood."[32] To illustrate the deliterious effects of lead some contend that the collapse of the Roman Empire was in part due to lead poisoning of the upper classes who consumed wine prepared in lead-lined pots.

Lead was added to gasoline by the petroleum industry to improve octane rating. This is still done, but environmental legislation has made it apparent that lead will soon have to be removed from gasoline. Low lead gasoline is available on the market, but only recently have prices begun to drop to make it attractive for other than environmental reasons to the average consumer. As many environmentalists have pointed out, the majority of automobile owners in America have been so indoctrinated as to the performance qualities of high octane gasoline that it will take some effort to change attitudes.

B. LAND USE

1. Highways vs. Available Land

The land pollution caused by the automobile is currently a much more controversial subject than the effects of air pollution. Some argue that both are interrelated. The demand for cars creates a demand for more highways which creates more air pollution and eats up valuable land in the form of highways and attendant suburban sprawl. Others argue that if automobile air pollution is effectively reduced highway expansion can continue.

There is sufficient evidence to indicate that automobile air pollution does have a large impact on land resources. Crops in California and elsewhere have suffered severe damage from smog (see Air Pollution). Some authorities indicate that even if effective emission controls can be developed, the sheer quantity of automobiles that will result from current production rates will override this effort within a decade or two.

How much land can be used to support human populations in the manner of suburban dispersal? A recent article in Audubon stated the case like this:

> Of the earth's thirty billion acres, already nine billion are desert. Look at it this way: plastic surgeons tell us that if a man loses one-third of his skin, he dies; As a botanist and arboriculturist, I know that if a tree loses one-third of its bark, it dies. I therefore submit that if the earth loses one-third of its green mantle of trees and other vegetation, it too, will die. The water table will sink beyond recall and life on this planet will become impossible.[33]

One million acres are being paved and developed annually in the United States. To what extent this can continue and what specific environmental safeguards must be considered as the population expands is a question that must soon be answered.

2. The Highway Trust Fund

Large scale highway construction in the United States began in 1956 when congress passed a Federal-Aid Highway Act. Concern for national defense during World Wars I and II had accelerated road building, but the 1956 Act channeled federal taxes on gasoline, cars, and accessories into the Highway Trust Fund. The Trust Fund has financed highway construction all

over the United States since that time.

The United States interstate highway system has been called "the largest public works system in history." Throughout the 1960's an annual average of $3 billion was spent by the federal government on the project. In 1971 total expenditures amounted to $4.7 billion. By comparison, $300 million was allocated to the Department of Transportation in 1969 for grants toward the development and construction of rapid transit and other public transportation facilities. Funds allocated for mass transportation were increased in 1970 by the Urban Mass Transportation Act to $3.1 billion over a five year period, but one-third of this amount has been frozen for budgetary reasons. (Current figures for the construction of the San Francisco Bay Area Rapid Transit System alone amount to $1.3 billion - the San Francisco project was financed without federal funds.)

The interstate highway system now includes some 31,900 miles. Its total cost is in the area of $43 billion. By the mid 1970's the cost is expected to be about $50 billion. The Trust Fund pays 90 per cent of major interstate highway construction costs, while the states pay 10 per cent. In the case of mass transit systems the states must pay a minimum of one-third of the construction costs.

The following list of supporters of the Highway Trust Fund was published in a 1970 article titled "Private Interest and Public Lands" in Current History:[34]

(1) The American Road Builders Association (ARBA): This group started in the era of bicycles in the 1880's as the American

Wheelmen. Today it has 5,300 members representing:

(a) the entire highway construction industry

(b) highway contractors

(c) manufacturers and distributors of highway construction equipment

(d) materials producers and suppliers

(e) faculty and students of engineering colleges and universities

(f) engineers

(g) investment bankers

(h) state and federal highway officals

(i) members of Congress

(2) The Associated General Contractors of America: This group is more diversified than the ARBA even though it boasts 3,423 highway contractors as members.

(3) The National Highway Users Conference.

(4) The American Trucking Association: Representing most of the trucking industry, this group is a national federation of 64 organizations consisting of 50 independent state trucking associations. It came into being back in 1935 when federal regulations on the trucking industry were established.

(5) The Portland Cement Association.

(6) The Asphalt Institute.

(7) The Automotive Safety Foundation: This was originally the safety division of the Automobile Manufacturer Association. It was

reorganized in 1937.

(8) The Highway Research Board: This group is supported by public as well as private funds. Its function is highway research, but members are often involved with other pressure groups that promote highway building.

(9) American Automobile Association

(10) Automobile Manufacturers Association.

(11) American Petroleum Institute.

(12) American Right-Of-Way Association.

(13) The Roadside Business Association.

(14) The National Safety Council.

(15) The National Joint Heavy and Highway Construction Committee.

(16) Miscellaneous engineering, auto insurance, lumber firms, and rubber tire industry interests.

3. Wilderness Vehicles

The American need for mobility has spread rapidly in the past decade into the area of camping vehicles, from pick-up truck campers to camping vans and most recently literal mobile homes with a steering wheel and driver's seat in the front room. On consequence of this boom has been the inability of the National Park Service to deal effectively with increased campers. Numerous studies are now being conducted to determine how best to provide camping opportunities for the maximum number of people without irreparable damage to the environment. But the desire for wilderness

exploration via machine has not stopped at the campground. Advertisements for trail bikes, airboats, swampbuggies, and snowmobiles abound on television, in magazines and in newspapers. One recent cigarette advertisement pictured a man sitting in a vehicle designed to drive through the woods, smoking a cigarette and getting "away from the crowd." A page in a recent issue of Audubon held an aerial photograph of permanent airboat scars on the Florida Everglades, just beyond the national park boundary, along with the following comment:

> SPORTSMEN OF AMERICA, why walk where you can ride? Why use musclepower when you can buy horsepower? Drive right in to that back-country lake. A Terra Tiger, the all-terrain vehicle from Allis Chalmers, "will take you there in style... through the woods and across the swamp." Or, "Discover nature" with a Yamaha. "There's a trout stream about 5 miles north of here. What's so neat about it is there's no road. So nobody's ever around. You have to ride to get there. Through the timber. Then up over a hill. It's easy." Same way to climb a mountain. "From the bottom it looks impossible. But you grit your teeth and grab a fistful of power. When you get to the top it will be absolutely beautiful." And then there's Chevrolet's Blazer. "Call it a car, call it a truck...just call it great! Blazer takes you into wild roadless places with more power and a wider tread than others of the breed." Wow! Feel the wind in your face. Hear the roar in your ears. See the animals flee. Hear the little trees crunch. And you know what's the most fun of all? Zooming around the Florida Everglades. Why, for only $1,800 you can get a custom-made airboat to take you anywhere in the River of Grass. Or you can build your own glades-buggy --a tank on giant wheels or treads -- to slurp through the Big Cypress. And with 1,500 fellow state-licensed airboaters in the Glades, you won't be lonely. But stay away from the national park. Spoilsports, those rangers. No airboats allowed. Some nonsense about a fragile ecology,

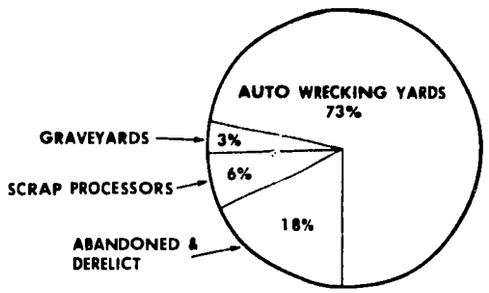
about airboats and buggies leaving their marks for years. About an inch or two difference in elevation causing a change in the type of vegetation. About permanent scars devoiding an area of plant life and wildlife. Bunk! And anyway, what's Florida for if it's not to have fun in the sun?[35]

4. Automobile Junk

An American automobile has an average life of ten years. Most are eventually recycled into usable scrap for steel mills and foundaries, but the problem of efficient collection and recycling is becoming serious (one inhibiting factor is the vagaries of the scrap metal market). Abandoned cars and automobile graveyards are aesthetic eyesores in many parts of the country.

According to the Environmental Protection Agency about 7 million cars are junked each year. Approximately 15 per cent of these are abandoned by their owners. Many cars are abandoned in rural areas where it doesn't pay to collect them for salvage or scrap. In Columbia County, a rural community near Albany, New York, the County Health Department decreed that abandoned cars were breeding grounds for rats and classified the cars as health hazards.

The following graph, developed by General Motors, shows the approximate distribution of junk car accumulation.



	URBAN %	RURAL %	TOTAL %
AUTO WRECKER	28	45	73
ABANDONED & DERELICT	6	12	18
SCRAP PROCESSORS	3.5	2.5	6
GRAVEYARDS	.7	2.3	3
	38.2	61.8	100

It is clear that if recycling is to be an effective solution to environmental problems in the future awareness and responsibility must extend to what happens to products after they are placed in the hands of consumers. The automobile is the most obvious example, but many other products, even if not contributing to environmental burden when in use, do so when discarded. Sterling Brubaker makes this suggestion in regard to the automobile: "Perhaps a simple solution of the growing problem of discarded automobiles would be a tax on new car sales to finance a bounty on junked cars delivered up for salvage."[36]

C. WATER POLLUTION

Transportation by private automobile uses almost one-half the crude petroleum in the United States. In 1966, 224 million tons of petroleum fuels and lubricants went into internal combustion engines. The movement of this vast amount of fuel entails great risks. Aside from the environmental questions raised by the trans-Alaskan pipeline, we are presented with pollution problems created by offshore drilling and supertanker accidents. In 1969, a drilling accident off the coast of California spilled oil over the beaches of Santa Barbara. In 1967 the Torrey Canyon ran aground and released over 100,000 tons of oil (18 million gallons) that covered the beaches of Southern England and Northern France. Offshore drilling has been limited in many areas until improved technology can be developed to prevent mishaps. The problem of tanker accidents becomes more acute as more and more are constructed. According to one source, there were 180 tankers with a carrying

capacity of 100,000 tons in 1970. As of December 1969, 310 supertankers with a carrying capacity of 200,000 tons or more were in the drawing board stage. Sterling Brubaker makes this observation:

> The sea is a significant and expandable source of food. It is also important to photosynthetic activity, absorbtion of CO from the atmosphere, and regulation of the earth's climate. We know all too little of how the sea and its biotic communities impinge on global ecology, but there is every reason to treat this relationship with great respect. Instead we utilize the sea thoughtlessly as the ultimate sink for all sorts of chemicals generated on land and transported by air and water... Oil spills thus far have a localized effect, but are disastrous for sea birds and some other marine species caught in them. However, with increasing ocean traffic there is a risk of marine accidents that could disperse highly toxic materials and lay waste vast areas of the ocean as accidental discharges already have done in inland waters. The ocean's capacity to degrade oil, already taxed by routine tank cleaning and spills, will be severely tested if supertankers of the future break apart at sea. This problem, along with many others concerning the ocean, needs further study.[37]

III. SOLUTIONS

A. IMPROVING THE INTERNAL COMBUSTION ENGINE

1. Federal Clean Air Act Standards and Testing Procedures

The following is excerpted from the Semiannual Report by the Committee on Motor Vehicles of the National Academy of Sciences to the Environmental Protection Agency, published in January 1972:

> According to section 202 of the Clean Air Amendments of 1970, the Administrator of the EPA is required to prescribe emission standards for light-duty motor vehicles and measurement techniques on which such standards are based. Persuant to section 202 (b) (1) (A) such standards require that the emissions of carbon monoxide and hydrocarbons from light-duty vehicles manufactured during or after model year 1975 shall be reduced by 90 per cent from those required of 1970 vehicles; also, emissions of oxides of nitrogen from light-duty motor vehicles manufactured during or after model year 1976 are to be 90 per cent below the average of those actually measured from 1971 model year light-duty vehicles.
>
> Standards and test procedures were promulgated by EPA and are contained in the Federal Register of November 10, 1970, and July 1, 1971...
>
> The Clean Air Act Amendments further call for vehicle compliance with these standards for the useful life of the vehicle, defined in the law as five years or 50,000 miles, whichever occurs first.
>
> Testing to ensure compliance with these standards is to be conducted in three stages. First, prototype models of each engine class are to be tested prior to issuing a "certificate of conformity." Next, production line testing is contemplated to ascertain whether production models conform with the regulations with respect to which a certificate has been issued. Finally, provision is made for testing emissions and for continuing compliance while a vehicle is in actual use.[38]

> ...A number of uncertainties still exist concerning the definition of compliance with the law... These uncertainties are allowable maintenance during the 50,000 mile certification procedure, the testing of vehicles at the end of the assembly line, and whether all vehicle emissions or only the average of vehicle emissions must meet the standards during the vehicle's useful life.[39]

In regard to testing vehicles that are actually in use, the EPA "contemplates" testing sample vehicles. According to the National Academy of Sciences, "The responsibility for correcting vehicle emissions, if found necessary, will lie with the manufacturer, provided the owner has complied with the terms of a legally acceptable warranty concerning maintenance of the emission control system."[40] State governments are to be encouraged to initiate procedures for periodic inspections. New Jersey and California are about to begin inspections of this type.

The efficacy of adding controls and going to the expense of extensive inspection over long periods of time have been severely questioned. It may cost the nation billions of dollars a year to conduct adequate inspections similar to those proposed for California and New Jersey.

2. Attitude of the Industry

According to the law the Administrator of the Environmental Protection Agency can extend the 1975 and 1976 deadlines one year if sufficient evidence is submitted by the automobile industry stating the deadlines cannot be met. The industry has said again and again that it cannot meet the deadlines. William Ruckelshaus, EPA administrator, after hearings on the subject, stated on May 13, 1972, that extensions will not be granted.

General Motors vice-president, Ernest S. Starkman, told a Senate committee in Washington that "you can't legislate a timetable for invention. We'll do everything we can to meet the '75 and '76 deadline. But I don't think we can." Senator Howard Baker asked what GM would do several years hence "if you still haven't met the emission requirements and you've run out of time... It would seem you could get us (Congress) to amend the law or quit making cars. What would you do then?" "Punt," Starkman retorted.[41]

In July 1971, the Environmental Protection Agency stated that much of the information on pollution control progress that had been furnished to it by the automobile industry was classified by the industry as confidential because it related to "trade secrets." The EPA also stated that it "does not agree that all of the information so indicated relates to trade secrets" and that "work is underway to develop appropriate protocols to permit the release of this information."[42]

3. Proposed Emission Control Devices

The technology for meeting 1975 federal clean air standards is available. The durability of these systems remains to be established. According to the National Academy of Sciences proposed emission control systems "must reach final design stage by mid-1972 to permit system testing, endurance testing of components, modifications and corrections, and to assure that the final systems are acceptable to the public." Technology for meeting 1976 nitrogen oxide emission standards is reported to be largely uncertain.

Some of the requirements for a complete emission-control system that shows promise for meeting 1975 standards are as follows: improved carburetor

performance, more accurate choke, inductive or electronic ignition system, exhaust gas recycle, secondary air pump, catalytic converter, and possibly a thermal reactor.

a. Exhaust-Gas Recycle (EGR)

Exhaust-gas recycle will be used to decrease nitrogen oxide emissions. This will be accomplished by recycling 10 to 20 per cent of the exhaust back through the intake manifold and into the cylinders of the engine. Nitrogen oxides result from high combustion temperatures. Since the recycled gas is already hot the temperature the engine needs to burn new gas will not be as great thus reducing nitrogen oxide emissions. In order for the system to work effectively and maintain satisfactory engine operation the fuel-air mixture flowing through the carburetor, intake manifold, and into the cylinders must be enriched. This enrichment increases hydrocarbon and carbon monoxide emissions which must then be burnt up in a thermal reactor or catalytic converter. Fuel enrichment also increases fuel consumption.

b. Secondary Air System

The use of EGR and rich ruel-air mixtures necessitates the addition of air to the exhaust flow before a thermal reactor or catalytic converter can do its job (primary air would be the air that is mixed with new gas as it enters the engine through the carburetor). An engine driven air pump will provide this air at the exhaust ports of the engine.

c. Thermal Reactor

A thermal reactor is an enlarged exhaust manifold that bolts directly on to the cylinder head. Its job is to promote rapid mixing of exhaust

gas with the secondary air at high tempreatures in order to burn up hydrocarbons and carbon monoxide.

d. Catalytic Converter

At present this system is preferable to a thermal reactor. Hydrocarbons and carbon monoxide are oxidized by means of a catalyst, converting them into carbon dioxide and water vapor. This can be done at much lower temperatures than are required in a thermal reactor. A catalytic converter can also be placed further from the engine than a thermal reactor. It can remain effective without fuel enrichment and consequently saves gas. The promise of the catalytic converter has prompted moves to make gasoline lead free because lead can ruin most catalysts in a short time. Although lower than the thermal reactor, operating temperatures are still high (900° F) which will require modification of underbody construction.

e. Major Engine Modifications

Improved carburetors are being developed to provide more accurate fuel-air-ratio control. Intake manifolds are being redesigned to improve fuel, air, and recycled exhaust gas flow between cylinders. Means for compensating for air density changes with altitude will also be required. Methods for reducing emissions during engine and control device warm-up are under development. One way to do this is by retarding spark timing during warm-up to increase exhaust gas temperatures and reduce the time required for warm-up. Improved ignition systems are also necessary because malfunction due to wear and inadequate maintenance have increased hydrocarbon emissions in the past.

4. Cost Analysis

The cost of proposed emission control systems for the 1975 model year have varied widely. Informal estimates given to the EPA in 1971 ranged from $80 to $600.[43] A survey reported by the National Academy of Sciences in January 1972 indicated that seven foreign manufacturers had given estimates ranging from $200 to $500, while "of the five American manufacturers, two submitted estimates of about $250 while the others were of the order of $500." The National Academy of Sciences itself estimated "an increase of initial cost of $288 for the 1975 model year projected system over the 1970 model year system, and an increase of $214 for the 1975 system over the 1973 system."[44]

Increased dollar cost to the customer must include increased fuel consumption (manufacturers estimate that fuel consumption will increase by 3 to 12 per cent). Decreases in driveability are also anticipated. Many 1972 new car owners have already experienced this problem even though major pollution control devices are yet to come. (The industry has used the possibility of inadequate and "unsafe" operation to argue against the present emission control deadlines.) Finally, it is anticipated that the cost of routine maintenance will increase several times over present cost.

B. ALTERNATIVES TO THE CONVENTIONAL INTERNAL COMBUSTION ENGINE

Many alternatives to the conventional internal combustion engine have been proposed. Five possibilities are discussed below: the Wankel, gas turbine, steam, electric, and mass transportation.

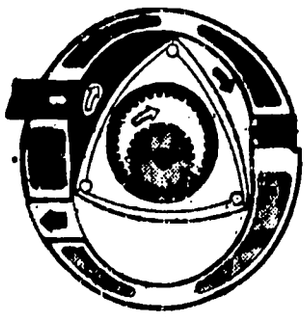
1. Wankel

The Wankel is an internal combustion engine, but it operates on a different principle than the conventional engines now in use. It is looked upon as a possible alternative because it is "quieter, smoother, and simpler."[45] The Wankel has fewer moving parts than a piston engine, weighs about two-thirds less and is estimated to cost about half as much to build. Instead of pistons the Wankel uses a rotor that revolves in a chamber shaped like a flattened out figure eight. This creates less vibration and wear and tear on parts. Producers claim that it can deliver the same horsepower as a conventional internal combustion engine twice its size and that it has faster pick-up (although fuel economy is reduced).

The Wankel creates hydrocarbon and carbon monoxide problems, but its compact size and simplicity will make it easy to add emission control devices. One of the primary reasons for the attention being given the Wankel is that it produces far lower nitrogen oxides. Reduction of nitrogen oxides is currently one of the greatest problems in trying to clean-up the internal combustion engine.

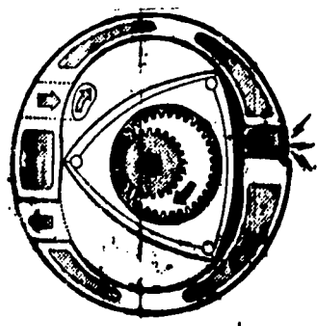
General Motors has done extensive research on the Wankel. Ford Motor Company has a contract with Audi-NSU which makes the Wankel powered RO-80 for the European market. Chrysler and American Motors also have an active program for testing the RO-80 and Japanese Mazda. The Japanese company Toyo Togyo Ltd. has produced about 200,000 Wankel powered cars since 1967 which are now on the road in eighty countries. Over 20,000 Japanese models have been sold in the U.S. since 1970.

HOW THE WANKEL WORKS



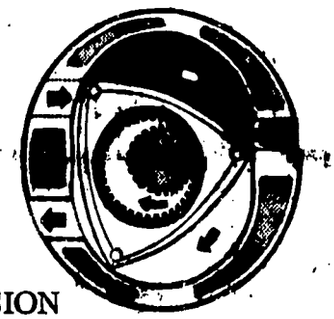
INTAKE

As the piston at right starts downward in the cylinder, it opens a valve at the top and draws in a gas-air mixture. In the Wankel, this "charge" flows into the chamber when one of the three points of the triangular rotor sweeps past an intake port (white arrow) in the wall.



IGNITION

As the rotor face moves down the comparatively flat side wall, the gas is ignited and expanded, providing the thrust to keep the rotor turning. At right, ignition propels the piston on its downward "power stroke."



COMPRESSION

As the Wankel rotor turns, the gas (in dark gray area) is pushed toward the spark plug, while a second point of the triangle trails across the intake port and covers it momentarily. At right, the valve shuts as the piston starts upward, beginning to compress the fuel mix.

EXHAUST

The rotor cleans house by sweeping the waste products of combustion out an exhaust port (white arrow). While this completes the final phase, new cycles have already begun in what is a continuous process. In the conventional piston engine, the exhaust goes out through a second valve as the piston thrusts up for the last time.

2. Gas Turbine

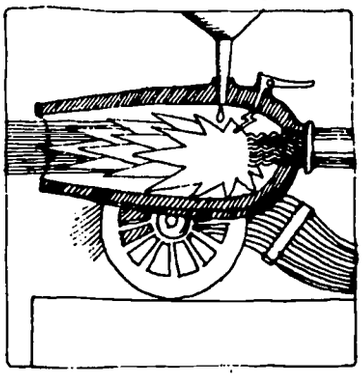
According to the Environmental Protection Agency, "more work has been done on the gas turbine engine than on any other candidate." EPA sponsored research efforts are being focused on solving specific problems which have made the gas turbine unattractive for use in cars. These problems include the need for reducing the nitrogen oxide emissions in the exhaust, developing manufacturing techniques for mass producing turbines inexpensively, and increasing system reliability.

The gas turbine engine is an internal combustion engine, but it operates in a manner quite different from the internal combustion engine currently manufactured by Detroit. It differs from jet turbines, which are a major source of pollution, in that it is driven by a standard transmission and not by thrust that pushes pollutants directly into the atmosphere. Unlike the conventional internal combustion engine where fuel burning is intermittent between cylinders, combustion in the gas turbine is a continuous process. Combustion takes place in one large chamber that never has a chance to cool off,with the consequence that the burning of hydrocarbons and carbon monoxide is more complete. The turbine also uses large amounts of excess air that increases the intensity of the combustion process with a consequent increase in nitrogen oxides.

At least one gas turbine engine manufactured by the Williams Research Corporation has been tested by the Environmental Protection Agency and found to meet Federal hydrocarbon and carbon monoxide emission control standards for 1975.

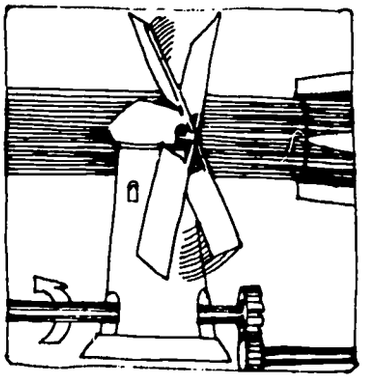
The fuel that the gas turbine uses is also different from the conventional internal combustion engine. Instead of gasoline, the turbine can run on a variety of liquid fuels such as JP4 and JP5 jet fuels, or even pure kerosene. All of these fuels are lead free.

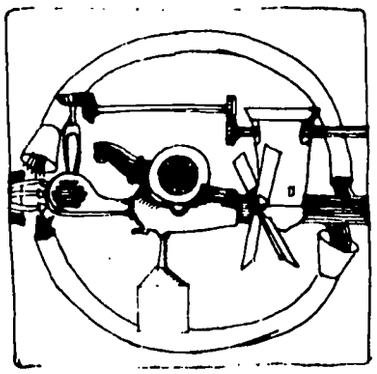
HOW THE GAS TURBINE WORKS



Power in the turbine is generated when preheated and compressed air is blown into the burning chamber (cannon at left), mixed with fuel and ignited.

Exhaust from the burning chamber (right) turns the turbine's blades. Spinning like a windmill, the blades provide power to drive the vehicle and its compressor.





A heat exchanger (curving pipes) makes the turbine more efficient. It uses exhaust heat to warm air entering the chamber and also cools the exhaust to safe levels.

3. Steam

Proponents of steam-powered automobiles list among its most valuable assets the fact that it produces only minimal amounts of air pollution. "Even a Ford representative said that he found it difficult to envision a way to reduce the internal combustion engine emissions to the level already reached by steam cars." Those who favor steam-mobiles list these additional advantages: (1) it does away with the need for a carburetor, muffler, distributor and air pollution control device (however it requires a boiler and combustion controls); (2) significantly cheaper to manufacture; (3) average thirty miles per gallon of kerosene; (4) can burn any distilled fuel; (5) would be comparatively silent. In spite of these facts there are barriers to the mass production of steam cars. Professor of Economics at Indiana University, Lloyd D. Orr, described the barriers as "economic factors, such as resistence to change and so-called barriers to entry, including the high capital commitment necessary to establish a new automotive corporation ... consumers today do not perceive freedom from pollution in the exhaust of a vehicle as desirable for which they are willing to pay very much."[46]

Several companies are doing experimental work on steam buses, but reports of progress up to this time have been varied. Some feel that the gas turbine is a better bet for eventually replacing the internal combustion engine because it is a simpler design. Others, such as William Lear, who has been working for several years on steam power, feel that such an engine will have a major role in future transportation.

Steam buses now in operation use boilers made from coiled tubing and

fired by diesel fuel. Because diesel fuel is burned continuously, rather than in a series of explosions, combustion is cooler and more complete with minimal hydrocarbon, carbon monoxide and nitrogen oxide emissions. At least two of the experimental steam buses now in operation use reciprocating engines to translate steam into power. William Lear has developed a small turbine to do the same job.

4. Electric

Proponents of the electric car maintain that it is (1) silent, exhaust free and otherwise kind to the environment, (2) powered by a simple motor that is 90 per cent efficient; (3) easy to handle; (4) inexpensive to maintain." However, the electric car faces the same strong opposition from automobile manufacturers experienced by proponents of steam cars, plus the fact that it is plagued by a host of engineering problems. As many as sixteen expensive, low-energy-density batteries are needed to make an electric car go. Together they weigh the car down and completely fill what is now trunk space. More serious, no electric car can cruise much farther than eighty miles or longer than a few hours without having to stop to be recharged. This combination of technical and economic problems does not seem to discourage manufacturers of the electric car. They are trying to develop better batteries while producing smaller, local-use vehicles such as electric golf carts, lift trucks, and postal delivery vans. Whether or not electric vehicles will ever be feasible for individual cars remains one of the important questions of the 1970 decade.

C. MASS TRANSIT

Warren Magnuson, chairman of the Senate Commerce Committee

recently remarked, "Virtually every major urban area in the country is experiencing some sort of movement demanding a reallocation of resources toward a more balanced transportation system."[47]

In 1970 the Urban Mass Transportation Assistance Act authorized $3.1 billion in capital outlays over five years for extension or construction of bus and rail commuter systems, but one-third of this sum was frozen in 1971 and 1972 for budgetary reasons. There is approximately $4 billion in grant applications from ailing transit companies back-logged at the Department of Transportation. Two hundred fifty-eight public transit companies have collapsed since 1954. Between 1960 and 1968 passenger trips on public systems declined 15 per cent. The entire industry ran an operating deficit of over $400 million in 1971.

The common carrier principle has forced railroad, airline and other companies to serve both profitable and unprofitable commuter markets. Many railroads have attempted to shut down passenger service because of its unprofitability. Higher passenger fares brought on by inflation and decreased patronage has forced more and more people into commuting by car.

States that request federal money for mass transportation facilities must pay one-third the cost. As pointed out above, states pay only 10 per cent of the cost of constructing highways. Secretary of Transportation, John Volpe, has recommended that at least part of the Highway Trust Fund be earmarked for mass transit construction.

Mass transportation can take several different forms. San Francisco spent $1.38 billion constructing its Bay Area Rapid Transit system. It will

be seventy-five miles long when complete and carry passengers in smooth running, comfortable cars at speeds up to eighty miles per hour. It will operate between the suburbs and the heart of San Francisco. Washington has begun a similar mass transit development project (Metro) and several other cities are planning to do the same. Sterling Brubaker gives an example of what can be achieved by switching from cars to electric rail transit:

> The general aim would be to produce transportation with a smaller or less noxious throughput of fuels, perhaps by concentrating combustion in generating plants where the process would be more efficient and the residuals could be controlled more easily... one calculation showed that for 100 million passenger miles the saving would amount to 16,000 tons of gasoline, a net decrease of 6,000 tons of CO, 1,300 tons of vaporized HC, and 200 tons of NO_x. If the power is derived from conventional thermal plants, there would be an ofsetting increase in production of SO_2.[48]

Reserved bus lanes appear to hold some promise. The Department of Transportation experimented with such a system providing service between the nation's capital and suburban Virginia. Passengers increased 19 percent in the first eighteen months. New York, Seattle, and San Francisco now have special bus lanes.

It is apparent that mass transportation is badly needed. It is also apparent that the American public must begin to develop an awareness of its potential. "The alternative," a recent Business Week article stated, "is an increase in congestion to the point where, some day everything will stop."[49]

IV. CONCLUSION

The following concluding statement is excerpted from "The Twilight of a God" by Aurelio Pecci, Italian industrialist, Director of Fiat, and founder of the Club of Rome:[50]

> If we suppose that population growth cannot be slowed and that certain basic articles of consumption must necessarily increase in order to decently ensure man's subsistence, then one result will be a limitation of freedom of movement. We know, for example, that the United States currently spends 20 per cent of its gross national product on transportation and travel, and this sector is constantly growing. But its expansion comes up against more pressing needs in other areas, and its share seems bound to decrease. We can already see symptoms of this tendency in Europe: the national increase in the number of cars in circulation and in the volume of traffic was 12 per cent in the Fifties; it went down to 7 or 8 per cent in the Sixties; and the forecast for the Seventies is an annual increase of only 2 per cent.
>
> Without going so far as to draw a science-fiction picture of the future in which city dwellers would have to buy a ticket and wait in line to see a forest, a river, and birds is special reserves, we must nevertheless admit that the spread of wealth, the reduction in working time, and the general growth of people's means to travel will lead us to point of saturation. Travelling man's freedom of movement will consequently be restricted. It is impossible to have a large population that simultaneously enjoys a high standard of living and a high degree of mobility. If, on the other hand, we feel that movement is the most important expression of our life style, then we must make other choices: reduce other elements of our standard of living in order to devote a larger share of the GNP to transportation and, above all, adopt a severe birth-control policy. Or else we must give up even an occasional desire to enjoy forests, fresh air, wild fauna and flora.

Before such a degree of saturation is attained by all the industrialized countries, there will be major changes in the cities. The motor-car is living its last years of glory as a personal object, private property, status symbol. The absurd situation in our great metropolises - Paris, Rome, New York, Tokyo - is due to a survival of the past, to a mental block. Nevertheless, we can no longer doubt that the private car, which we use two or three hours a day, which jams and pollutes the geographical areas in which we spend most of our time, is an anachronism. The motor-car will necessarily become a mere utilitarian object characterized by a great degree of safety, a minimum of pollution and bulk.

There are various possibilities for replacing the privately owned car. In the long range, an automated order system seems the most likely because it would enable collective transportation to respond to individual needs: along with buses that follow fixed itineraries, there will be computer-operated minibuses taking variable routes. The person who wants to go from one place to another at a particular time will order a minibus to pick him up at his house. The computer will decide on the size of the bus to send according to the number of requests it receives from the same neighborhood. All calls from clients will be registered automatically and bills sent out every month or every three months.

For the immediate future, this form of public transportation will probably be adopted because of the urgency of the problem. The exodus from the cities that has already taken place in the United States will undoubtedly occur in the near future in Europe if transportation is not improved. Yet the proportion of urban ground taken up by public transportation is twenty-five times smaller than that needed for individual means of transportation.

In the medium range, there will probably be some specialization. Along with public transportation, individual transportation will come into its own again thanks to a small, specially designed car which will probably cease, however, to be private property. These city cars will either be collective property or they will be rented out and their maintenance ensured by private companies. When

this happens, it will become pointless, if one wants to visit Bruges or Amsterdam, for example, to drive there in one's own car on saturated highways. A plane or a train will provide a quicker and pleasanter journey, and on arrival there will be a little car for one's individual movements. This formula already exists, thanks to the numerous car-rental agencies, but using today's cars which are inappropriate in big cities. The automatic reflex of using "my" car on the slightest pretext will disappear once the idea takes hold of the car as a utilitarian object to be used when needed and left to others when one doesn't need it oneself....

If renting a car becomes possible anywhere and everywhere, the number of available means of transportation will be increased and people's choice will depend on the distance they want to travel and the time at their disposal. One could make the same remarks about private property in the form of apartments or country houses. Such possessions limit one's choice of a place in which to spend a vacation and one's mobility in general. In the near future, there will be a more and more pronounced trend to spend vacations in hotels or in rented houses which are subsequently occupied by others; the same will be ture of apartments, especially once Europe is united. It will then seem absurd for an engineer to put down roots by purchasing an apartment in Lyons, when he could very well be called upon to transfer to Lille, Turin or Dusseldorf. As in the case of the car, private property would, in such a case, become a brake, an obstacle to mobility.

From the point of view of production, there will also be major changes in the years to come, if one takes into account all the factors that will influence the development of our society. Fifteen years ago, there were a few large aeronautical firms that turned out complete planes on an assembly line. Today, this industry has literally exploded: there are still a few very large firms, but they assemble their planes with parts manufactured by a large number of subcontractors. The motor-car industry will gradually follow the same trend: huge automotive complexes such as those of Volkswagen in Wolfsburg and Ford in Detroit will become old-fashioned.

On a planetary scale, moreover, there is a highly irrational element in the relations between rich and poor countries. Enormous industrial complexes - steelworks,

refineries, motor-car factories - are concentrated in the former, which get their raw materials from all over the world, The United States and Europe, which contain only 10 per cent of the world's population, use two-thirds of the raw materials extracted from our planet. Yet at the same time these industrialized countries suffer from such concentration: they realize what a price they must pay in terms of the quality of life for this accumulation of wealth and industry. In Pittsburg or Antwerp, the air is unbreathable and the water is polluted because ore from overseas and oil from the Near East are refined there. All those who are worried about the future know that there is a logical way of relieving congestion in the industrialized countries: this consists of transferring refining operations to the sites of extraction of the raw materials - in other words, to the poor countries. Instead of extracting iron ore in Brazil and transporting it to Genoa to be transformed, it would be much better to transform it on the spot. In Genoa, the air would be purer, the ocean would be a bit less polluted, and Brazil would be developed....

If we take other considerations than profit into account, this spreading out of the motor-car industry will benefit the rich countries as well as the poor. While it has enjoyed a privileged position for a long time in the United States, Great Britain, France, Italy, Germany and Japan, the motor-car industry is no longer in a period of expansion. A technical threshold has been reached, and it is no longer a matter of great interest to knock off a few more fractions of a second from the remaining margin of productivity. "Macro-rationalization" is going to win out over criteria of "micro-efficiency." In the future, it will be a matter of only minor importance if a car is manufactured in Brazil at a lower rate of productivity than that of Detroit, because the production and distribution of this article of consumption will respond to new criteria of rationality. Political requirements (the need to develop the poor countries) and considerations related to the quality of life (the need for pure air, clean water and leisure) will transform the motor-car industry, which will cease to be monopolized by the great industrial centers.

FOOTNOTES

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16. The National Geographic Society, op. cit., p. 118.

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43. Ibid., p. 6-2

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