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Automotive Displays and Controls - Existing Technology and Future Trends

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16. Abstract

This report presents overview information on high-technology displays and controls that are having a substantial effect on the driving environment. Advances in electronics and computers, in addition to cost advantages, increase the technologies' impact. The status of these displays and controls, and the concerns that may be raised in relation to safety and the driving task, are discussed. Several industry brochures and articles are reprinted as appendices, and a detailed reference list for further study is supplied.

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PREFACE

This report was prepared by the U.S. Department of Transportation, Transportation Systems Center, for the National Highway Traffic Safety Administration's (NHTSA) Office of Crash Avoidance Research. The support and advice of Robert Nicholson, chief of that office, is gratefully acknowledged.

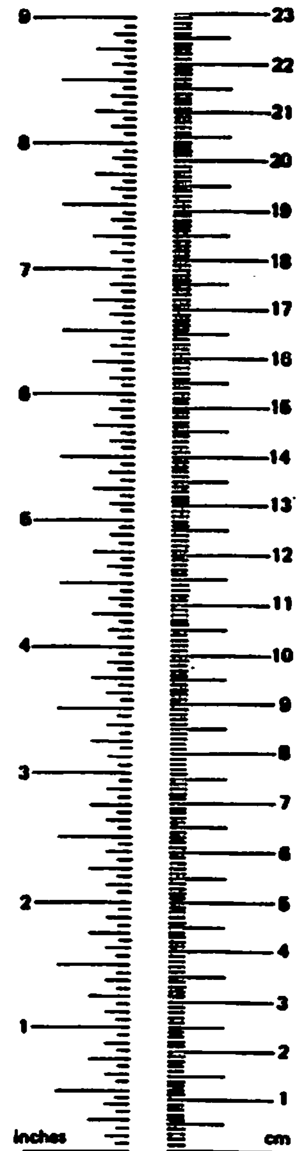
High-technology displays and controls are having a substantial impact on the driving environment and, in the future, this impact will increase because of advances in electronics and computers as well as cost advantages. This report reviews the status of these displays and controls and the concerns that may be raised in their relation to the driving task.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

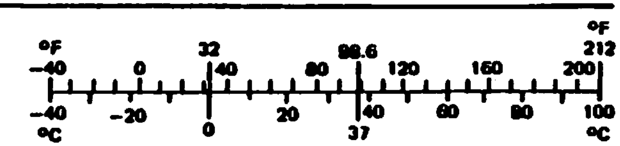
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286. Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This report provides an overview and description of "high technology" electronic control and display systems found in today's vehicles and discusses potential future developments in these systems. The report describes the need to integrate this technology into the driving environment, thereby enhancing safety, convenience and comfort without degrading or distracting from the primary driving tasks. Automotive manufacturers are beginning to develop methodologies for evaluating the impact of these new technologies on safety, but at present no single methodology exists. This report outlines the requirements for such a methodology.

New display technology utilizes electronic graphic displays to replace, expand, and augment more traditional analog displays. The advances in microprocessor technology and related cost advantages have fostered a new era in displays and controls. The Japanese car manufacturers have made the greatest use of the technology in this field with the European manufacturers adhering to the more traditional type of display/control systems. The U.S. manufacturers occupy a middle position.

Four main types of display technologies are available, vacuum fluorescent, liquid crystal, light-emitting diodes, and cathode-ray tubes. The advantages and disadvantages of each type regarding resolution, brightness, color, cost, and other features are described in the report. These display types are now used for instrument clusters (speedometer, tachometer, odometer, temperature, and fuel gauges), radios, clocks, trip function and driver information monitors. New vehicle diagnostic systems continuously monitor up to twenty vehicle functions and alert the driver through both visual and auditory warnings of an out-of-specification condition. A likely future trend in display systems is the use of the multi-functional cathode-ray tube (CRT) type display for systems which provide detailed information. The 1986 Buick Riviera is an example of this application. The CRT can provide an interface for vehicle systems such as status, climate control, and audio entertainment systems, and also display maps required for navigations systems (i.e., Etak Navigator). A good indicator of the use of CRTs in the future is the extensive use of them in concept cars. Examples of display use in concept cars can be found in Appendices D, F, and G.

The proliferation of display systems has been accompanied by similar increases in microprocessor-supported control systems. As with displays, many of the controls affected are related to the driver's comfort and convenience. In some cases the availability of microprocessor-aided controls has resulted in a suboptimal control configuration. The trend is toward many, small, densely-packed push buttons or small touch screen areas on a CRT. Although the basic driving controls (steering wheel, brake, and accelerator) are largely unchanged, augmentation by microprocessors for braking and handling control are beginning to appear.

The future trends for controls designs are likely to include the increased use of CRT touch-screen technology for navigation and vehicle diagnostics and placement of controls in locations both more convenient and within the driver's field-of-view. Examples of 1986 vehicles and concept cars with duplicate radio and other controls in the center of the steering wheel and use of control pods are described. Criteria for such controls are discussed.

This report concludes that most of the new display and control systems available in the current U.S. automotive market have been applied to comfort, convenience, and entertainment systems. Although these systems are not directly related to safe vehicle operation, it is critical that their design does not interfere with safety-related functions.

1.0 INTRODUCTION

This report provides an overview and description of the "high-technology" electronic control and display systems found in today's vehicles. The availability of a wide variety of new control and display technologies at ever decreasing cost provides the automobile designer with both opportunity and temptation. Current advances in control and display technology cannot be separated from advances in microprocessor technology. Microprocessors, in the form of microcomputers, store, analyze, and format the information displayed to the driver. Similarly, microprocessors form the sophisticated links between driver control inputs and vehicle system responses. As microprocessor technology evolves, the use of microcomputers in cars will increase. Currently, microcomputers are used in engine control systems, trip computers, electronic radios, electronic HVAC (heating, ventilating, and air conditioning), digital instrument panels, and navigation systems. Memory seats, transmission control, voice synthesis and voice recognition are potential near-future applications. The automobile of the future can be designed to adjust everything for each driver, automatically personalizing the settings for seats, mirrors, HVAC, radio, etc. as the driver gets into the car.

This report describes many of the applications of this new technology. The challenge will be to integrate these new technologies into a safe, convenient, comfortable, and even entertaining driving environment.

Automotive displays and controls have evolved from simple analog gauges and toggle-type switches to digital displays and "touch screen" CRT controls. A typical new automobile now contains the electronic processing capability of a small desktop computer. The automobile manufacturers have taken advantage of this capability by offering the driver an almost bewildering choice of standard and optional displays and controls that contain far more information than is required to safely operate the vehicle. Of concern is whether these new displays and controls, due to their complexity, attractiveness, and demand for driver involvement, may actually detract from the primary driving tasks and indirectly degrade safety.

The objective of this report is to review the status of this instrumentation and indicate the direction in which this technology is likely to evolve.

1.1 Design Criteria

While it is beyond the scope of this document to rate individual systems or even types of systems in terms of their potential impact on highway safety, some global preliminary discussion of design criteria is warranted. At this time there are no official or even unofficial standards for design or application of the new technologies to road vehicles. In fact, objective methods to evaluate the effect of these new systems on driving safety have not been developed. Many of these systems are being used because they are believed to provide to the vehicle purchasers an enhanced level of comfort, convenience, or entertainment at a cost which is low relative to other vehicle components. It appears that these systems are being adopted in the absence of an evaluation methodology. It is valuable, therefore, to speculate on how such a methodology might be developed.

An evaluation methodology will obviously require objective criteria. The most commonly used criteria for the design of control and display systems for consumer appliances are aesthetics or attractiveness, cost, and convenience. In the design of industrial equipment, a formal attempt is usually made to achieve an ergonomically correct design. In the design of military systems and complex and/or safety-related industrial equipment, an additional criterion is added, system integration.

Because of the safety critical nature of driving, the criteria for design of the "driver's station" must include system integration even though the majority of displays and controls in the automobile are not directly related to safety. The goal of the system integration in this application is to meet product attractiveness requirements and still maximize safety.

The safety critical operations, i.e., velocity control, position control, and obstacle avoidance, which make up the driving task, are almost entirely dependent on the driver directly sensing changes in the external environment, rather than indirectly obtaining information from in-vehicle displays. Such changes are detected through visual observation of the roadway and perception of vehicle vibration and acceleration. Even the speedometer, the display most closely associated with vehicle control, is probably not the primary information source for quick detection of velocity changes. Reference to the speedometer provides a relatively more accurate, quantitative representation of velocity than visual observation or perception of vehicle motion.

In the case of vehicle systems used to control velocity, road position, and obstacle avoidance (the steering system, braking system, and power train), the driver's inputs were, until relatively recently, almost entirely direct. Changes in the acceleration, velocity, and position of the vehicle were a direct result of changes in the position of and in the force on the controls used by the driver. In the last few years, indirect "smart" controls such as "cruise control" and "anti-skid" braking have become available. However, direct control over safety critical maneuvers is still the rule and safety critical inputs remain the province of the driver.

We must assume that the high-technology control and display systems will find their greatest use in comfort, convenience, and entertainment systems. Therefore, the first step in insuring system integration is to evaluate the impact of control or display system design on the accomplishment of safety critical aspects of the driving task.

To accomplish this, it is important to know the following:

> <u>Relationship to the driving task</u> or the contribution that the system makes to safety critical operations (i.e., direct, indirect, or unknown);
>
> <u>Frequency</u>: the number of times the driver is likely to use the control or display during critical driving operations; and
>
> <u>Interference</u>: the extent to which attending to a display or manipulating a control will distract the driver from a more safety critical operation.

The determination of the level of a particular system's contribution to safety critical driving tasks is usually straightforward. In the case of controls, such as headlight or horn switches, easy and quick access is vital. In the case of controls for comfort and entertainment systems, there is room for debate as to their contributions to safety. For example, a stereo system can arguably improve performance on boring, long distance trips or can detract from safety by interfering with the drivers' perceptions of warning sounds from outside the vehicle.

The relative frequency with which a system is used in different types of driving can be estimated, but empirical studies will be necessary to actually establish such frequencies. The extent to which a system is distracting can be inferred. In the case of a visual display, distraction increases to the extent to which the visual display requires:

- "Foveal vision" (Are the display elements so small that they tax near vision acuity and require that the driver change visual accommodation or refocus from the road, and/or require careful discrimination between different colors?); and

- More than a minimum level of interpretation or cognitive processing. (Must the driver perform analyses, calculations, or derive information each time the display is consulted?)

In the case of an auditory warning or advisory system, relative distraction is a function of the extent to which:

- The message is annoying (Is the message discordant, unnecessarily repetitive, or loud?); and

- The sound level is high (Does the message mask other critical sounds?).

The distraction inherent in a control system is a function of the difficulty that the driver has when using the control system to make an adjustment. Control systems are distracting to the extent that controls:

- Have a large number of functions;

- Require precise adjustment;

- Do not have distinguishable physical positions associated with their actions;

- Do not provide immediate and direct feedback when used;

- Are sized and spaced so that their use interferes with and/or becomes confused with other controls; and

- o Require that the driver look away from the road and/or move from the normal driving position to use them.

It is possible to rank the majority of in-vehicle display and control systems in terms of their relationship to safety critical operations. The displays which provide information on the function of safety systems, i.e., brake subsystem failure warning lights, can be ranked higher than displays which provide information on engine status, i.e., temperature. Engine status displays in turn can be ranked higher than comfort and convenience displays, i.e., radio reception mode (mono/stereo). In a similar manner, it should be possible to rank controls with those which are used in safety critical operations, i.e, brakes or turn signals ranking higher than those which provide convenience and entertainment functions, i.e., air conditioner and radio controls.

Because most in-vehicle comfort, convenience, and entertainment systems rank relatively low in terms of their direct relation to safety critical operations, good practice dictates the use of the controls or displays which do not distract or otherwise interfere with higher ranking operations.

These and similar operational considerations combined with observational studies of display and control use can be used to develop evaluation methodologies and design guidelines. In fact, at least one of the major U.S. automobile manufacturers is working toward these ends as is shown in the recent AP article below as published in the Providence, RI Evening Bulletin.

A-2 TUESDAY, JANUARY 21, 1986

FROM PAGE ONE

Just when you got your talking car to shut up . . .

By EDWARD MILLER
Associated Press

DETROIT — Those glitzy new auto dashboards with high-tech digital readouts don't say much to most motorists, says a researcher who suggests the fancy light displays contain some less-than-bright ideas.

Paul Green, a professor and assistant research scientist, said motorists taking part in a study for the University of Michigan Transportation Research Center had problems with digital readouts for engine information such as oil pressure, coolant temperature, electrical voltage and current.

The study team, working under contract for Ford Motor Co., interviewed 66 motorists and used 140 film slides, each depicting a hypothetical dashboard layout.

Green said most of those interviewed were unable to use the engine information on their dash because they didn't know such things as normal oil pressure, operating temperature or electrical requirements.

Pointers and bar charts, especially those color-coded to show normal ranges, were more helpful, he said.

On the other hand, the large miles-per-hour numerals often used in place of the conventional speedometer are a plus, he said.

"Old people say, 'I can finally read the speedometer,'" Green said.

Digital readouts showing speed, miles traveled, time of day, fuel mileage and engine functions have increased in popularity as carmakers put more computers and electronics under the hood.

There's also a pizazz factor. Customers who load up their cars with gas shocks, electrically heated windshield, compact disc player, intermittent rear-window wiper and anti-theft computer are likely candidates for dashboards that do more than flash a red light after the engine conks out.

"A lot of people are satisfied as long as a car is running. But there's a whole segment of people out there who love to know if their engine is running at 180 degrees," said John Dinan, a spokesman for GM's AC Spark Plug division, which makes GM's dashboards.

The university's research "doesn't say you shouldn't use digital displays," Green said, but automakers have shown "some confusion between high-tech and complicated to operate."

"I think something can have a high-tech feel and still be understandable," he said yesterday in a telephone interview.

American and Japanese carmakers appear fascinated with digitals while the Europeans have been slow to adopt them, preferring old-style analog gauges.

Digital dashboards are standard equipment on a few cars but usually are sold as expensive optional equipment.

Standard on General Motors Corp.'s 1986 Riviera, which at a base price of $21,577 is nearly $2,800 more expensive than the 1985 model, is a digital dash and cathode ray tube that displays a computerized "menu" of functions. Touch a spot on the screen and a computer sets the air conditioning at a certain level and remembers which radio station to tune in.

Almost anyone eventually can figure out a new-tech dashboard, Green said, but that's not good enough.

"You still have to bear in mind that there a lot of borrowed cars, rented cars and instances in which a family might have many vehicles," he said.

Green, who has begun similar work for Chrysler Corp., said Ford's goal is to make digital displays "intuitively obvious" — meaning that when the light on the dash goes on, so should the one in the driver's brain

2.0 DISPLAY TECHNOLOGY

Displays have evolved from basic instrumentation, giving the operator simple vehicle performance indicators and control functions, to complex diagnostic systems and navigational aids. Only a few years ago vehicle performance was judged by a few simple gauges (or red warning lights) indicators of oil pressure, engine temperature and charging system. Speedometers, fuel guages, and odometers were the prime vehicle instrumentation. The gauges were mechanical analog devices. Electronic graphical displays have begun to replace, expand, and augment the functions these mechanical displays served. In addition, many new displays have been added for comfort, convenience, and entertainment purposes.

2.1 Display Evolution

The displays currently available in vehicles range from the "traditional" analog-type displays (Figure 1) to high technology displays (Figure 2). In general, the European manufacturers appear to adhere to a "traditional" design school, although this is changing in response to market pressures. Japanese car manufacturers lead in high technology display applications, particularly in vehicles destined for their home markets. The U.S. manufacturers occupy a middle position, offering limited high technology displays as standard features on some vehicles and offering more complete high technology displays as options on others. Overall, the consumer acceptance of such displays has been very good (although there also exist consumers who prefer a more traditional approach). Much of this acceptance is probably based on the consumer's desire to have the newest technology and on the perception that more information is better.

2.2 Electronic Display Technologies

The display technologies now available include vacuum fluorescent (VF), liquid crystal displays (LCDs), light-emitting diodes (LEDs), and cathode-ray tubes (CRTs). VFs and LCDs are currently the dominant forms of advanced displays in the automotive industry. Table 1 contains a comparison of four display types and Table 2 indicates where these technologies are being used.

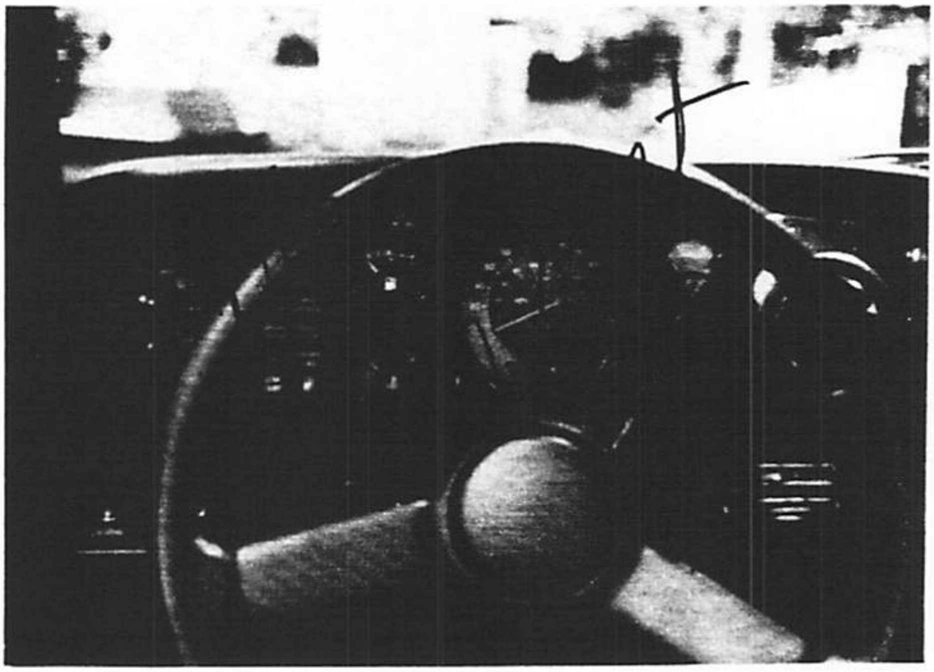


FIGURE 1. TRADITIONAL ANALOG DISPLAY, 86 ROLLS ROYCE

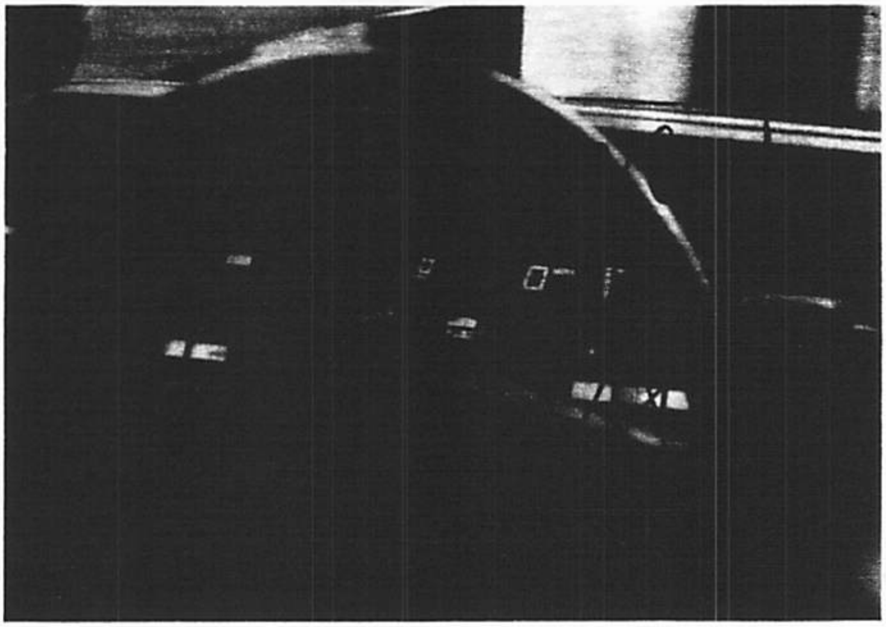


FIGURE 2. HIGH TECHNOLOGY DISPLAY, 86 SUBARU TURBO

Table 1
Comparison of Display Techniques

Display Type	Resolution	Brightness	Color	Cost	Special Feature
VF	low-med	very high	limited (6)	med-high	easily read, high reliability
LCD	low	low	yes	low	low voltage requirements, reliable
LED	low-med	med	limited	low	cheap, easy to manufacture
CRT	high	high	yes	high	applicable to navigation systems which "draw" maps

- o VFs have excellent readibility under high ambient light conditions, they are very reliable under severe weather conditions, and they have multi-color capability (up to six colors). The major disadvantage of VFs is that they are more expensive than some of the other types of displays such as LCDs and LEDs.

- o LCDs are available in a wide variety of colors, shapes, and sizes, and they are relatively cheap to manufacture. Because LCDs do not emit light, reflected ambient light or light from another source such as an incandescent lamp is required. Where ambient lighting is inadequate or conversely is too bright (causing glare), LCDs can be difficult to read (backlighting can alleviate this problem to some extent). Also, LCDs are almost impossible to read when drivers use polarized sun glasses, or when the viewer is off axis (at a shallow angle to the screen). Under high temperature conditions there can also be contrast problems which reduce legibility.

- o LEDs are also used in automotive displays. LEDs are available in a variety of shapes and sizes but only in a few colors and are hard to read at high ambient light levels. The preferred use of LEDs is for warning lights.

Table 2

Electronically Displayed Functions

Model	Speedo-meter	Tacho-meter	Odo-meter	Temp. Gauge	Fuel Gauge	Trip Functions	Driver Info. Monitor	Radio
FORD								
Continental 84	VF			VF	VF	VF	VF	VF
Thunderbird 84	VF			VF	VF	VF	VF	VF
GENERAL MOTORS								
Corvette 84	LCD	LCD		LCD	LCD	LCD	LCD	LED
Cutlass Ciera 83	VF			VF	VF			LED
Buick Regal & Riviera 83	VF				VF			LED
Pontiac STE 83							LCD	LED
Cadillac Eldorado & Seville 83	VF				VF			LED
Buick Riviera 86	VF	CRT	CRT	CRT	VF	CRT	CRT	CRT
CHRYSLER								
Dodge 83						VF		VF
Imperial 83	VF		VF		VF	VF		VF
LeBaron 83						VF		VF
Dodge 600ES 84	VF	LED	VF	VF	VF			VF
Daytona & Daytona Turbo						VF		VF
Laser XE 84	VF	LED	VF	VF	VF	VF	VF	VF
Executive Sedan 84	VF		VF	VF	VF			VF
New Yorker 84	VF		VF	VF	VF	VF		VF

- CRTs (small versions of the screens used in color televisions) are favored for more complicated displays. CRTs are used for navigation systems to display the maps stored in memory or on tape and in conjunction with touch screens for complex multi-function systems.

For a more detailed description of these displays, the reader is referred to papers in the Technology section of the References.

Table 3 shows the progress that has been made by the major domestic manufacturers in introducing these new displays. Clocks were among the earliest instruments to be converted to the new technology. The instrument cluster, which provides the primary driving information to the driver, can include speedometer, tachometer, fuel, oil, temperature, and charging sytem gauges and is rapidly being augmented with new display technologies. Examples of the new clusters are shown in Figures 3 through 7.

Of particular interest is how the cluster information is presented to the driver. Displays of speed, both vehicle and engine, can be digital or analog and vary widely in design. Other gauges (fuel, oil, temperature, and charging) can also be presented in different ways. Examples of these are shown in Figures 8 through 12.

With the advent of micro-electronics, new display functions have become available to the designer and therefore the driver. These include trip monitors and vehicle diagnostic systems. The trip monitors provide data on factors such as as fuel volume remaining, mileage to destination, estimated time of arrival, time elapsed, average speed, and estimated fuel economy. Examples of such displays can be seen in Figures 13 through 15. Vehicle diagnostic systems are available that continuously monitor various vehicle operations and alert the driver to any out-of-specification systems. Most diagnostic systems also offer a scan function that, at the driver's command, will cycle through each vehicle system represented and present a display of the status. Some systems also have a voice overlay for audio confirmation of system status. The diagnostics, besides monitoring the standard systems (oil, temperature, and charging), also check such things as light function, brake fluid level, windshield washing fluid level, etc. Up to 20 different systems can be monitored. Figures 16 and 17 show some typical diagnostic system displays.

Table 3

Electronic Display Milestone Events

Year	General Motors	Ford	Chrysler
1974			led gauge warning system
1975	low fuel warning (light emitting diode)		
1976			
1977	cluster and trip computer (gas discharge display)		clock (vacuum fluorescent)
1978	cluster and trip computer (vacuum fluorescent)	miles to empty (gas discharge display)	
1979		electronic radio display (vacuum fluorescent)	
		clock (vacuum fluorescent)	
1980	cluster and trip computer (vacuum fluorescent)	cluster (vacuum fluorescent)	
	fuel monitor (light emitting diode)	cluster w/message center (vacuum fluorescent)	
1981	clock (vacuum fluorescent)		cluster (vacuum (fluorescent)
1982		trip computer (vacuum fluorescent)	
1983	diagnostic/service display (liquid crystal)		trip computer (vacuum fluorescent)
	cluster, standard, equip. (liquid crystal)		driver information monitor (vacuum fluorescent)
1984	driver information monitor (liquid crystal)	driver information monitor (vacuum fluorescent)	
1985	CRT (prototype)		
1986	control center (CRT)		

FIGURE 3. CADILLAC ELDORADO AND SEVILLE CLUSTER

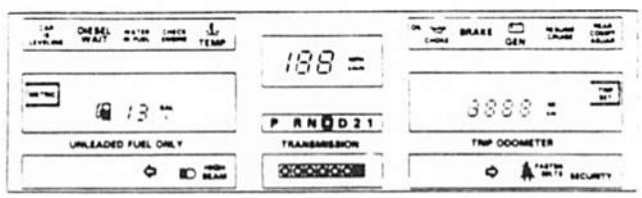


FIGURE 4. BUICK RIVIERA AND REGAL CLUSTER

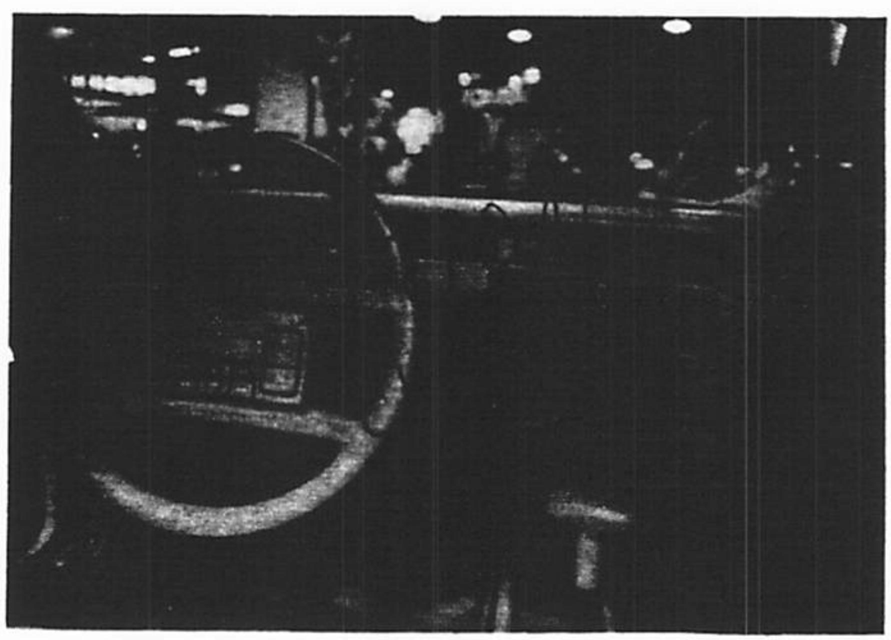


FIGURE 5. 86 PONTIAC 6000 STE INSTRUMENT CLUSTER

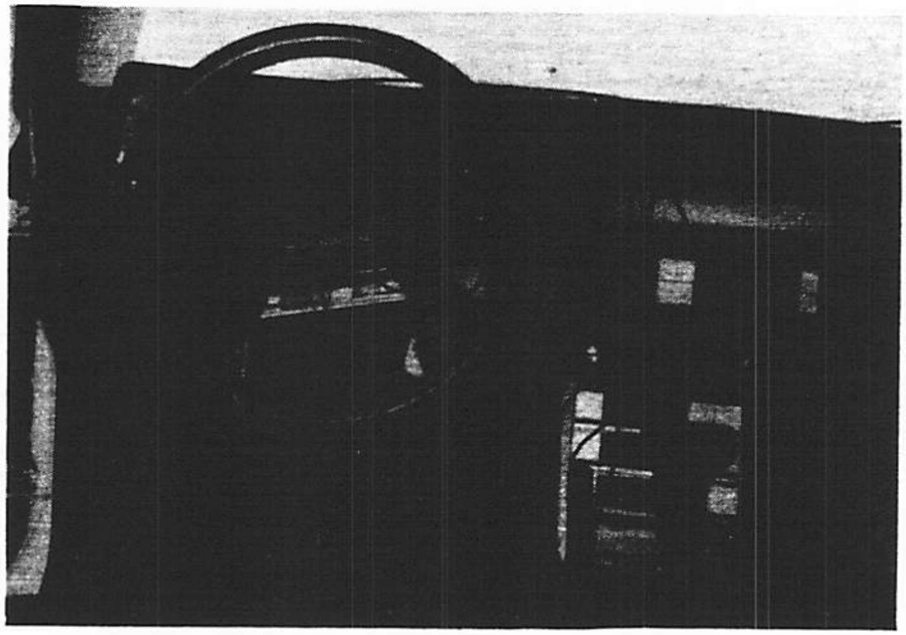


FIGURE 6. 86 MITSUBISHI STARION INSTRUMENT CLUSTER

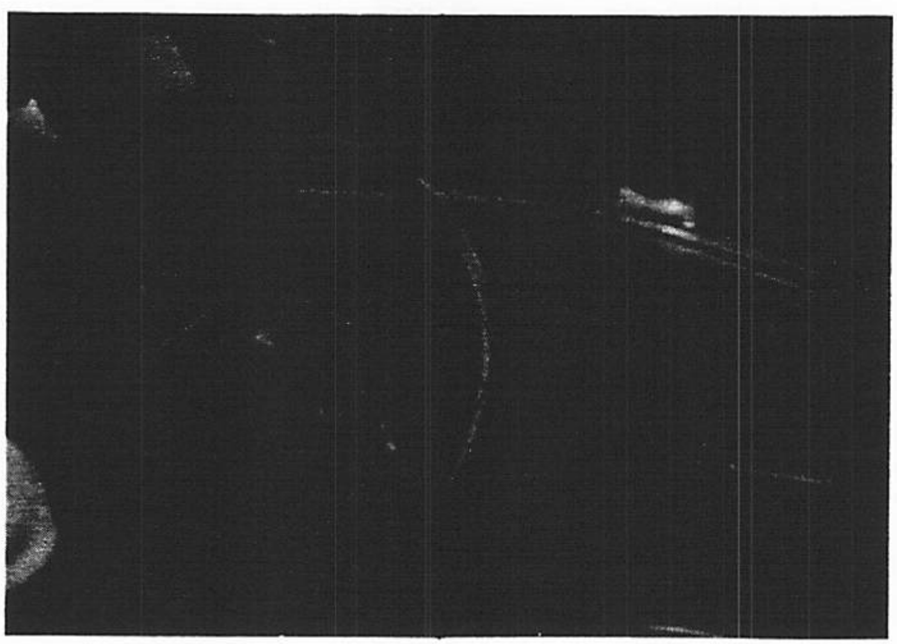


FIGURE 7. 86 FORD TAURUS INSTRUMENT CLUSTER

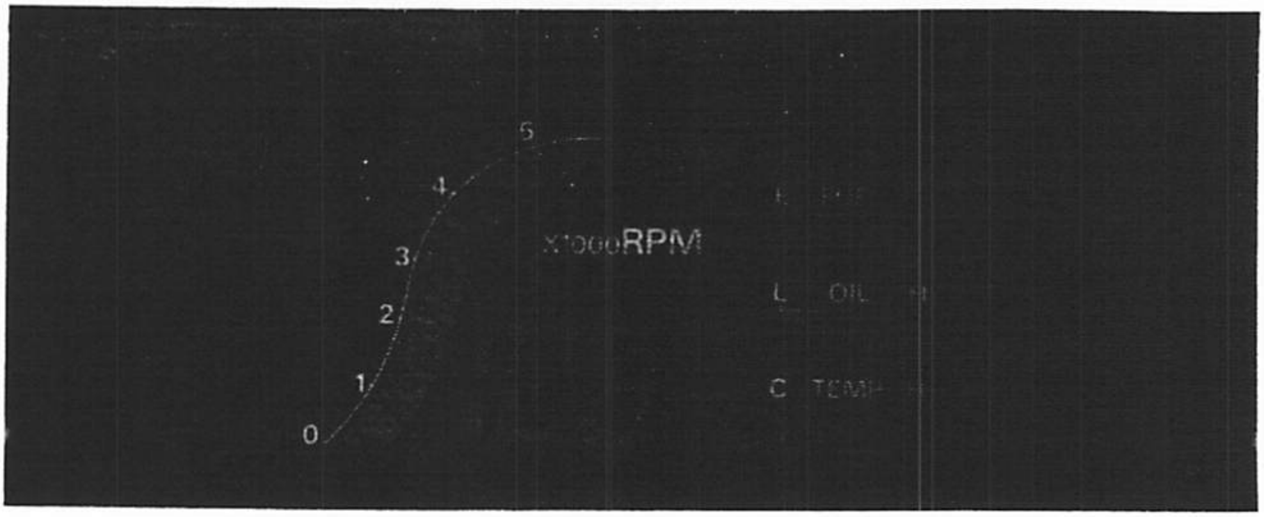


FIGURE 8. ALPS, INC. LCD DISPLAY

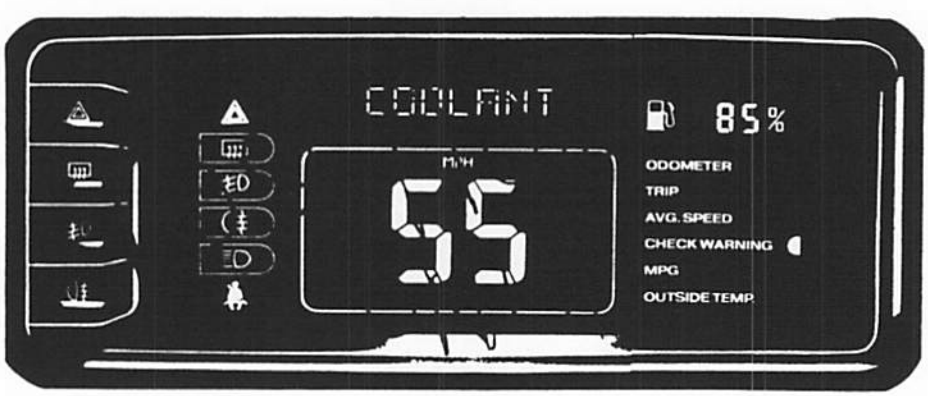


FIGURE 9. BOSCH, INC. INTEGRATED DASHBOARD

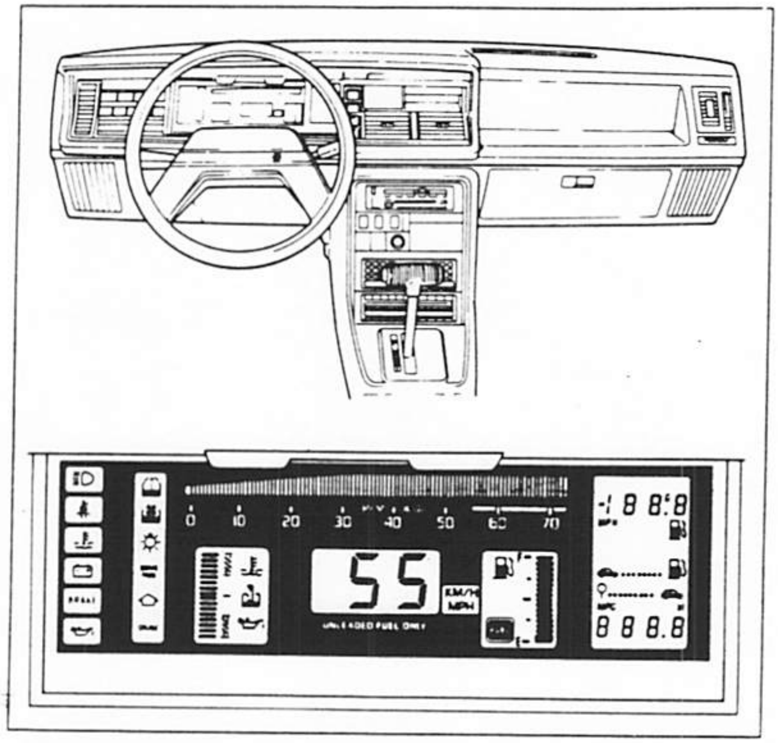


FIGURE 10. 86 RENAULT ENCORE ELECTRONIC INSTRUMENT PANEL

FIGURE 11. OLDSMOBILE CUTLASS CIERA CLUSTER

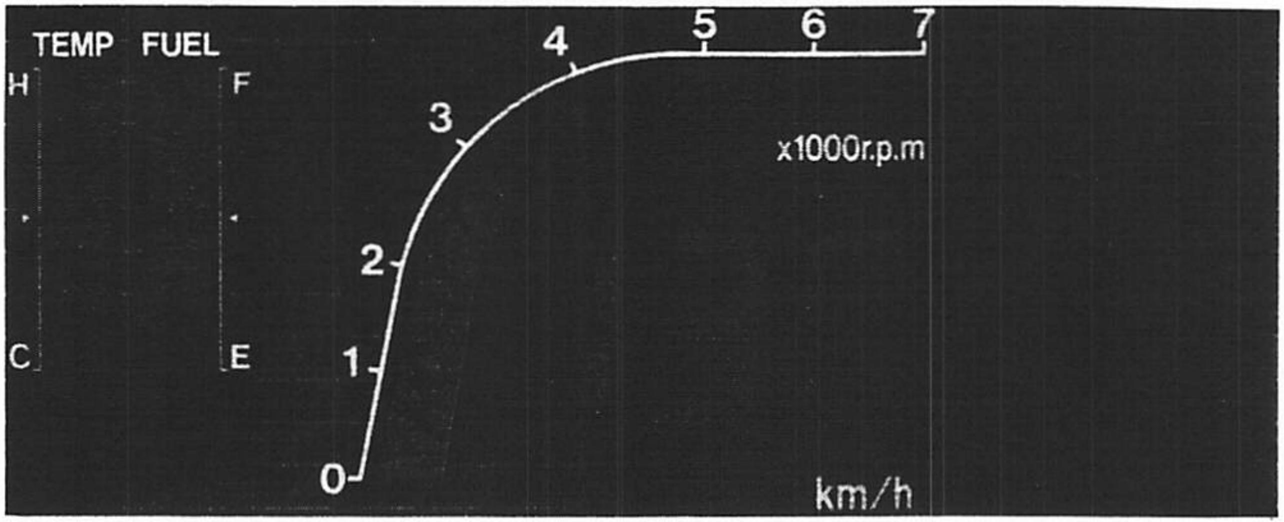


FIGURE 12. ALPS, INC. LCD DISPLAY

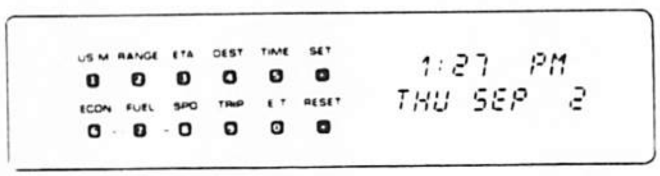


FIGURE 13. CHRYSLER NAVIGATOR

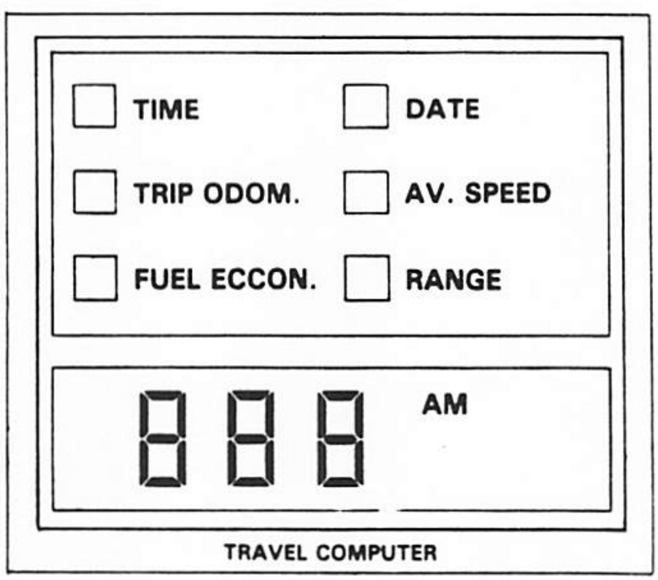


FIGURE 14. CHYRSLER TRAVEL COMPUTER

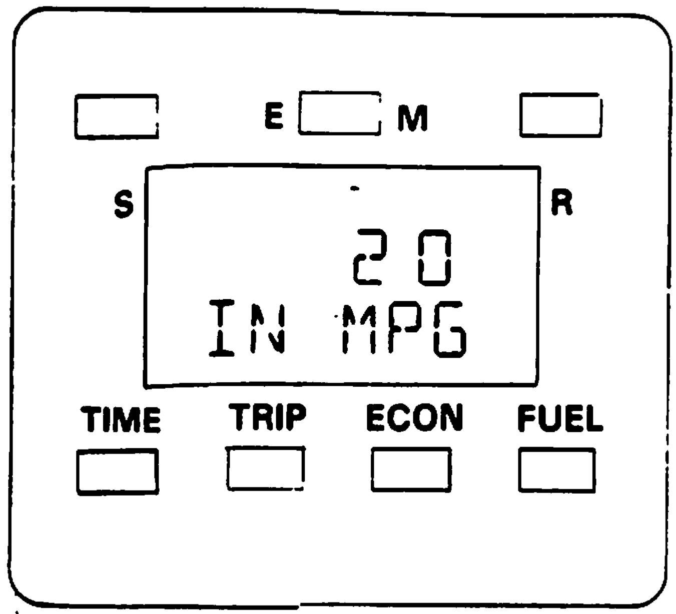


FIGURE 15. FORD TRIPMINDER

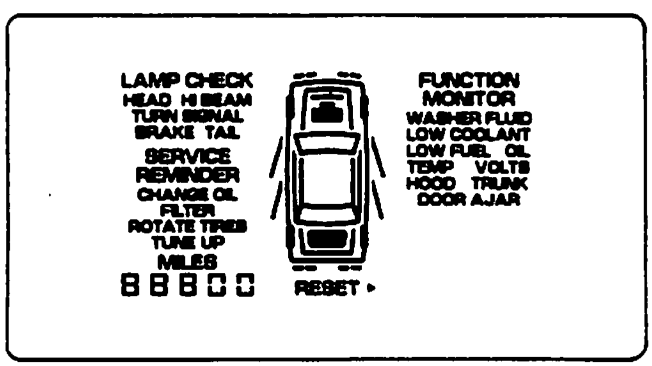


FIGURE 16. PONTIAC STE DRIVER INFORMATION CENTER

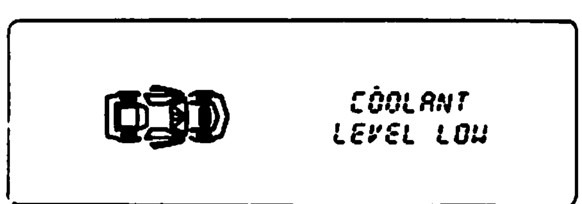


FIGURE 17. CHYRSLER ELECTRONIC MONITOR

Very recently car manufacturers (and after-market distributors) have introduced multi-function display systems using CRTs. In Buick's Riveria, the CRT is utilized in the Graphic Control Center (GCC) option in 1986 vehicles. Up to six functions including diagnostics, trip information, radio status, environmental parameters, and summary data are available for monitoring and control. The functions can be selected through the use of six buttons located around the periphery of the display screen. When a particular function is selected, sub-functions are displayed for observation or for further selection. Selection is accomplished by touching the CRT screen at small (approximately 1" x 1/2") visually but not tactilely defined areas. Figures 18 through 24 show some of the displays available in this system. Figure 25 shows the GCC in relation to the instrument panel.

Some CRT display systems, either presently available or under development, are also used for navigation. Examples include Ford's TRIPMONITOR or the Etak Navigator. The Ford Motor Company's TRIPMONITOR is still in the experimental stage and no specific plans for marketing to the general public have been announced to date. This system will have many of the features found in the Buick's Riveria as well as a navigation function. This system uses "touch-screen" CRT technology. Navigation is planned to be accomplished through periodic satellite fixes and "dead reckoning" between fixes. The details of this system can be found in Appendix A. Figure 26 shows each category's main pages. The Etak Navigator is currently available as an after-market device on the West Coast and will be offered on the East Coast in 1986. General Motors Corporation also has exclusive rights to the system as original equipment and plans to offer it in luxury models by 1990. The GM version of Etak will contain maps on compact disc rather than cassette tapes. This will allow each map to contain a larger geographical area than the cassette versions. The details of this system can be found in Appendix B.

VDO Systems Inc. is developing a navigation system called "VDO City Pilot." The prototype system contains a geomagnetic fluxgate sensor, a microcomputer, and an LCD display with a 360-degree scale and manual control unit. The details on this device can be found in Appendix C.

The Japanese and European manufacturers have also been developing navigational equipment for the U.S. market. Honda, Nissan, and Toyota are producing systems that require CRTs for display and control. Honda's system is available in the Japanese

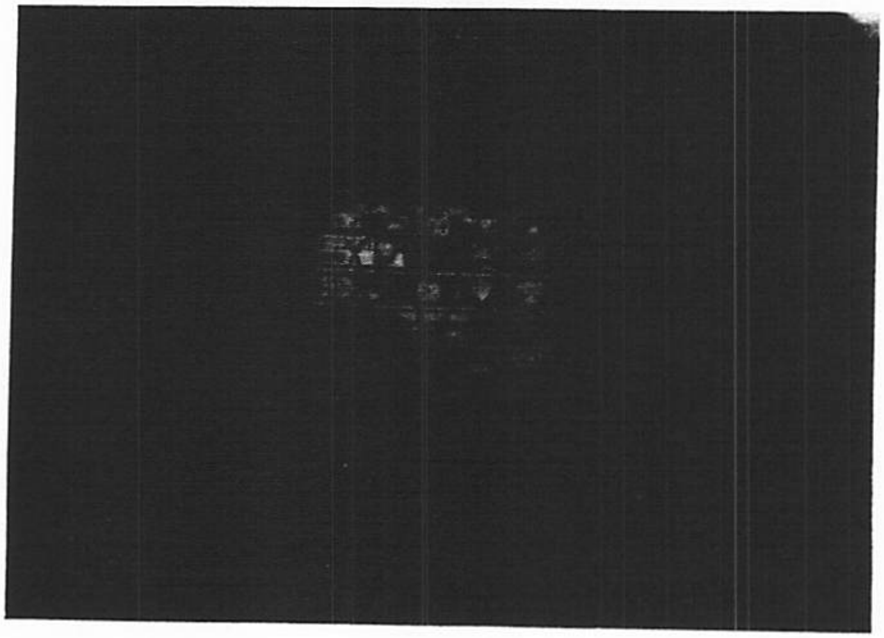


FIGURE 18. 86 BUICK RIVIERA GCC SUMMARY PAGE

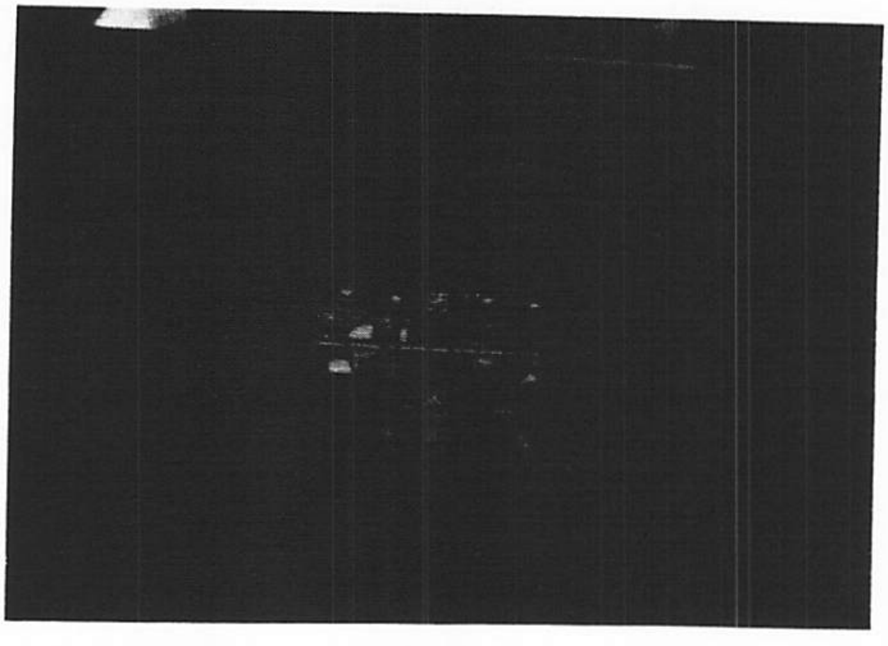


FIGURE 19. 86 BUICK GCC RADIO PAGE

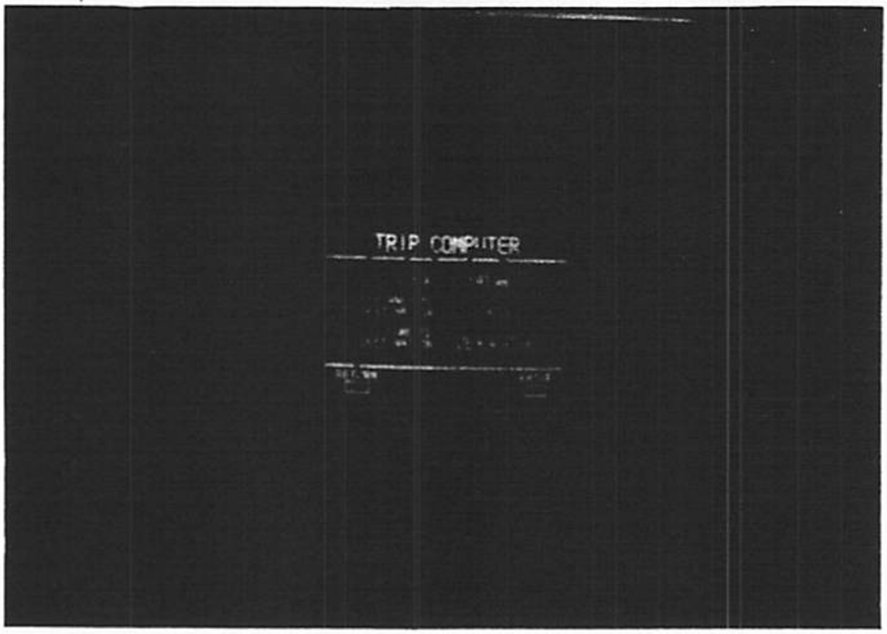


FIGURE 20. 86 BUICK RIVIERA GCC TRIP COMPUTER PAGE

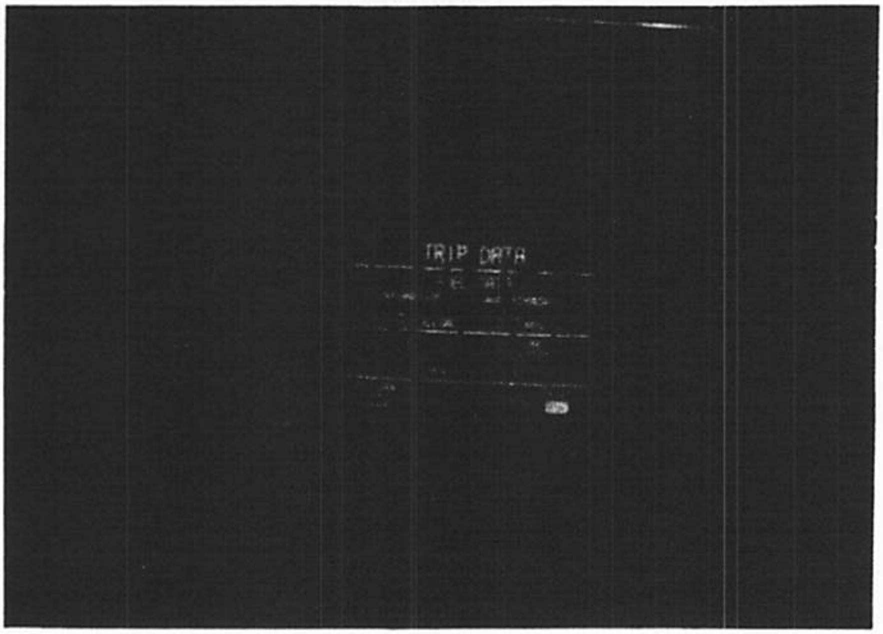


FIGURE 21. 86 BUICK RIVIERA GCC TRIP DATA PAGE

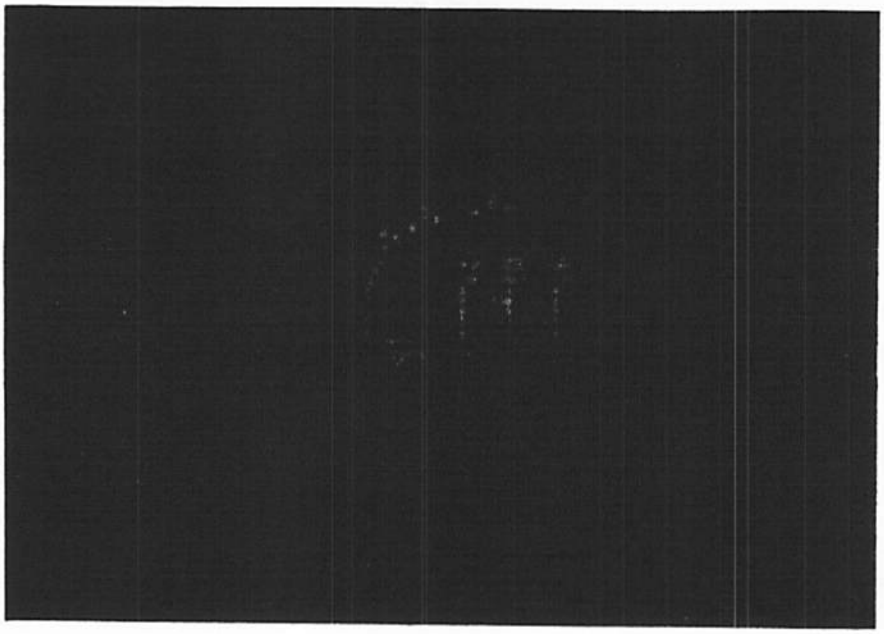


FIGURE 22. 86 BUICK RIVIERA GCC GAUGES PAGE

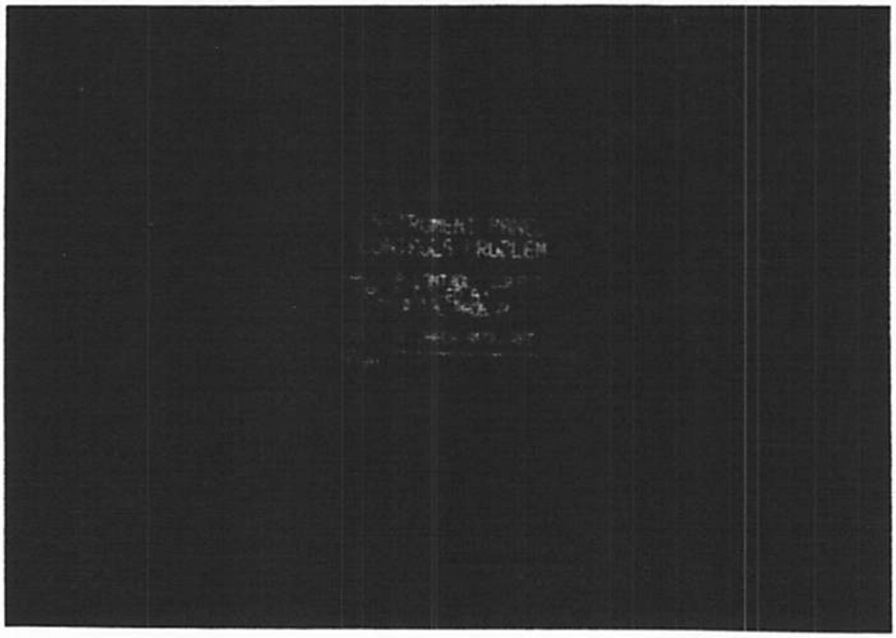


FIGURE 23. 86 BUICK RIVIERA GCC DIAGNOSTICS PAGE

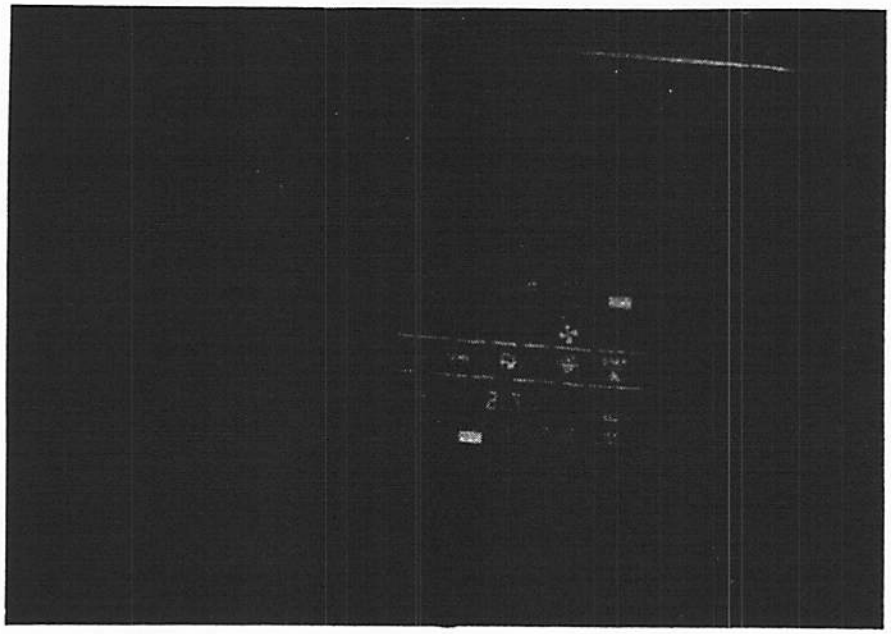


FIGURE 24. 86 BUICK RIVIERA GCC CLIMATE CONTROLS PAGE

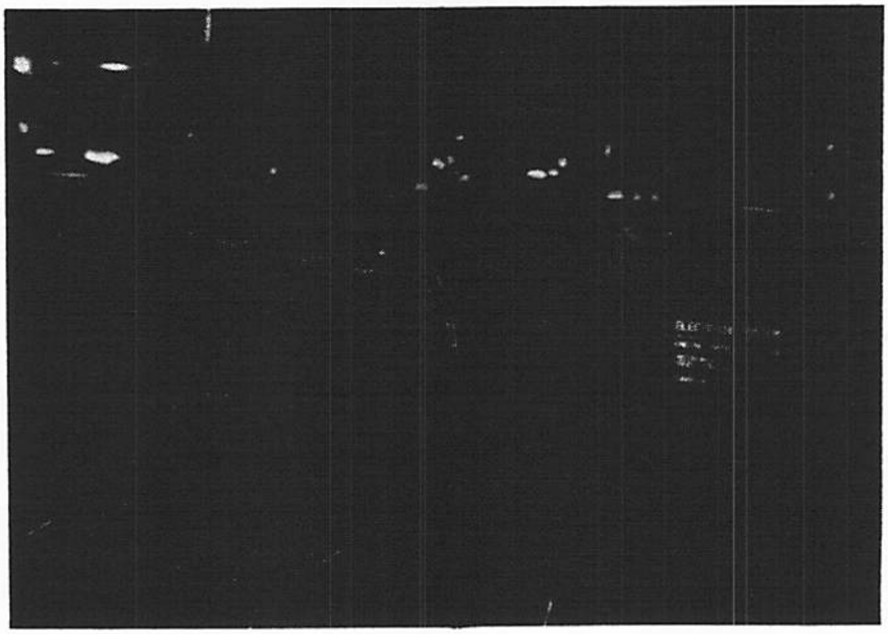


FIGURE 25. 86 BUICK RIVIERA DASHBOARD WITH GCC

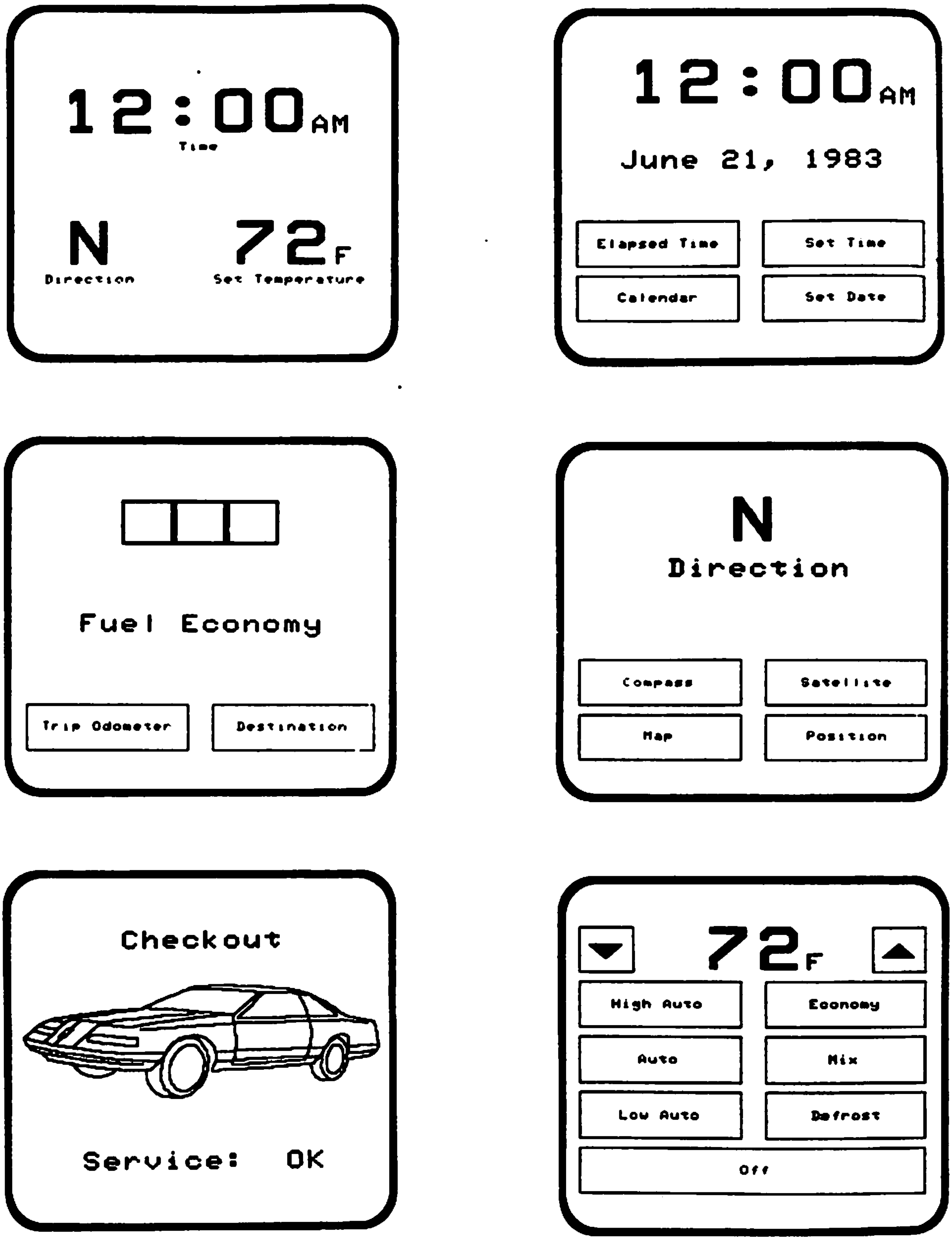


FIGURE 26. FORD TRIPMONITOR MAIN PAGES

market Accord-equivalent and works on the principle of a gas tube "gyro" or inertial guidance system. Nissan's prototype navigational system was displayed in its NRV-11 research vehicle (Appendix D). The system uses a magnetic direction sensor and distance recorder. The CRT also has date/time, diagnostic and radio functions. The basic control input is by touch, but route information can also be entered verbally and the computer will be capable, via voice synthesis, of keeping the driver informed of current position. Appendix E contains the translation of a Japanese article describing some of the new options, such as multi-function CRT systems, available on 1986 models for the Japanese market. Volkswagen Siemens in Germany is also developing a navigational system. This system uses an on-board magnetic field sensor.

2.3 Future Display Technology

The CRT, due to its versatility, is finding favor with automobile designers because it lends itself to both multi-function and specific (navigation) applications. It is anticipated that CRT use will increase as more functions are monitored in the next generation of automobiles. Various automobile manufacturers have been displaying "concept" cars that highlight features that may be available in five to ten years. In Buick's Questor (Appendix F), a line-of-sight "heads-up" display is used for the speedometer and gauges. Other features of this vehicle that affect the driving environment include a map and navigation system, a voice-activated radio telephone, a television rear-view system, and touch-control for entertainment, comfort, and convenience functions. (Two CRTs are used in this vehicle.) A copy of the magazine article "Electronics in the Passenger Compartment" from the September 1985 issue of Radio-Electronics is contained in Appendix G. This article contains a good description of the Buick Questor as well as other concept cars such as the Chrysler Stealth.

The Chrysler Stealth concept car uses a nine-inch CRT to display navigational data from NAVSTAR satellites. This vehicle has placed all instrument panel controls at the center of the steering wheel including lights, radio, wipers, and cruise control.

Future vehicle systems will be equipped with both voice synthesis and voice recognition systems. The best example of this is Nissan's NRV-11 car that was previously mentioned (Appendix D). The voice operated functions include navigational data, speed warning settings, control of exterior mirrors, interior lights, and hazard flashers.

3.0 CONTROLS

Important considerations for the design of controls are their location, frequency of use, function, size, and shape. In general, driver controls should be located such that they can be utilized without excess hand, head and eye, foot, or body movement. Also consideration must be given to the concept of "traditional" location. For instance, headlight switches are commonly located on the dashboard to the driver's left and are usually the push-pull type. Turn signals are located on the left of the steering column and horn buttons in the center of the steering wheel. Most vehicles continue these conventions. However, variations of these controls are appearing. Examples include using a rotary switch in a "pod" on the steering column for the light switch. Figure 27 is an example of pods attached to the steering column. The location of controls that are secondarily related to safety such as cruise control and windshield wipers and washers show more variation. Comfort, convenience, and entertainment features are generally located in the center of the instrument panel, a relatively less convenient location for the driver. Because of their high frequency of use, these controls should be as convenient as the primary controls. For example, headlights are usually turned on and off once each trip whereas the radio or HVAC controls could require frequent attention. The mode of operation, i.e., sliding, rotary, may also affect the attention span required by the driver. A multi-function rotary switch may require the driver to observe its position to determine its current operating mode, whereas the mode of a simple on-off switch can be determined, to some degree, by its position. The size and shape of a control can also affect the driver's attention requirements. Very small, densely packed, push-buttons require the driver to focus attention on the correct button selection. These problems are compounded by such things as the touch-screen CRT where the switch location can only be determined by observation and activation gives the driver no tactile feedback. When the driver has a gloved hand, such operations are made more difficult. (Some vehicles confirm switch operation with an audio signal or a light on the dashboard.)

3.1 Control Automation

The use of automation to augment automotive control systems is increasing. In many cases, control functions are significantly changed by the use of microprocessors, and entirely new functions are frequently added.

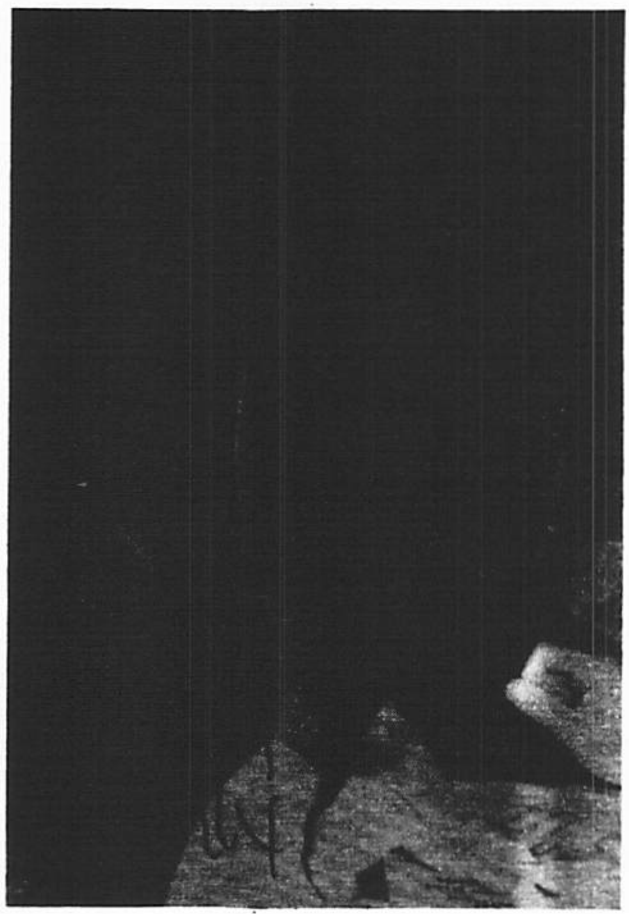


FIGURE 27. 86 ISUZU IMPULSE INSTRUMENT CLUSTER WITH PODS

The typical vehicle of the early 1970s had relatively simple controls for primary driving functions such as: steering, braking, accelerating, activating lights, signaling turns, and clearing the windshield. Similarly, controlling comfort and entertainment functions, such as heating, air conditioning, and ventilation (HVAC) and the radio, was accomplished by relatively straightforward mechanical or electromechanical means. In the mid-1980s, the basic controls available to the driver for steering, braking, accelerating, activitating lights, and signaling turns have remained relatively unchanged although they are now sometimes augmented with microprocessors. Examples of the growth of augmentation are features such as ride control, anti-skid braking, and cruise control. Some basic driving control systems have reached a high level of sophistication as exemplified in the following quote from a popular automotive magazine during the testing of a new Japanese sports car.

> The new car gets rack-and-pinion steering. With power assist, it also gets computer control which regulates the amount of boost according to the speed of the car, the cornering force and the grip the tires have on the road. The feel the driver gets from steering, is in effect, controlled by what the 'assistant' is doing, that is, steering effort is light in parking maneuvers because the speed is low, it gets progressively heavier as cornering loads build, but it's light on the edge of traction because it senses the tires haven't got much grip left.
>
> In large measure the driver thus drives at one remove: The driver tells the steering wheel what's wanted and the wheel reports to the computer delivering the forces to the valves and servos actually linked to the front wheels.

The greatest apparent change to the drivers is in the design and operation of comfort and convenience systems. The vehicle purchaser can now choose complex sound systems, fully automatic climate control systems, power mirror systems, memory seat positioning systems, cellular radio systems, and vehicle diagnostic systems (Figure 28).

Perhaps the change which is most significant to the driver in using the new microprocessor enhanced comfort and convenience systems are the system's controls or switches. The controls themselves have remained relatively unchanged over the years. Most switches are push-button (momentary or locking), rotary, sliding, push-pull, or toggle (momentary or locking) or rocker (momentary or locking).

FIGURE 28. 86 PONTIAC GRAND AM DASHBOARD WITH CLIMATE CONTROL AND STEREO SYSTEM

Currently touch switches (momentary push-button switches or touch sensors) which activate logic modules are popular with system designers. In one common application, the magnitude of the control effect is proportional to the duration of the time that the switch is pressed. This switch type seems to be supplanting more traditional switches where the magnitude of the effect is proportional to the distance the switch is moved. As an example, audio volume control has traditionally been accomplished by turning a rotary potentiometer. Many of the "high-tech" sound systems now use double push-buttons to accomplish volume change (one button increases the volume, the other decreases it). Similar applications are found on lighting and HVAC systems. Although such controls add to system versatility and flexibility by providing a large number of controls in a small space, their impact on driving performance is potentially negative.

Figure 29 depicts the center console of a 1986 vehicle. It shows only the sound and HVAC system controls. Approximately 50 buttons and switches are provided for these two systems. The use, by the driver, of this many densely arrayed swiches, to control only two systems, can obviously result in a distraction from driving. To the extent that the controls are close together, they require that the driver make precision movements rather than the ballistic movements that further spaced switches would require. The potential problems which may result from concentrating a large number of controls into a small area may be alleviated or aggravated by other factors. In particular, the extent to which the visual and tactual identification of controls is facilitated, and the nature and timing of the feedback is provided by the controls. The use of controls which provide little or no positive tactile feedback or even simple visual indication of function seems to have become common. There are of course exceptions, a positive example is a design for the cluster of switches which control power windows. Some manufacturers have chosen to have the switches oriented in the same way as the windows operated and have given the most frequently used switch (the driver's window switch) a distinctive shape.

3.2 Future Trends in Control Design

It is doubtful that the function and location of the basic controls for steering, acceleration, and braking will change in the next five years (not withstanding the common incorporation of aircraft-type controls in "concept" vehicles). Major changes in these controls will probably await the development and adoption of automated vehicle-highway systems. Given this assumption and the likelihood that the basic

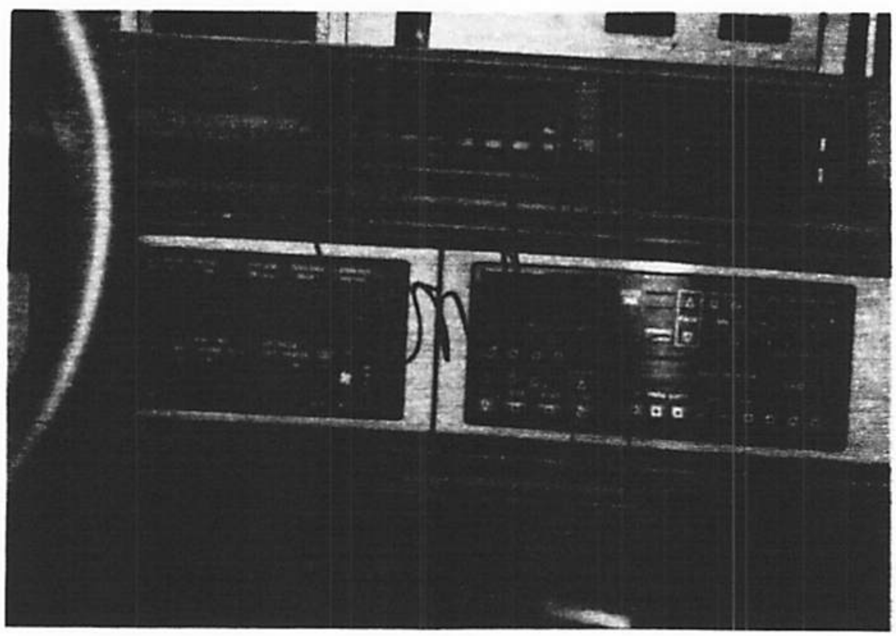


FIGURE 29. 86 PONTIAC 6000 STE CLIMATE CONTROL AND STEREO SYSTEM

functions of the comfort and convenience systems will remain the same, the major impact on the driver is the introduction of new systems.

Two new automotive systems are now being introduced: vehicle diagnostics and navigation. Both systems are similar in that the controls do not directly affect the vehicle or its internal environment, rather they change the information available to the driver. As such, they require a higher degree of involvement by the driver. That is, the driver must do the following:

- Determine what and when this new information is required;
- Identify and use the proper controls to produce the information;
- Interpret the information;
- Determine that the information provided by the system is what was required and is sufficient; and
- If the information is sufficient, take appropriate action based on the information; or
- If it is not, begin the process again.

The use of these systems is often complicated by the use of a "paged" system arranged in the form of a "logical tree." In such a system, the different pages of information are displayed at the same location and the same controls have different functions for different pages.

It is important that the controls for these systems do not require significant driver concentration beyond that required to interpret the information sought. The current trend in these systems is to use momentary push-button switches and touch panel controls.

A number of potential problems must be considered. The designated touch area should be large enought to insure that the driver does not have to concentrate on the touch site to make the input. The controls should be within the driver's reach and not far from the driver's area of visual concentration. They should also provide direct and immediate feedback that the input made was sensed by the system (auditory feedback if tactile is not possible), and that the correct input was made.

The trend in diagnostics and navigation systems is to use touch panels. The CRT function is selected by placing the finger within a predesignated area (usually small) on the CRT screen. These switches can be of three types; infrared optical, transparent membrane, and glass panel. The infrared optical is a non-contact switch that only requires the finger to intercept a light beam in a matrix of light beams (and detectors). The other two types require some force on the screen to affect a switch closure in the selected area. See Appendix H for a more detailed description of some control devices.

A more positive trend is the duplication of frequently used controls in the steering wheel hub, thereby providing quick access to these controls. Both Pontiac and Mitsubishi now offer such controls.

In the case of controls in the center of the steering wheel (and to a lesser degree the "pods" on each side of the steering column), the accessibility of the controls is improved and their location is more within the drivers field-of-view. However, they will require increased visual accomodation. (In fact, farsighted drivers may have focusing problems with steering wheel controls.) Again, these controls could be improved by positional or tactile ergonomic design.

4.0 FUTURE EFFORTS

The advances in microprocessor and display technology will result in a greater use of automated display and control systems in highway vehicles. Although most of the applications will not be in primary safety systems, they could potentially affect driving safety because they require some share of the driver's attention.

As with all technological advances, the development of technical guidelines for the application of automated display and control systems is important. In the U.S., such guidelines are usually the product of cooperative efforts between the industry which develops the technology, the research community which evaluates the performance of the systems, and the government which represents the public interest in the system.

The development of such guidelines would now have to be based on informed speculation because there is little or no objective data on the impact of incorporating such systems into the driving environment. As noted, to determine the impact on driving safety for different classes of display and control systems, we must develop quantitative data on their:

- o Relationship to the driving task;
- o Frequency and duration of use during critical operations; and
- o Interference with safety critical processes.

A sharply focussed research program would be required to develop such data. This program would be composed of the following elements:

- o Determining the functional classes of existing and planned control and display systems;
- o Defining descriptions of the basic phases of driving in terms of the contribution of these phases to safety;
- o Establishing demographically defined groups of drivers for their ability to respond to potential driving interference or enhancement resulting from the use of such automated systems; and
- o Determining, through observational and experimental studies, the frequency and duration of use of such advanced systems by different classes of drivers during different phases of driving.

The results of the program would be valuable to the public because it would provide NHTSA with objective information with regard to the appropriateness of the incorporation of various classes of advanced display and control systems into new vehicles. The results of such a program would also be valuable to the automotive industry in planning for the development of new systems and for the application of new technologies in vehicle designs.

5.0 CONCLUSIONS

The material reviewed in this report describes much of the new control and display technology currently available for the U.S. automotive market. More significantly, it provides an indication of the tremendous growth, sophistication, and complexity possible through application of automation to these control and display systems. Because these systems are usually concerned with comfort, convenience, and entertainment, their impact on these systems on safety is generally indirect. Nevertheless it is vital that these systems do not interfere with the safety critical functions. To minimize this interference, it is important that automotive system designers have access to objective guidelines. These guidelines should deal with the relationship of the control or display to the driving task, the frequency with which the control or display system will be used, and the possible interference with other driving tasks. Research will be required to develop the qualitative data on which such guidelines must be based.

APPENDIX A

Ford TRIPMONITOR

APPENDIX A

The Ford TRIPMONITOR

Ford Motor Company is developing a information system called TRIPMONITOR. This system provides more than navigation systems like the Etak Navigator or VDO Citypilot. TRIPMONITOR is designed to contain other features such as an electronic automatic temperature (EATC) system. TRIPMONITOR contains six major subsystems: a color CRT monitor, touchscreen and feature controls, a microcomputer system, sensor environment, EATC system, and a satellite navigation system. A touchscreen system was chosen to reduce the number of controls. Switches below the screen serve as a main menu to allow the driver to quickly change between the six subsystems.

The navigation system in TRIPMONITOR combines satellite navigation and dead-reckoning. Vehicle position is determined by dead-reckoning and periodically updated by satellite. TRIPMONITOR makes use of the U.S. Navy Transit navigation system to determine the exact location of the vehicle and eliminate accumulated errors in the dead-reckoning system. Maps are stored in system memory and drawn on the color monitor with the vehicle location when requested by the operator.

The major categories are summary, information, time, trip information, navigation, check out, and EATC. Each category has a main page which will be displayed upon pressing the button corresponding to that category. This main page displays the most frequently requested data of that category with touchscreen labels for additional information. Examples of the display pages are contained in Section 2.2. The summary page displays the time, vehicle heading, and the set temperature of the EATC system. It is expected that the summary page will be displayed for the majority of the time. The information pages guide the new user to the TRIPMONITOR system. The time category displays the current time and date. Additional features available are elapsed trip time, calendar, set time and set date. Figure A-1 shows the set time page. The set functions allow the user to enter numbers directly rather than counting through to the correct time. The trip information main page displays fuel economy in a graphic format using colored rectangles to show poor, average or good fuel economy. Additional features the driver may select include a trip odometer with start/stop/reset and distance to destination. The latter feature is a driver entered value. Figure A-2 shows the trip odometer page.

The navigation main page displays the vehicle heading in N/S/E/W format. Alternative presentations are a compass display, digital heading in degrees, a map showing vehicle position, a satellite information page, and vehicle position in latitude and longitude. Figure A-3 is an example of a map page.

"Check out" displays an outline of the automobile with the status of car systems. The information indicated ranges from regular service required to low pressure in the tires. The EATC page displays the current selected temperature and allows the driver to change the set interior temperature and mode. Figure A-4 shows the EATC mix mode page.

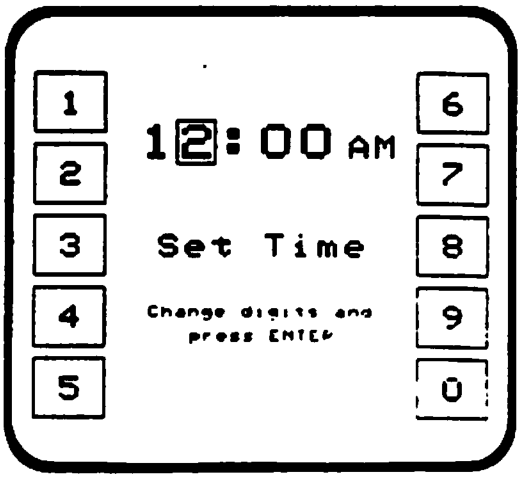


FIGURE A-1. SET TIME PAGE

FIGURE A-2. TRIP ODOMETER PAGE

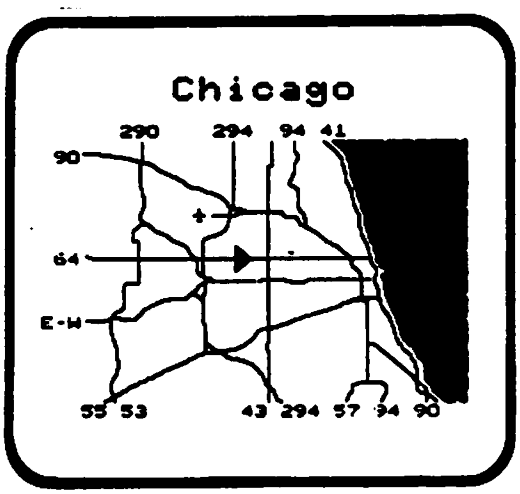


FIGURE A-3. MAP PAGE (CHICAGO)

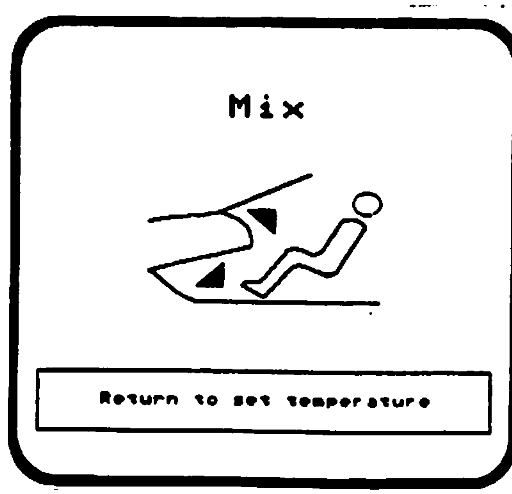


FIGURE A-4. EATC MIX MODE PAGE

APPENDIX B

Etak Navigator

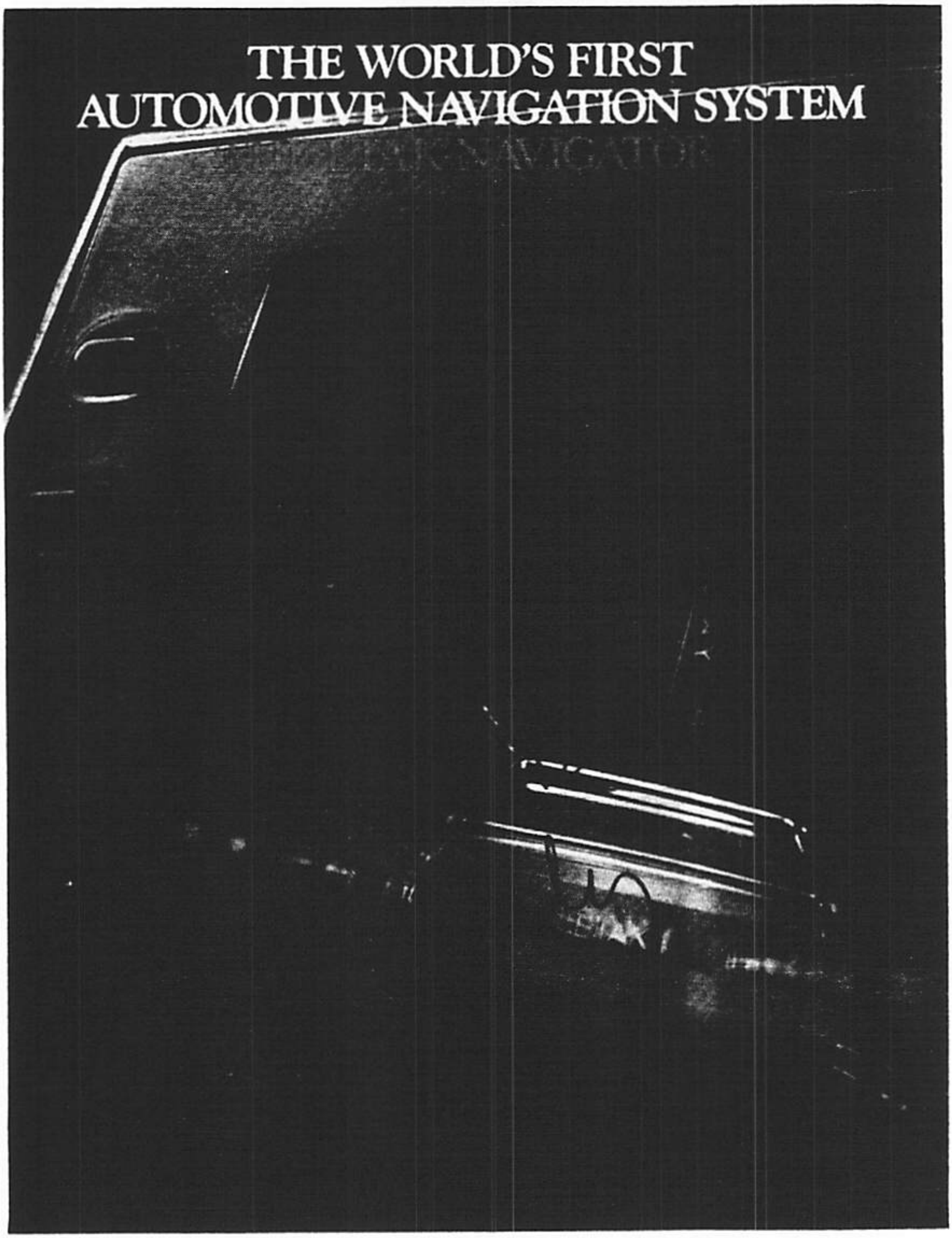
APPENDIX B

The Etak Navigator

The Etak Navigator is the only automotive navigation system currently on the U.S. market. The system consists of a CRT, an electronic compass, motion sensors, a computer, and a tape drive. The computer is approximately the same power as a home computer. There are two models available; Model 450 has a four and a half inch display with a flexible stalk for mounting and the Model 700 which has a seven inch display. Model 450 retails for $1,395 and Model 700 retails for $1,595. Installation time is estimated at two to three hours, costing about $100 - $200. The Navigator is based on "augmented dead-reckoning." The computer compares the measured location with the location on the map and if they disagree, the computer assumes the car is in the right place and corrects the position on the map. The system can be fooled when driving on long, straight roads but corrects itself after a few turns. Etak claims accuracy within fifty feet.

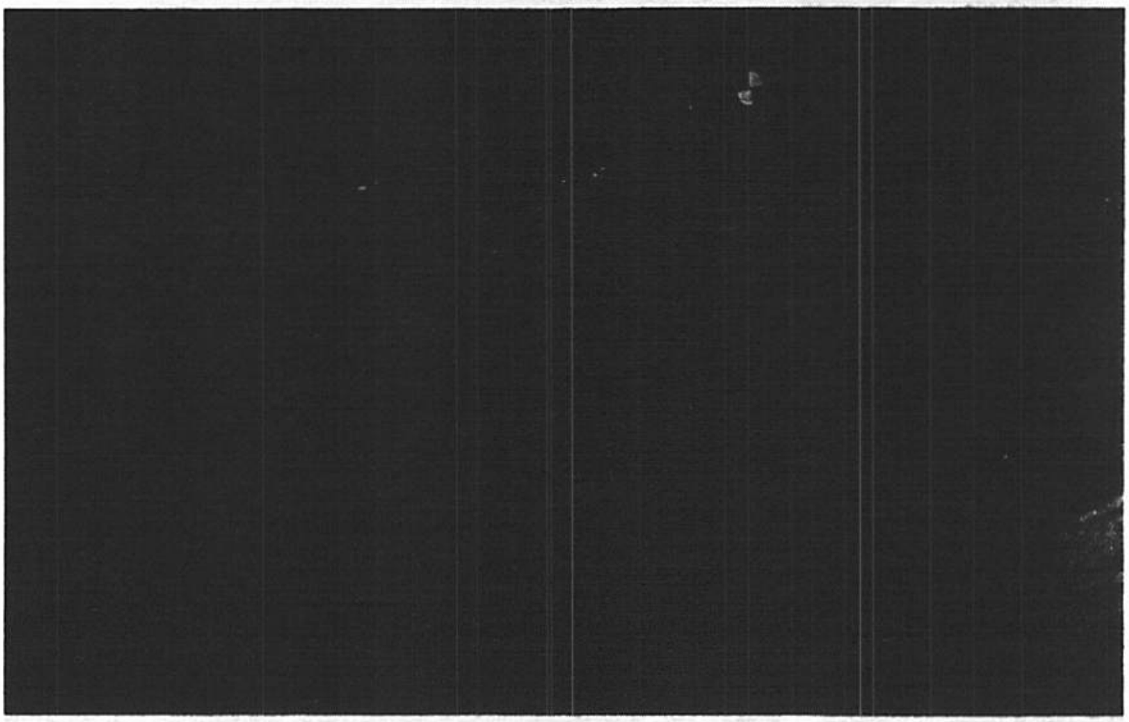
The Etak maps are digitized on tapes similar to audio cassette tapes with each tape containing the equivalent of two paper maps. The cassettes, called EtakMaps, retail for approximately thirty- five dollars each. Four cassettes cover the entire San Francisco area.

There are seven display options in the system: zoom, scan, destination, calibrate, relocate, north-up, and heading-up. The zoom-in/zoom-out feature allows the driver to choose an area as small a quarter of a mile or as large as the interstate highway system (each tape contains the entire national interstate highway system.) The vehicle position is shown as a triangle at the center of the screen and the chosen destination is shown as a flashing star. If at any time the destination is off the screen, its direction is indicated by a flashing arrow. If the operator drives beyond the of range of the EtakMap, the same flashing arrow appears with a message instructing the driver to insert a cassette covering the current area. The zoom feature is the only feature available to the driver while the car is in motion. When the car is stopped, the driver may reposition the car, "leaf through the street directory" and choose a destination, scan the map, or change the map heading (north-up or heading-up). Etak felt that safety could be compromised if the other features were accessible in a moving vehicle. The system is calibrated at the dealer upon installation and the user should not have recalibrate the system after that time.


THE WORLD'S FIRST
AUTOMOTIVE NAVIGATION SYSTEM

For Position only

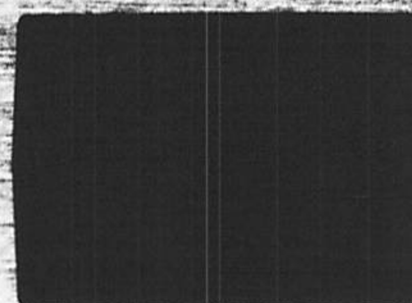
No Training Required. The Navigator was designed for ease of use; no training is required. Using the Navigator is as easy as using most automobile accessories. Should you ever need assistance or a reminder, the Navigator will provide helpful instructions on the display screen.



Just start your engine and drive away—your correct position will be displayed automatically. The system requires no programming or external communication source, and does not accumulate positioning error—no matter where you start or stop, the Navigator will continue to display your current position.

ETAK NAV

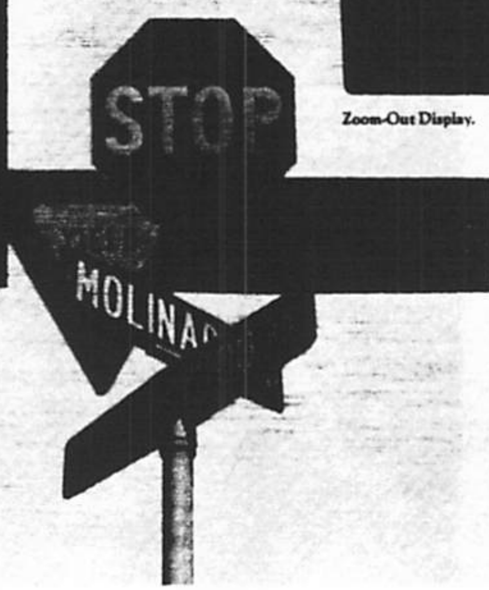
Position only



Zoom-In Display.

Zoom-Out Display.

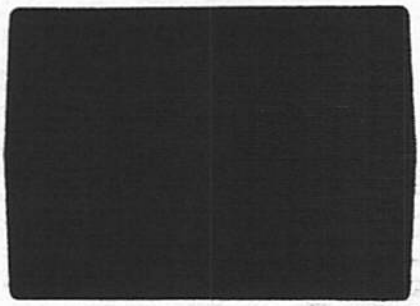
The Navigator Model 450 is an attractive addition to virtually any size vehicle.



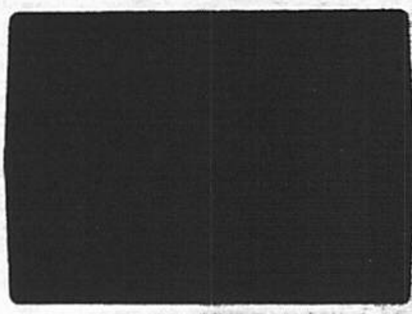
Zoom-In, Zoom-Out
The touch of a button lets you zoom-in or zoom-out for a detailed close-up or larger overview. At the most detailed level every street is shown. The widest zoom level gives you a look at the national interstate system.

The scan button can be used to view areas of the map outside your current driving area. Scanning is useful for trip planning. The map can be scanned at any zoom level and will return to your current driving area by touching a single button.

IGATOR



Map Index.



Display with Destination.

Select and Display Destinations. By scrolling through the EtakMap index, you can select and display destinations, by street address, intersection or landmark—in seconds.

The destination appears as a small flashing star along with your current location and the distance between the two.

Should a zoom level be selected that does not include the destination star, a directional arrow will appear, constantly pointing to the off-screen destination.

EtakMaps—a View of the Neighborhood or the Nation. Electronically-stored maps, called EtakMaps, represent a dramatic improvement over paper maps in ease of reading and available information.

Each inexpensive EtakMap™ cassette contains every street and address for an area about twice that of ordinary paper maps, major state and regional roads, plus national interstates.

And regardless of the detail level you choose to display, EtakMaps are clearly marked and easily read from the driver's position behind the wheel.

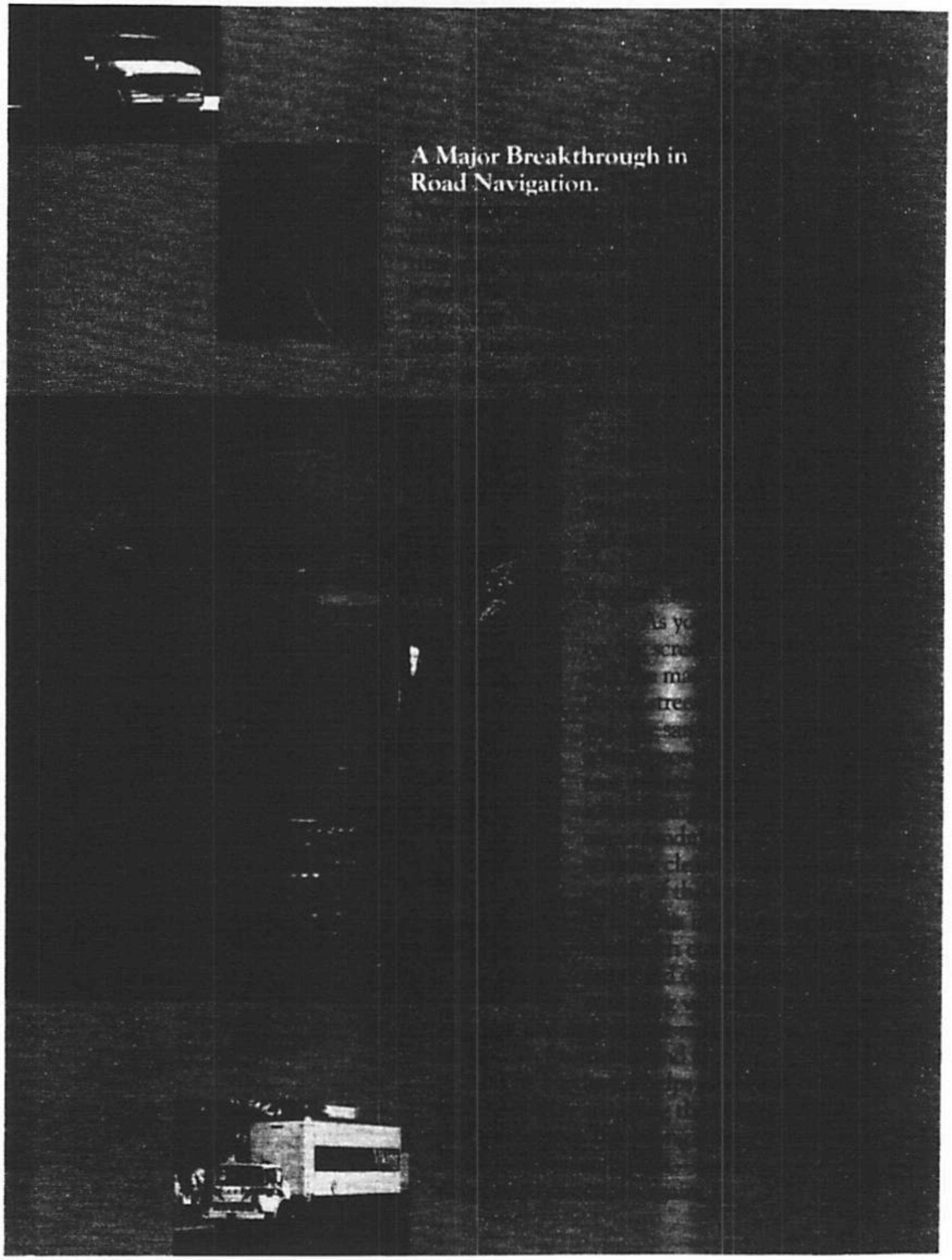
position

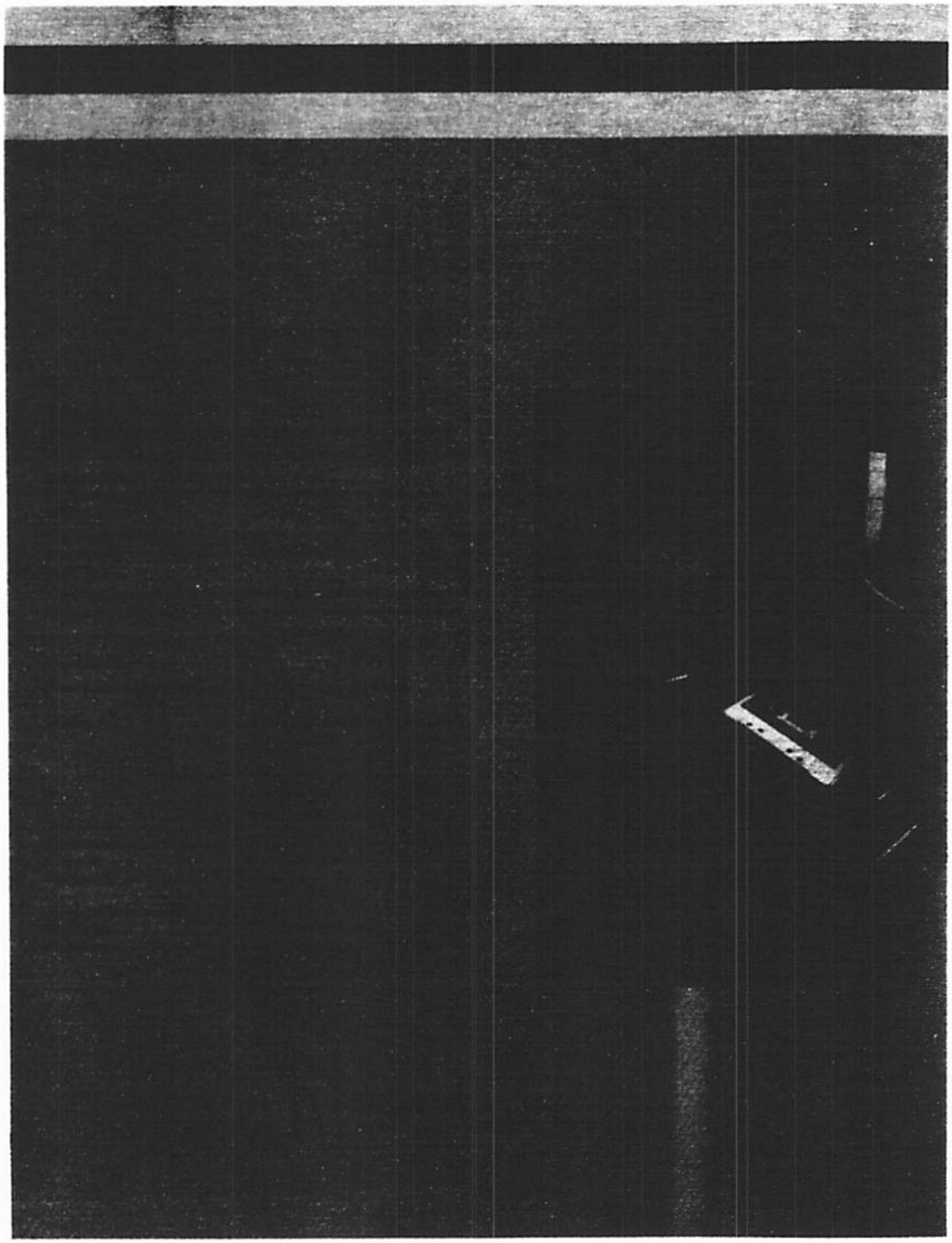
only

A Tool for all Drivers. The Etak Navigator offers wide-ranging benefits for commercial and consumer applications.

Imagine—never being lost again. Frustrating driving conditions, wrong turns, missed exits, and poorly-chosen routes will practically disappear. You'll develop a whole new feeling of driving confidence.

Wherever drivers need to travel in minimum time, at minimum cost with safety and control, the Etak Navigator makes getting there easier and more dependable than ever before.


A Major Breakthrough in Road Navigation.



APPENDIX C

VDO City Pilot

VDO CITY PILOT

Contents **Page**

VDO INSTRUMENTS, INC.

General

Automotive "navigation" today depends entirely upon guide and road signs as well as on road and city maps, while the latter may be studied only after the driver has stopped his car; then he may take the map to look for his actual position and his destination. He has tc remember his route which, to many drivers, represents a great strain that may lead to increased tension and impaired reaction. The benefits of a vehicle navigation system, which presents a cure to these problems, ought to be highly appreciated. They become obvious especially in bad weather, at night, and in unfamiliar cities.

Basically, there are two different systems - the independent self-contained vehicle navigation system and systems evaluating guiding information received from outside. The latter principle requires an appropriate infrastructure while imposing various questions and problems with respect to its administration, organization, and financial support. Naturally, such a system will be hardly flexible thus hampering technological progress. Therefore, VDO has decided in favour of an independent vehicle navigation system.

Independent, Self-Contained Vehicle Navigation System

With a self-contained navigation system, calculation of the actual position of the car is based on the principle of dead reckoning navigation.

Apart from a known starting position, two data are required - the direction being followed and the distance travelled. These data are varying with time and every change of heading. The individual distances travelled with different headings are added or, in other words, reckoned up which explains the origin of the term "dead reckoning navigation".

With a given starting point, the actual position of the vehicle is obtained at the same time.

Mileage and Direction Sensors

The data on the distance travelled may easily be obtained from a speedometer drive pulse sensor which generates a defined number of pulses per tire revolution. The pulse total represents a direct measure of the distance travelled.

The wide range of different direction sensors makes it difficult to select the appropriate type for vehicle dead reckoning navigation:

- Steering or wheel angle sensor
- Rotational speed differential between inner and outer wheels
- Gyroscope systems
- Geomagnetic fluxgate sensor

- Optical circular interferometer (fibre gyro)
- Satellite navigation systems.

Steering or Wheel Angle Sensor

The radius of the curve taken by the car may be calculated on the basis of the steering angle or the wheel angle. However, since the wheel angle is not only related to the curve radius but also to the speed at which the curve is taken, direction sensing on the basis of the steering angle will lack the precision required.

Rotational Speed Differential between Inner and Outer Wheels

With the vehicle taking a curve the outer wheel covers a longer distance than the inner wheel. The problems involved in the evaluation of the rotational speed differential are similar to those described above.

Gyroscope Systems

Gyro systems - different types of which are available - have proved their reliability and thus have already found wide application for many years. However, the high production costs of these mechanical precision devices should represent a major obstacle to their overall employment in navigation systems.

Geomagnetic Fluxgate Sensor

Another system providing directional information is the geomagnetic fluxgate sensor. The geomagnetic field which features only minimum drift in time - 0.1 degree/year - is not exactly directed to the geographical north; however, this deviation called declination is known; it varies over Middle Europe but on average amounts to approx. 2 degrees to the west. While the geomagnetic sensor gives an absolute indication of the heading followed, the other systems described provide data on the yaw rate or yaw angle. The new heading is compared to the previous one followed by the car. As a result, directional errors accumulate while with the geomagnetic sensor these errors are eliminated.

Optical Circular Interferometer

Recently, the optical circular interferometer, also known as fibre gyro, has advanced into the centre of interest. Its operation is based on a complex physical effect, the Sagnac effect. Two light waves from a laser are diffusing in a glass fibre bobbin (beam waveguide) in opposite directions.

With directional changes, the whole sensor system is rotated with the effect that the transit time becomes offset, thus producing a phase shift which may be evaluated to indicate a measure of the vehicle yaw rate. Large-scale availability of the optical circular interferometer will require further thorough research and development and for all we know today, it will probably be too expensive for use in this particular application.

Satellite Navigation Systems

Satellite navigation systems are used in a variety of airborne and marine applications. They are not used as actual direction sensors but provide the means for direct position fixing without relying on dead reckoning navigation. However, since the reception and processing of the satellite data is very complex and expensive, wide application of these systems seems hardly feasible.

The VDO Vehicle Navigation System

In consideration of the different aspects discussed above, VDO decided to employ a geomagnetic fluxgate sensor in its newly developed navigation system. It consists of two crossed coils wound on a joint core of a specific magnetic material, with their respective positions to one another forming a right angle. The sensor which is fixed rigidly to the vehicle is inconspicuously mounted in the passenger compartment. A change of direction of the vehicle produces a change in the exposure of the individual coils to the geomagnetic induction; as a result, the output signal changes accordingly. The two signals generated in the coils vary with the sine or cosine of the heading, that is the angle between the direction followed and magnetic north. Thus, with the two signals known the heading may be calculated.

Navigation with the geomagnetic fluxgate sensor has to cope with the problem of magnetic interference fields which may emanate from the environment of the vehicle or originate from the vehicle itself. The vehicle as a big mass of steel embodies quasi a magnet of its own which distorts the geomagnetic field and thus produces considerable directional errors.

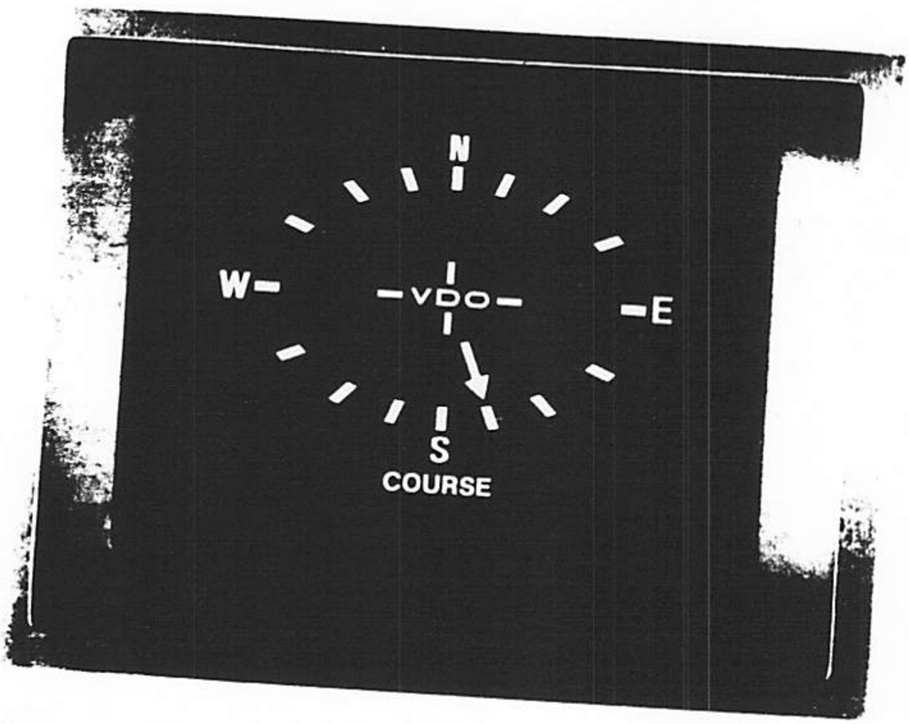
This problem was solved by application of a sophisticated evaluation programme stored in a microprocessor. The data generated by the sensor are tested and corrected before they are evaluated for dead reckoning navigation. As a result, vehicle-inherent interference fields are identified and automatically compensated to the highest possible degree.

Upon the driver's request, the corrected microcomputer data will furnish either of the following information on a display with a 360° scale:

- Heading (compass function)
  The pointer of the display in Fig. 1 indicates a south-south easterly course

- Bearing of destination (pilot function)
  The pointer indicates the direction to the selected destination. In order to obtain this function, the driver is required to enter the data of his destination as related to his actual position into the system. It is expedient to take a familiar place as reference position, e.g. the end of a motorway exit. On a keyboard, the driver enters the coordinates of his destination indicating how far to the north, south, east, or west of his

actual position his destination is located. He may obtain these data from a city map and enter them in advance of his trip. The display arranged within the driver's field of vision tells him the bearing of his destination thus providing useful guidance as, particularly in towns, the complex street network disallows a direct route to destination. The display also indicates the linear distance to the destination.



g. 1: Display with heading indication

g. 2 shows the bearing display of the navigation system. The vertical line presents actual driving direction; the destination with code number 2 is cated in the "2 o'clock" direction; the linear distance to the destination another 1.3 km.

lication of bearing ends when the vehicle has almost reached its precise stination, i.e. when it has entered the target radius which is a function the distance travelled. This state will be indicated by a flashing display.

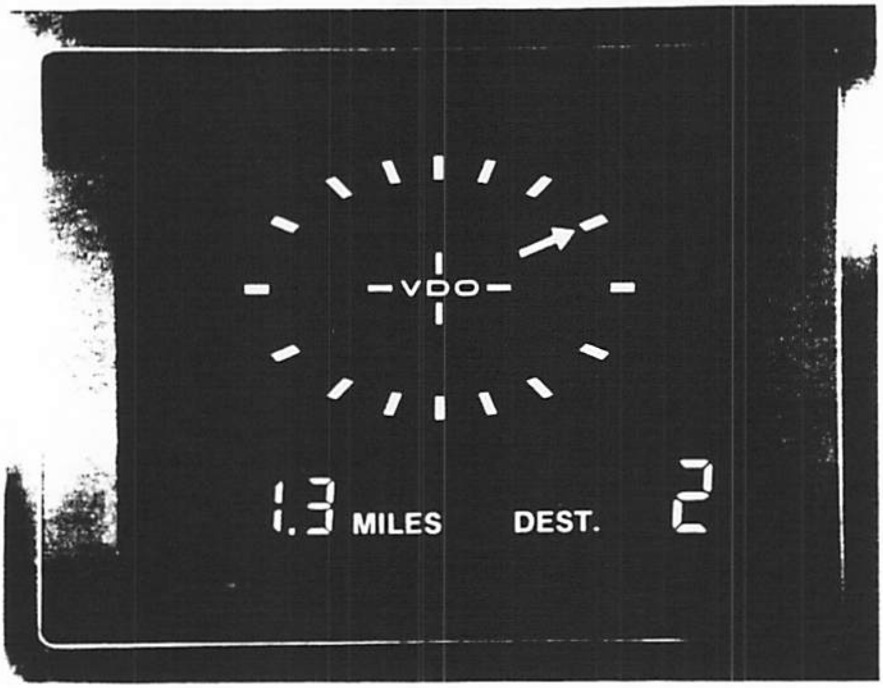


Fig. 2: Display with bearing indication

Fig. 3 illustrates the present state of the art of the navigation system on the basis of a recorded road test; the map section to the left shows the route followed by the car which - to the right - is opposed to the course as reckoned by the navigation system. The evaluation of the trial runs revealed that at present a deviation of approx. 3% from the actual distance travelled must be expected. Further development aims at increased accuracy.

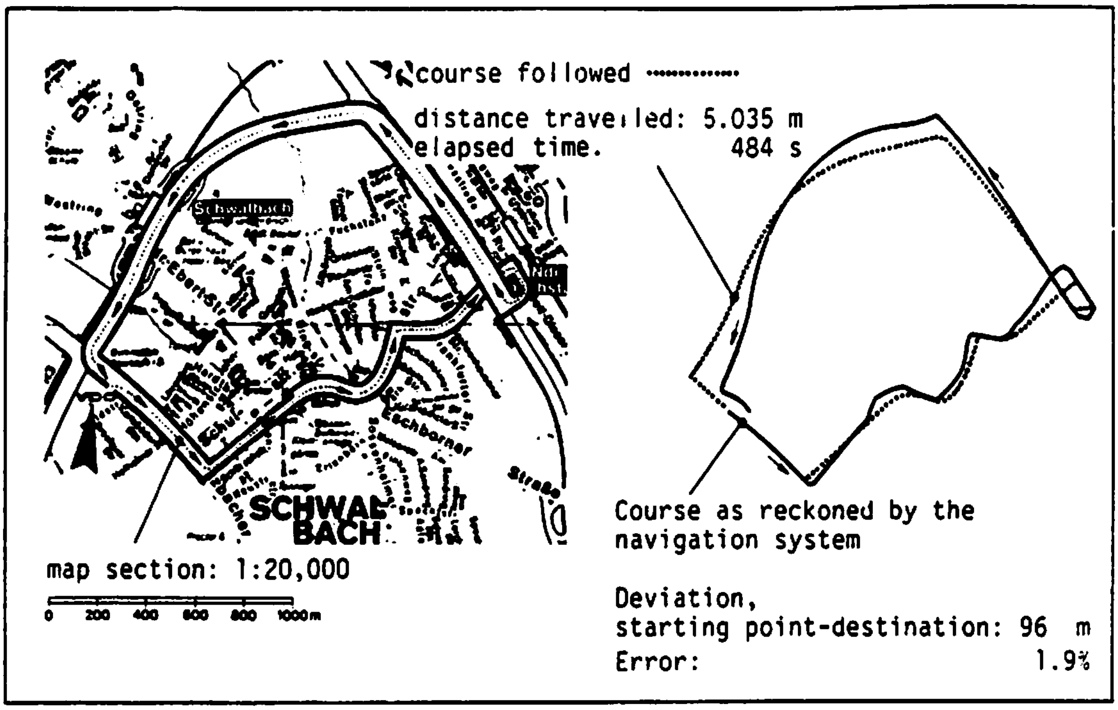


Fig. 3: Road test with VDO vehicle navigation system

Another objective development is geared towards is easy operation of the system which includes its easy calibration and adjustment to the vehicle, straightforward input of the destination coordinates as well as ergonomic design of the display and the manual control units.

As a result, VDO has come up with a fully operative prototype system which features extended functions such as the storage of various destination coordinates at the same time. When the driver calls the relevant code number, the navigation system will immediately furnish the required bearing. Thus, the driver may successively head for different pre-set destinations at will after he has looked up the relevant coordinates at home and at leisure, and entered them into the system in advance of his trip. Such a way of route selection may be of great benefit both to commercial travellers or forwarders and to tourists.

Fig. 4 shows the manual control unit of this prototype. The cross-shaped arrangement of keys to the right serves the input of the coordinates. With the rocker switch at the left bottom, the driver selects the code number of his destination thus calling the associated coordinates.

When reaching his destination the driver may enter the data of this additional localizing point into the system by pressing the "arrival" button; thus, potential accumulation of navigation errors and increased deviation from the desired destinations may be prevented.

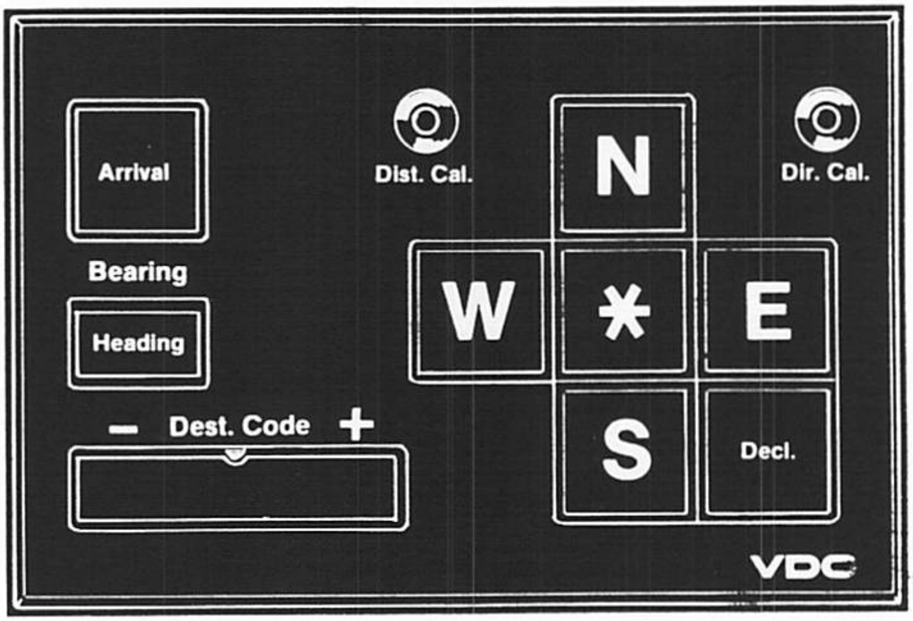


Fig. 4: Manual control unit of the navigation system

Furthermore, VDO has developed an improved straightforward procedure for determination and input of the destination coordinates introducing a light pen and a special map edition.

Each map sheet bears a special bar code imprint to be read by the light pen identifying the relevant map, its scale, and the declination. With the light pen the driver may directly read the linear and latitudinal coordinates of his destination encoded in a bar code imprint of a special overlay sheet into the navigation system. As a result, the keyboard becomes obsolete.

VDO is developing this streamlined operation concept of a user-friendly vehicle navigation system named "VDO Citypilot".

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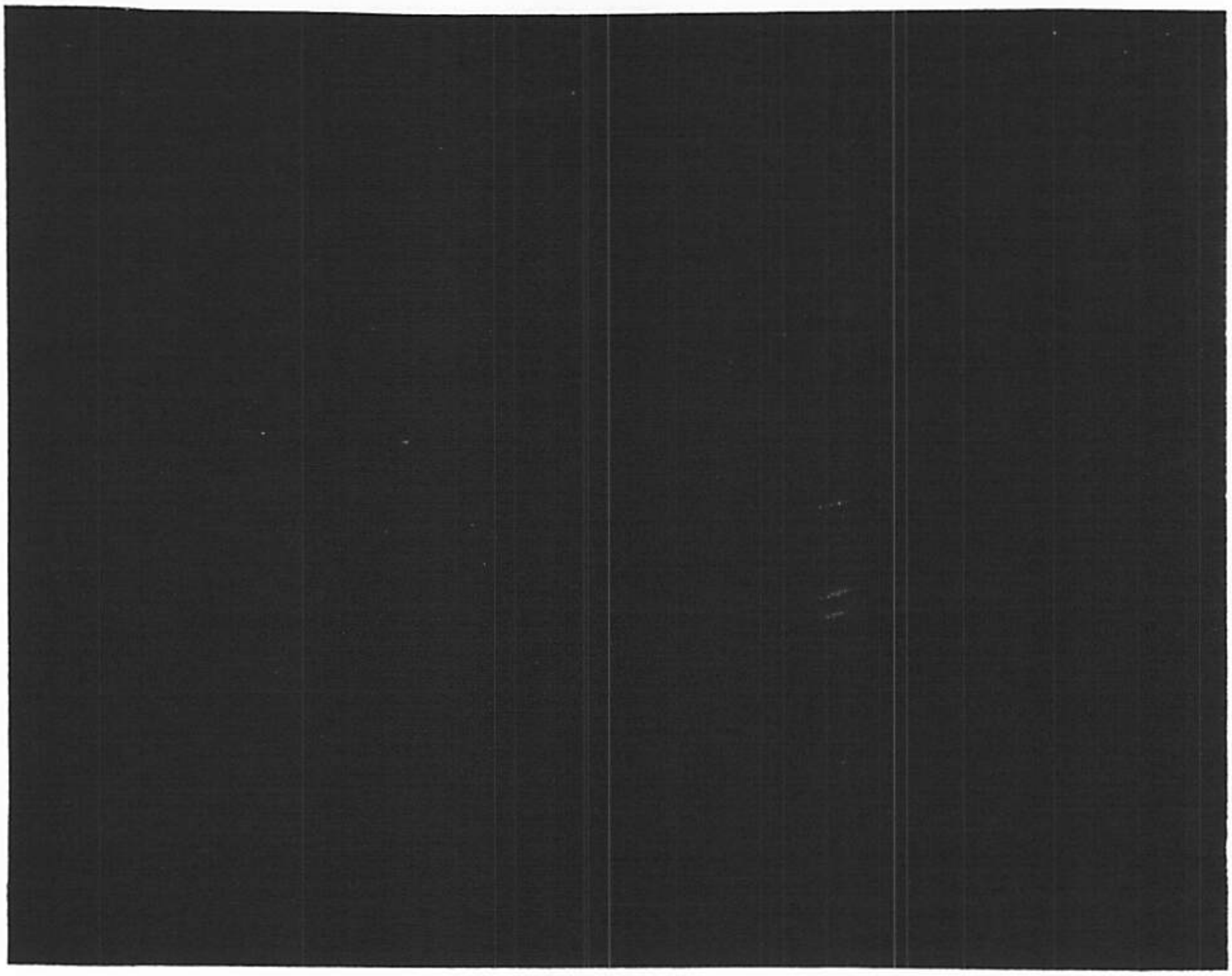
APPENDIX D

NRV-II Nissan Research Vehicle

NRV-II
Nissan Research Vehicle



NRV-II···NOT SO MUCH AN EXPERIMENT AS A CAR FOR TOMORROW

The NRV-II Nissan Research Vehicle is a working example of Nissan's ideas for the car of the future. A future of diminishing energy resources and an ever increasing traffic population, with its attendant needs of greater active and passive safety. The NRV-II meets this future with advanced but practical technology, much of which is already well on the way to production reality. Advanced composite materials are used for weight reductions, and a turbocharged methanol fueled spark ignition engine has been adopted to extract the maximum power (and hence efficiency) from a given displacement, while also paving the way for the use of alternative fuels. Safety in the NRV-II means both passive safety in terms of maximized occupant protection, and active safety, which is achieved by equipping the car with a variety of systems designed to keep the car out of accident situations, and to make the driver's task as simple as possible.

To emphasize the practicality of the many ideas incorporated, the NRV-II is based on the Nissan Sunny, Nissan's top selling small family car. The Sunny was selected to give the research team the opportunity to demonstrate the possibilities for producing an ideal "car of the future" within limited external dimensions. The NRV-II measures a compact 4185 mm long by 1620 mm wide, the same as the Sunny. And in spite of the many safety devices incorporated and substantial side protection in the doors, the only interior sacrifice has been a mere 6 cm reduction in interior width. Further, thanks to the advanced lightweight materials used throughout the car, a fully equipped production version of the NRV-II would weigh only about 70 kg more than the equivalent Sunny.

The practicality of the NRV-II is further enhanced with a high performance 1.3 litre methanol fueled turbocharged engine that puts the NRV-II in a performance league with a superior two litre car. Maximum power output is 120 bhp at 6,000 rpm, which gives the NRV-II acceleration that takes it from 0 to 100 km/h in just 7.7 seconds.

With performance, convenience and safety, the NRV-II is much more than just an experiment. It is truly a car for tomorrow.

FEATURES OF THE NRV-II

Methanol Fueled Turbocharged Engine
Plastic Fuel Tank
Plastic Road Wheels
Plastic Windscreen and Window

SAFETY

■ REDUCED DRIVER WORKLOAD

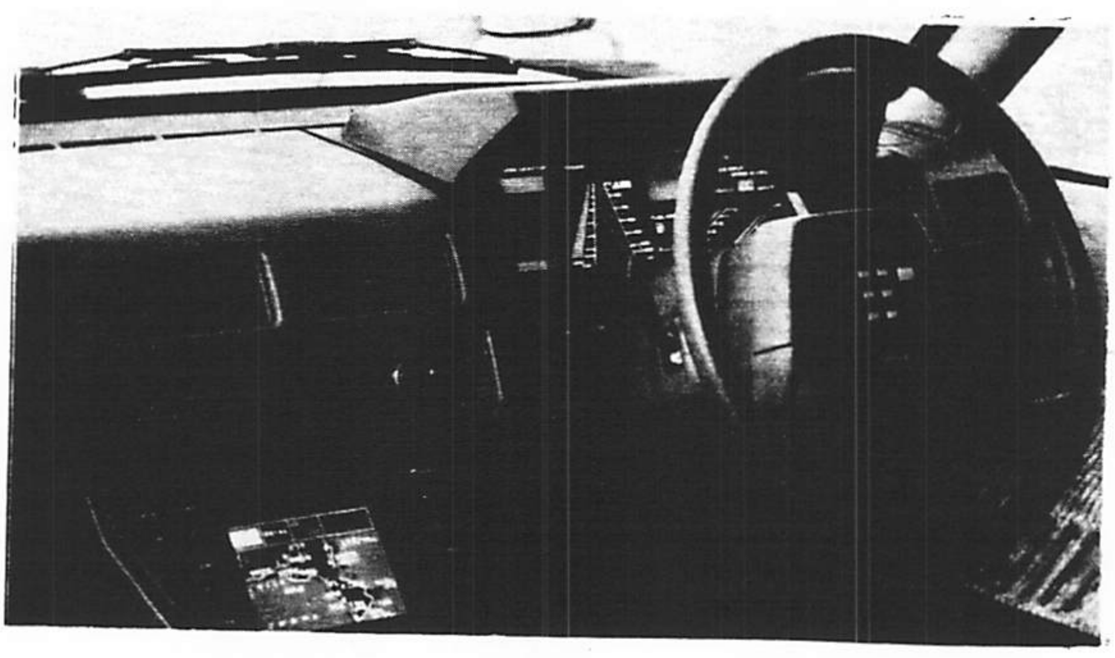
Radar Auto-Cruise
Multi-Colour LCD Instrument Display
Fibre Optics/Steering Wheel
Mounted Switches
Voice Dialogue System
Drive Information System
Automatic Light Switching
Automatic Windscreen Wipers
Variable Tension Seat Belts

■ ACCIDENT AVOIDANCE

Runflat Tyres
Tyre Pressure Warning Device
Drowsiness Monitor
Four-Wheel Anti-Skid System

OCCUPANT PROTECTION

Designing for Protection in Side Collisions



ENERGY CONSERVATION & WEIGHT REDUCTIONS

Methanol Fueled Turbocharged Engine

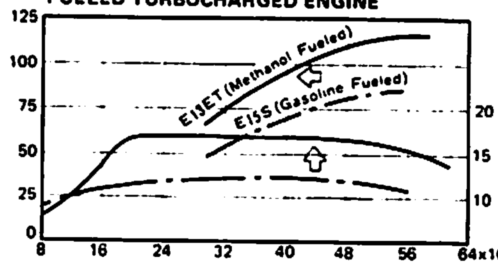
Powering the NRV-II is a small-displacement (1270 cc) spark ignition engine with ECCS controlled fuel injection and a turbocharger, and adapted to run on methanol fuel. Methanol is one of the leading alternatives to gasoline as a fuel for automobiles, and may be derived from coal, of which large unmined reserves are known to exist. It is now relatively more costly to produce methanol than gasoline, but with oil supplies becoming increasingly scarce, the attractions of methanol are growing, and it may well be a major fuel as soon as the early 1990s.

Methanol also has the advantage over gasoline in a spark ignited engine that it diminates knocking, allowing a virtually free choice of compression ratio. In the NRV-II, a ratio of 11:1 has been combined with a turbocharger running with 400mm (Hg) of maximum boost for a high specific output power and optimum economy, while requiring only minor internal changes to the engine. For the future, advances in engine materials and design will allow higher compression ratios and hence even greater specific outputs.

A high compression ratio also means excellent drivability, eliminating one of the weak points of a low compression ratio gasoline fueled turbocharged engine. The turbocharger itself is conventional, raising both torque and horsepower across the engine speed range, and in particular the torque curve is flat from 1,600rpm to 5,600rpm.

The chief problem currently associated with methanol concerns low temperature starting performance, as methanol will not atomize below 60°. The engine of the NRV-II is equipped with an electric fuel pre-heater.

FULL LOAD PERFORMANCE OF METHANOL FUELED TURBOCHARGED ENGINE



Plastic Fuel Tank

A 40% weight reduction, worth 4.8 kg in the NRV-II, has been achieved by replacing the conventional steel fuel tank with one that is made of blow-molded plastic. In addition to saving weight, the plastic fuel tank is molded as an integrated whole, and so does not require a flange for joining the upper and lower halves, allowing the maximum use to be made of the available space. In the NRV-II, this has allowed an 8% increase in capacity. Further, the formability of plastic means that odd shapes can easily be produced, allowing every cubic inch of space to be exploited.

To eliminate the problems of fuel permeation, and fuel loss thereby, normally associated with plastic containers, the fuel tank of the NRV-II is formed of a special multi-laminar plastic lined with a barrier resin that is totally impervious to the fuel tank's contents.

Plastic Road Wheels

The NRV-II is fitted with experimental 13 inch fibre-reinforced plastic wheels. These bring savings of 12.5 kg per car compared with a set of four equivalent steel wheels, or 8 kg per car if the comparison is with aluminium alloy wheels. Reduced weight means better fuel economy, while the lower unsprung mass permits better wheel control for superior handling and greater ride comfort. In addition the use of plastic gives the designer virtual freedom with regard to wheel design, and even wheel colour.

Further wheel related weight savings have been achieved in the NRV-II by the use of run-flat tyres that allow the spare wheel to be dispensed with.

Plastic Windscreen and Window

A large proportion of the weight of a car's bodyshell is accounted for by the glass windows. In the NRV-II, a polycarbonite resin windscreen and windows have been used, to save 8.5kg—a 30% reduction. The resin surface has been treated with a hardener to ensure resistance to damage by windscreen wipers, etc.

SAFETY

Multi-Colour LCD Instrument Display

The NRV-II's instrumentation consists of three large liquid crystal panels (LCDs) which cover 22 items ranging from a large digital speed readout to displays for the radar auto-cruise and the drowsiness monitor. To greatly aid identifiability, so that display information can be absorbed at a glance, the instrument displays are provided with colour coding, with the instrument light source filtered with four different colours (red, blue, green, and yellow).

The light source itself is a flat flourescent lamp that provides better light distribution and hence superior colour uniformity than conventional light sources. In addition, to ensure visibility in all levels of ambient lighting, the brightness of the instrument display may be adjusted automatically, or manually.

Fibre Optics/Steering Wheel Mounted Switches

Frequently used switches for the radio, auto-cruise, etc., are mounted on an elegant non-rotating pad in the centre of the steering wheel, where they are located for the greatest ease of access.

These switches and most of the electrical items throughout the car are interconnected by means of optical fibre which allow greater signal density than ordinary metal wiring, while the efficiency of transmission is also improved.

A multiplex transmission system is employed, with the optical fibres arranged in dual loops, for two-way transmission and an emergency back-up for reliability, with no weight penalty.

SAFETY

■ REDUCED DRIVER WORKLOAD

● Radar Auto-Cruise

Auto-cruise speed setting devices are gaining increasing popularity around the world as speed restrictions and the desire to drive economically increase the desirability of maintaining a steady cruising speed on the highway. With existing auto-cruise devices, however, there is no means for automatically responding to the presence of other vehicles.

The NRV-II is equipped with a 24 GHz radar that measures the distance to the vehicle in front, and displays the distance on a coloured graphic display on the NRV-II's instrument panel. In addition, a reference bar alongside the actual distance display indicates the calculated safe following distance, calculated in accordance with the NRV-II's speed and the prevailing weather conditions (a rain sensor is fitted to the windscreen in connection with the automatic windscreen wipers (see below)). In addition to displaying this information, if the NRV-II comes too close to the vehicle in front, a verbal warning alerts the driver and simultaneously interrupts the auto-cruise function to decelerate to the speed of the vehicle in front, in order to maintain a safe following distance. When the vehicle in front moves out the way, or accelerates out of range, the device automatically causes the NRV-II to resume the previously set cruising speed.

RADAR AUTO-CRUISE DEVICE

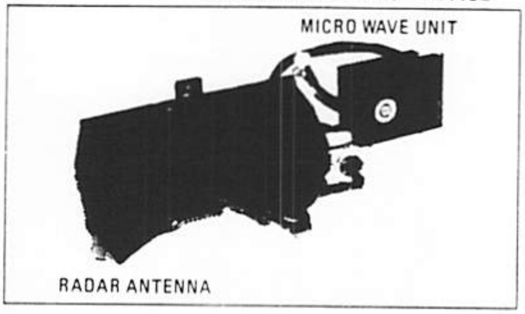
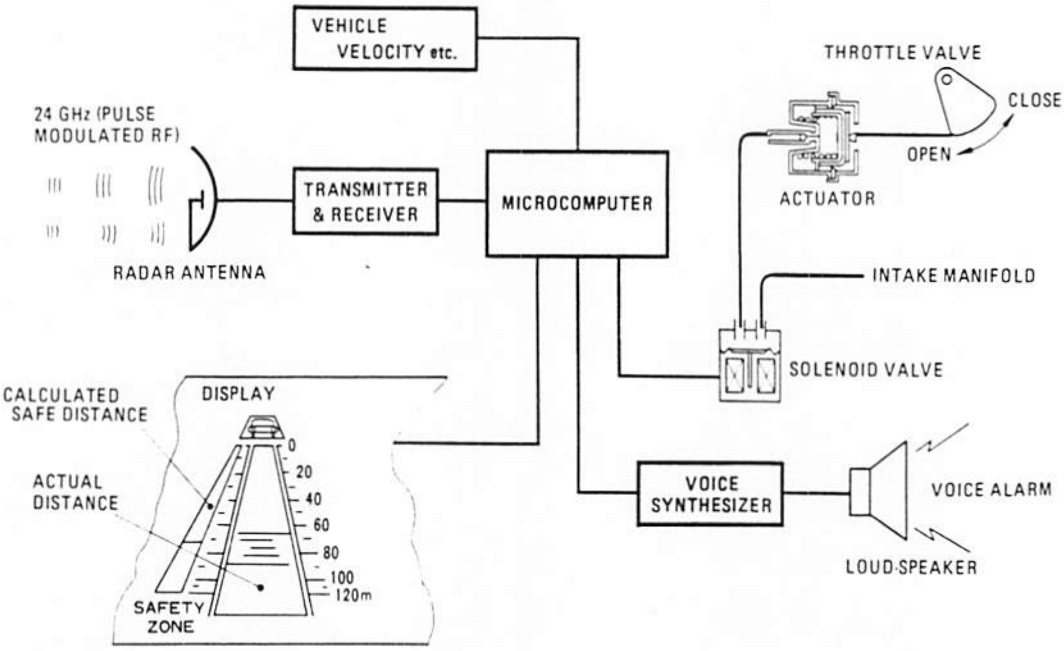


Fig. 1
RADAR AUTO-CRUISE DEVICE



SAFETY

● Voice Dialogue System

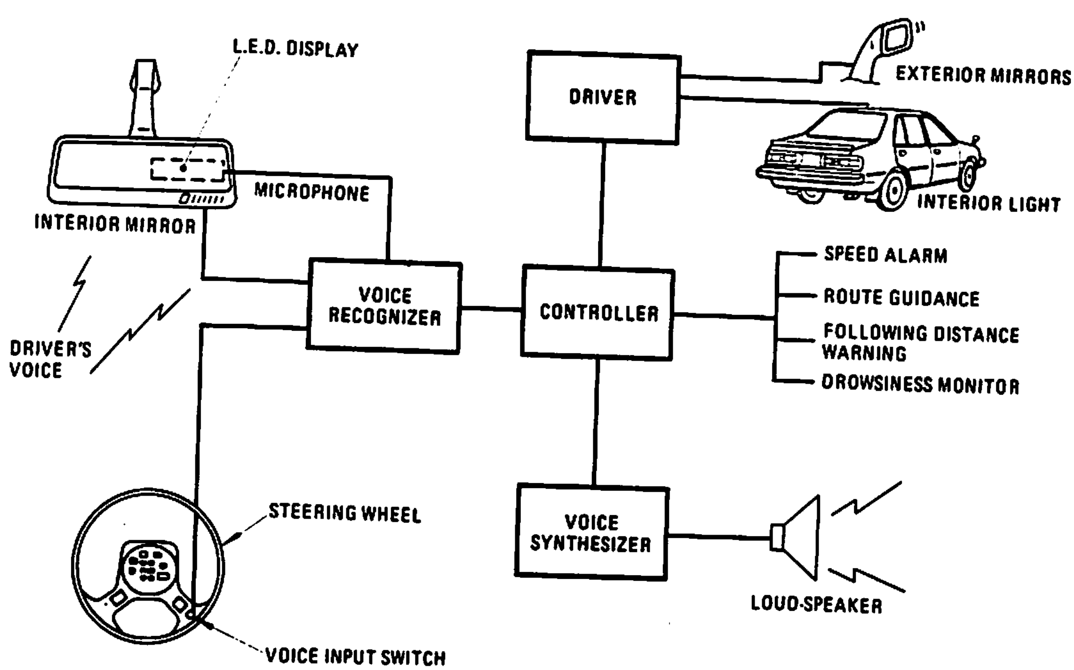
With the increasing volume of traffic on today's roads, the driver cannot afford to take his eyes off the road and his hands off the wheel. Thus to allow the driver to maintain his primary obligation, without missing important vehicle related information or having to do without control of certain vehicular functions, the NRV-II is equipped with a comprehensive voice dialogue system that allows the driver to interface verbally with his vehicle.

The driver simply presses a conveniently located "Voice Input Switch" on one spoke of the steering wheel, to switch on the microphone to accept any one of 26 verbal instructions. In return, the computer replies with an electronically synthesized voice which can issue instructions or warnings up to 50 seconds long.

Voice operated vehicle functions in the NRV-II include the input of route data for the drive information system, speed warning settings, and control of the exterior mirrors, interior light, and hazard flashers. The 26 commands may each comprise any repeatable sound, and so may be in any language, but a user must be registered with the system beforehand by running through the functions in sequence and recording his desired command for each specific function. Subsequent repetition of any of the commands by the registered user will be reliably identified by means of pattern matching with a filter bank, and the corresponding function will be automatically performed. For the registration process, the functions (and suggested commands) are spelled out on an LED display built into one corner of the interior mirror. Included in the commands are 8 possible directions of movement for the exterior mirrors and route guidance cursor, "stop", "clear", "faster", "slower", "advance", "return", 5 speed alarm settings, right or left exterior mirror selection, "interior light", "hazard flashers", "yes", "no", and "acknowledged".

The voice synthesizer that responds to the driver's commands also gives its own verbal warnings about driver drowsiness, insufficient distance from a vehicle in front, and route instructions (e.g. "Right turn ahead").

Fig. 2
VOICE DIALOGUE SYSTEM



SAFETY

Drive Information System

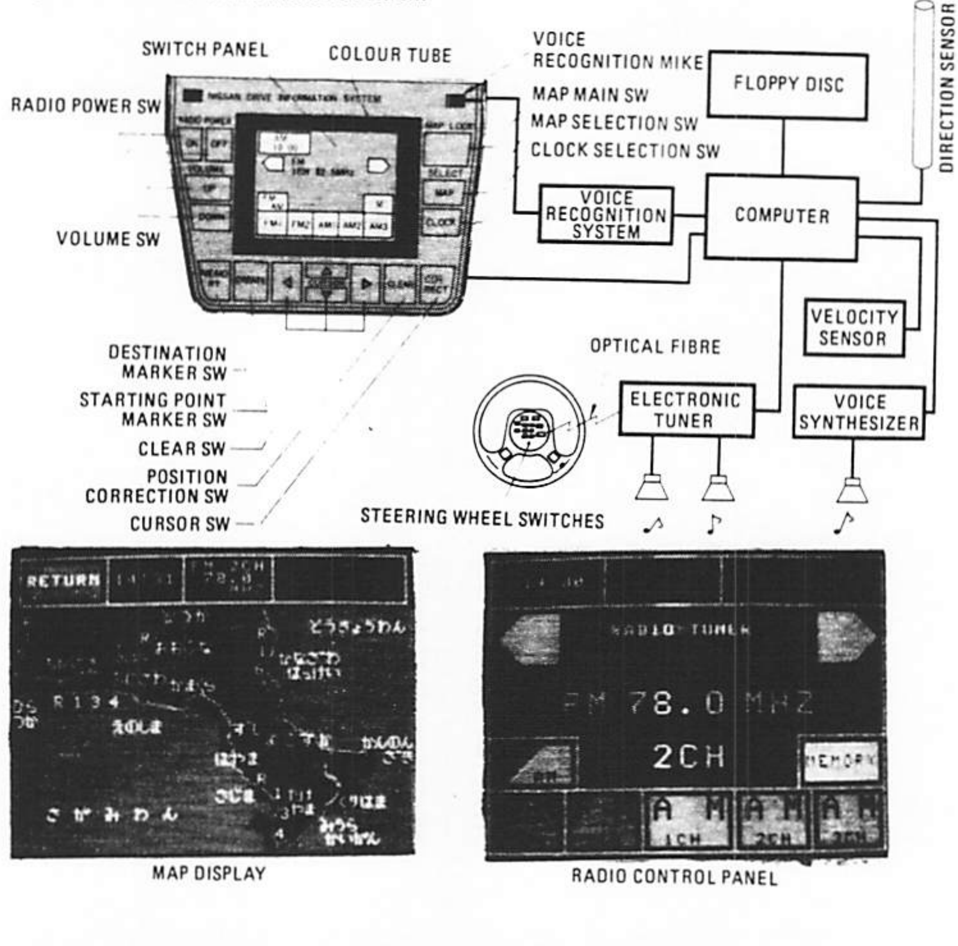
The NRV-II features a drive information system with a colour CRT to selectively display route maps, the time and date, malfunction warnings, and radio tuning information. In addition, the CRT is overlaid with a transparent switch matrix for a number of switching functions with a large touch target area. Switching is achieved by touching the relevant portion of the screen, as indicated by the display information, which may be changed to allow switch area to serve several alternative functions.

The principal feature of the drive information system is a route guidance system with a store of map information on a mini-floppy disc, which can be scanned and displayed in two scales on the screen. The driver designates his(her) present position by means of the cursor switches. A prospective route may be input verbally. Once on the move, the computer keeps the driver informed with verbal instructions (e.g. "right turn ahead") issued via the voice synthesizer.

The NRV-II's position in relation to the map, and a trace of the route actually travelled are indicated on screen. These are determined by a magnetic direction sensor and a distance recorder

Another function of the Drive Information System is to flash malfunction warnings on screen in the event of any problem. Such warnings automatically displace the existing screen information until the driver acknowledges the message. Once acknowledged, the display reverts to its previous function, and the warning is reproduced in miniature at the top right hand corner of the screen until remedial action is taken.

Fig. 3 DRIVE INFORMATION SYSTEM



MAP DISPLAY

RADIO CONTROL PANEL

SAFETY

● Automatic Light Switching

The NRV-II is equipped with an automatic light switching system that automatically controls the car's head and tail lights in accordance with ambient lighting conditions. Ambient lighting is detected by means of photosensors mounted on top of the dashboard, and when the vehicle is running the lights are switched on or off accordingly. The headlights are also automatically switched off within 3 to 5 seconds each time the vehicle comes to a halt, to save energy and prevent dazzle while waiting at traffic lights, etc., and are switched on again as soon as the vehicle starts moving.

Manual switching of the lights is also possible.

● Automatic Windscreen Wipers

The NRV-II is equipped with an automatic windscreen wiper system which optically detects raindrops on the windscreen and automatically starts or stops the wipers, and adjusts the wiping interval or speed in accordance with the amount of rain. Light is projected from inside the windscreen by light emitting diodes, and the presence or absence of rain on the windscreen is detected by light receptors which are sensitive to the light reflected from the front surface of the glass, and identify any sudden changes in the amount of light reflected such as are caused by the appearance of raindrops on the windscreen.

● Variable Tension Seat Belts

To encourage their regular use, the seat belts in the NRV-II have been made as comfortable and easy to use as possible. The degree of slack in the belts is electronically controlled to be ideal, in accordance with vehicle speed, with the slack being gradually taken up as the speed increases.

■ ACCIDENT AVOIDANCE

Runflat Tyres

The NRV-II has been equipped with special runflat tyres of steel radial construction, which are designed to allow safe driving for up to two hours at speeds up to 80 km/h even after a puncture resulting in a complete loss of pressure. These tyres were developed jointly by Nissan Motor Company and Toyo Rubber Company, and were put on sale in January 1982 for vehicles used by handicapped persons and the police. Secondary tyre beads are used to keep the tyre from coming off the rim after going flat, allowing the use of a conventional type wheel rim, which has not been possible with other runflat tyre types.

Tyre Pressure Warning Device

A tyre pressure warning device is mounted inside the hub cap of each wheel, with a battery operated transmitter that sends a signal to a receiver inside the car to warn of a tyre pressure having fallen below a preset minimum safe level, due to leaks, etc.. This device, which sounds a buzzer inside the car, not only warns of punctures, but, since it monitors the actual tyre pressure, it can also aid reduced tyre wear and fuel consumption by warning of low tyre pressures.

Drowsiness Monitor

One of the NRV-II's most innovative features is a unique drowsiness monitor which detects decreased driver alertness and urges him to rest. In the development of this system, a physiological evaluation was made of brain wave patterns and associated physical behaviour, such as eye blinking. From this it was learned to assess the degree of drowsiness, and hence observe the associated patterns of physical manipulation of the vehicle's controls, such as the steering wheel. As installed in the NRV-II, the drowsiness monitor constantly monitors the driver's operation of the controls, and when any change of behaviour suggesting drowsiness is noted, the driver is alerted by means of a flashing light and a buzzer. If the driver continues to exhibit signs of increasing drowsiness, the warning light flashes and a voice warns "You are getting drowsy. Please rest."

SAFETY

Four-Wheel Anti-Skid System

One of the major safety developments of the eighties is the four-wheel anti-skid system that electronically controls the braking pressure to all four wheels to prevent skid-inducing lock-up. This contributes greatly to safety as it allows full braking to be used at any time—on curves, slippery surfaces, etc., without any loss of directional control.

In addition, since the anti-skid system prevents wheel lock-up on all surfaces, it satisfies the conditions for maintaining friction between the tyre and the road surface at the optimum level, ensuring the shortest possible braking distances, for an extra margin of safety.

OCCUPANT PROTECTION
Designing for Protection in Side Collisions

Designing automobiles to protect their occupants in the event of a collision is one of the most difficult, and at the same time one of the most important tasks facing today's automotive engineers. Considerable attention has been paid in the past to energy absorption in head-on and nose-to-tail collisions which constitute a high proportion of all serious accidents. However, it has begun to be realised that the occupant fatality rate is probably higher in accidents involving side collisions with penetration through the relatively narrow sides of the car. Further, while it is not too difficult to design the relatively long front and rear extremities of the bodywork to absorb collision energy, this task is not nearly so easy when dealing with the relatively thin sides.

The US government's National Highway Traffic Safety Administration (NHTSA) is conducting a study of protection during collisions from the side as a matter of priority in its long-range safety programme. Nissan, too, has attached considerable importance to this area of vehicular safety, and in the NRV-II, the target has been to combine a high level of safety with the practicality that is necessary to make the concept viable for production.

• PROTECTION STANDARD

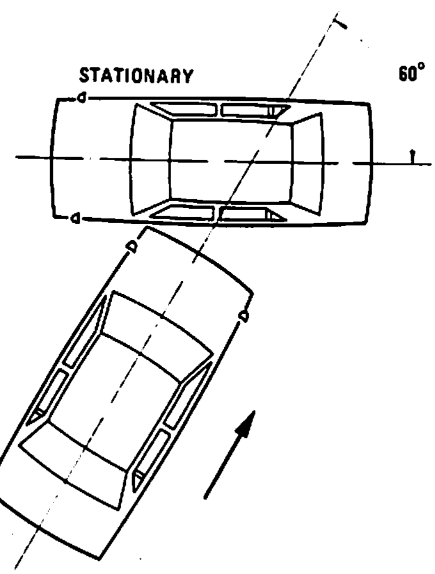
In designing a car for protection, one can only establish arbitrary standards based on repeatable experiments. This does not make the protection offered any less secure, but it does indicate the difficulty of ensuring absolute protection under all circumstances.

For the NRV-II the design brief was for occupant safety in a collision where a stationary vehicle is struck by a 2500 pound (1100 kg) vehicle travelling at 30 mph (48.6 km/h), at 60° to the stationary vehicle's longitudinal axis, as shown in figure 4.

• PROTECTIVE MEASURES

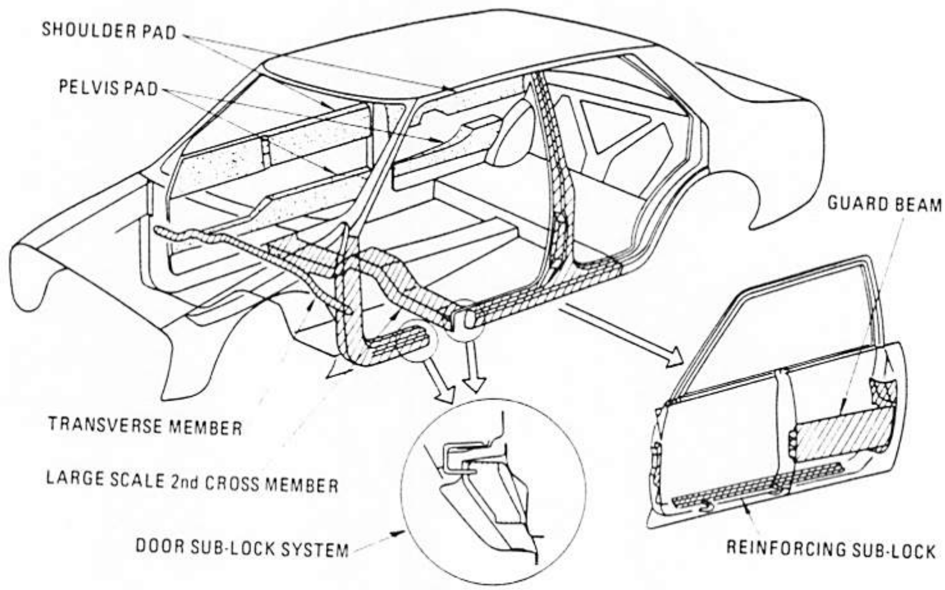
- Door reinforcement
- Reinforcing door sub-locks
- Sill and floor reinforcement
- A and B-pillar reinforcement
- Protective pads on the interior surfaces of the doors

Fig. 4
CONFIGURATION OF SIDE COLLISION TEST



SAFETY

Fig. 5
SIDE COLLISION PROTECTION



NRV-II – MAIN SPECIFICATIONS

Length	4185 mm
Width	1620 mm
Height	1390 mm
Interior Length*	1835 mm
Interior Width*	1305 mm
Wheelbase	2400 mm
Suspension Front	Independent struts, coils
Rear	Independent trailing arms, coils
Tyres	Runflat Tyres 165/70SR 13

* Measured to JIS measurement standards.

METHANOL FUELED TURBOCHARGED ENGINE – SPECIFICATIONS

Denomination	E13ET (ECCS)
Displacement	1270 cc
Bore × Stroke	76mm x 70mm
Compression Ratio	11.0:1
Turbocharger Max. Boost Pressure	400 mm (Hg)
Fuel	Methanol

Maximum Power	120 bhp/ 6,000 rpm (JIS)
Maximum Torque	17.0 kgm/ 3,600 rpm (JIS)

Acceleration 0 – 100 km/h. . . . . 7.7 seconds

APPENDIX E

Developments in Electronic Displays and Controls

The following summarizes an article from the Japanese magazine Car Graphic entitled "The Latest Electronics Technology" (April, 1985). Accompanied by many photographs, the article describes technological advances in several automotive devices, in particular, suspension systems and electronic indicators.

"Supersonic Suspension"

Adjustable suspension systems for controlling vehicle height, alignment, number of springs and decelerating power have not been used in commercial cars, as driver operation or automatic adjustment devices are required. The Citroen DS (1955) was the first car with a manual device that operated a fluid/gas system controlled by pressurizing. Adjustable damper deceleration was first available in the Aston Martin DB6. Rear damper deceleration could be adjusted to four different levels with a driver-operated switch. Manufactured in Japan, Kayaba's electric adjustable damper (1972) used a deceleration device that was rotated by a solenoid and ratchet, although its location under the spring occasionally cut off the wiring. The first car with a fully adjustable damper was the Skyline GT-E-S. A driver-operated switch adjusted the front and rear dampers, while the actuator was a solenoid mounted on the damper's chassis, creating problems similar to those of the Kayaba. The control rod, which went through the piston rod, was rotated by a solenoid. Since it did not use a rachet, only two deceleration levels were available.

Height control and rear suspension units were first used in the 1980 Leopard. This particular system, formerly used for air suspension of large buses, stabilized cruising position and head light angles. The device was constructed from a conventional coil spring and an air spring; its height sensor stabilized height by calculating car height and changing the air room pressure. This system was adapted for the Honda Accord hatchback (1981), but differed in that the system stabilized the height at two different levels and controlled front and rear heights. The Leopard's auto-levelizer was the first of its kind with electronically controlled suspension. Although only the height was controlled, the system used three major automatic control devices: sensor, control unit, and actuator.

More complete electronically controlled suspension can be achieved by damper deceleration, while deceleration can also be actively changed according to cruising conditions. This system, called TEMS, was used in the 1983 Soarer and consisted of speed, steering, throttle position, and stop light sensors. By using these four sensors, a microcomputer controlled the four dampers.

Three types of vehicle position obtainable were squat, dive, and roll. Squat was sensed through the acceleration pedal, dive through the stop light, and roll through the steering wheel. When a driver's foot was on the brake pedal, however lightly, the stop light switch turned on and the microcomputer received a signal to activate an actuator. The Soarer had two-level deceleration control and three modes, of which the "auto" mode could change deceleration when selected by a manual control. In addition to these height and deceleration controls, the 2000 Royal had a control that was combined with automatic spring control. By blocking and unblocking the air route through two different types of air pressure, the spring was altered.

Most electronic suspension systems use only adjustable deceleration, including the Bluebird Maxima's supersonic suspension. A unique feature of this vehicle, however, is its "sonar" sensor in addition to a steering speed sensor, vehicle speed sensor, stop light switch, and ECCS control unit. The ECCS corresponds to the throttle position sensor in TEMS. The sonar system sends a sonic wave to the road surface; the sonar wave between the road surface and the sensor system is calculated. Because the sonar system is mounted beneath a nose, a change of surface is detected before the front wheels touch a road surface. The system has four control functions and three levels of deceleration. By using sonar, more detailed deceleration control can be obtained than with TEMS.

It is anticipated that a suspension system with simultaneous control of height, spring, and deceleration will eventually be put into practical use.

"Electro-Multivision"

Since the introduction of devices such as cruise computers, self-diagnostics functions for complicated circuits have become necessary. Many indicators must be placed on the front dashboard or on a console where, because of space constraints, indicators must be small or share many functions. For instance, a mechanical speedometer which required a wide cable connection had to be attached to the ceiling until an electronic indicator was installed.

The electronic display meter of the 1981 Soarer has also been improved. The fuel tank indicator, coolant temperature gauge, and tachometer were electronic, but the odometer remained mechanical and not all the cables had been replaced. By 1983, the tripmeter was electronic, the speedometer was fluorescent-digital display, and the tachometer was diode-graph display. The fuel tank level indicator and the coolant temperature gauge were both fluorescent displays.

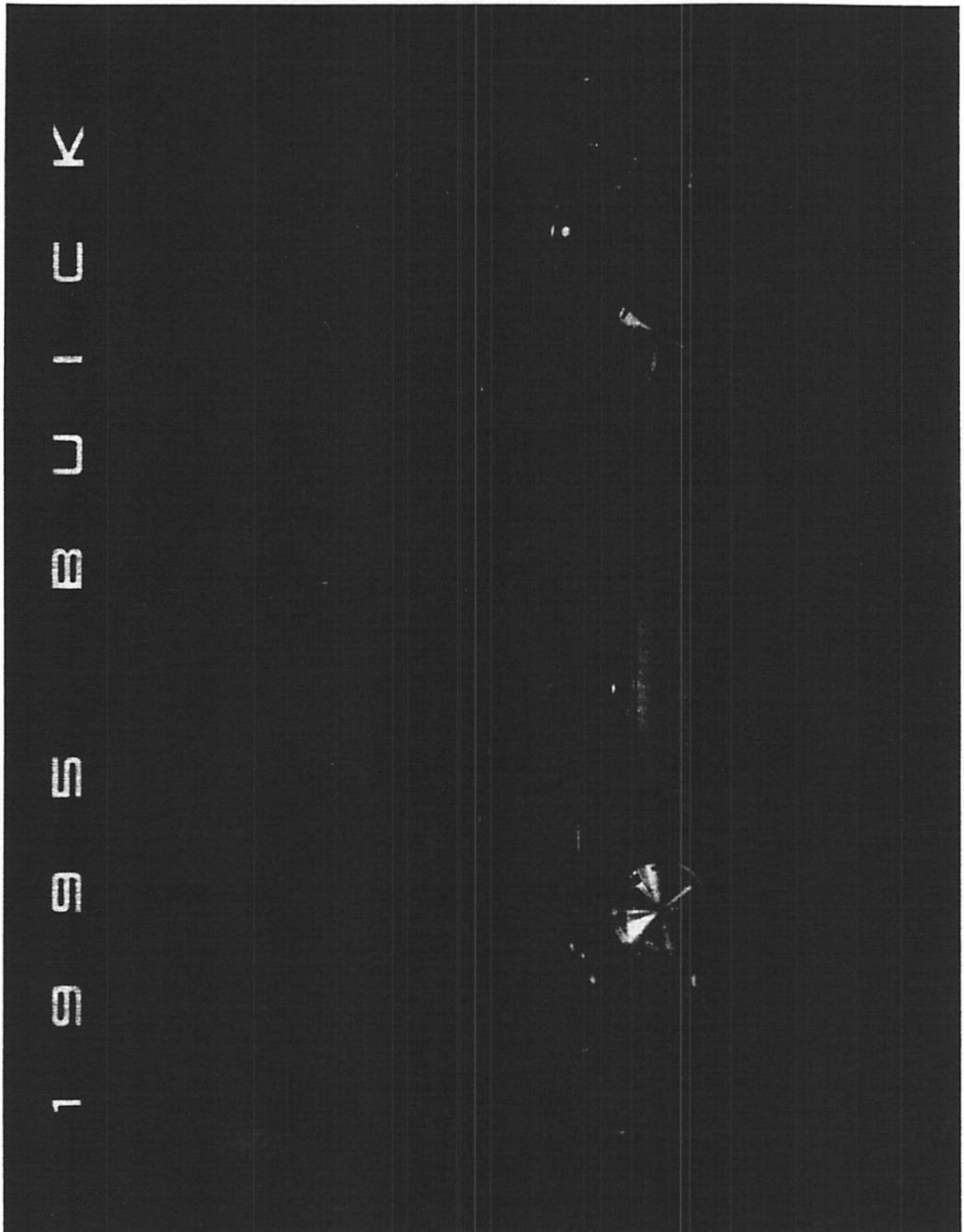
Other domestic cars have adopted electronic meter systems. In 1981, Sigma, Leone, Silvia, and Plazza had adopted the electronic speedometer, meters with fluorescent display systems. In 1982 liquid quartz was used for the speedometer. The 1982 century had a multi-meter unit called the "super monitoring display" that indicated by warning light, check switch, or electronic buzz. The display area was five by seven inches, and its fluorescent-dot indicator showed eight-digit numbers or English sentences. During regular driving it worked as a tachometer, during auto drive it showed operation conditions. When lights failed or coolant level dropped, a warning light appeared. It was also capable of diagnosing a non-functioning microcomputer control system.

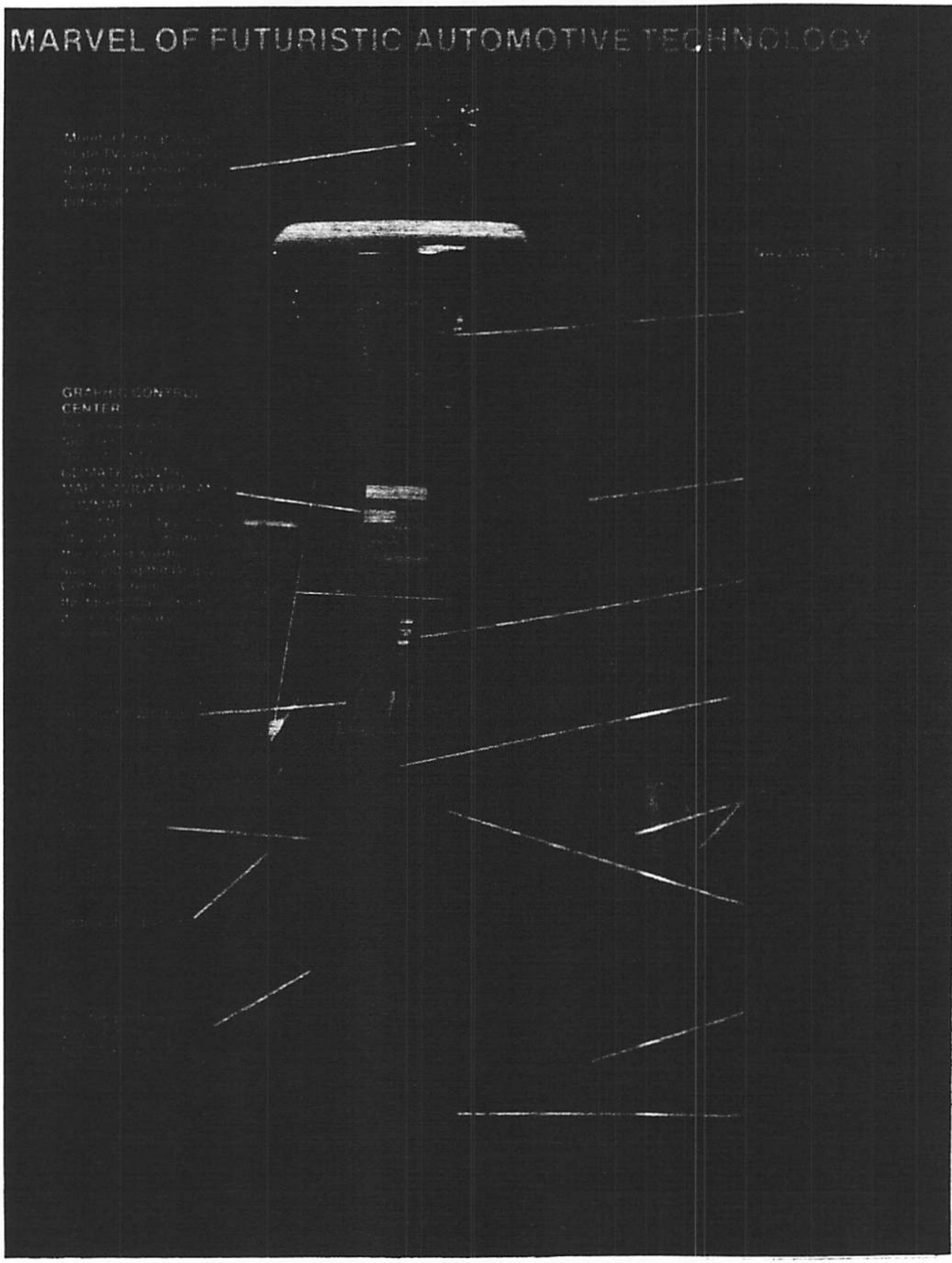
CRT displays have also been introduced to domestic cars; the first of this type was used in the Soarer and was called electro-multivision. Electro-multivision shows system check, driving monitor, fuel monitor, maintenance guide, insertion, and regular television programming. Of these, the fuel monitor may be used the most, because it displays fuel tank level, consumption rates, can be used as a tachometer, and can indicate auto dirve and ECT.

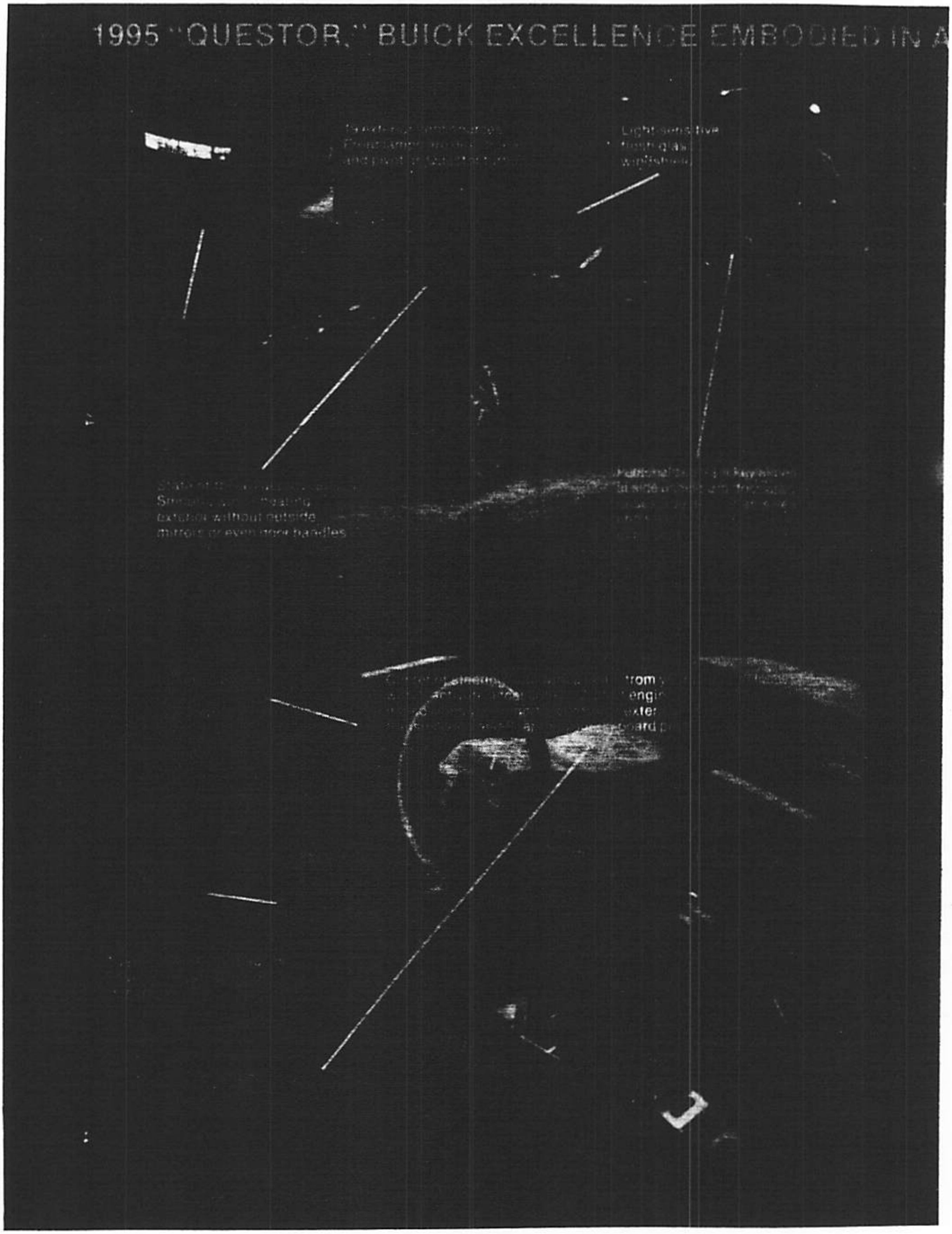
In 1981, Honda introduced the "electro-gyrocator", which, on film, marked cruising-trace by gyro and cruise distance sensor. Depsite much attention, the system was never used widely because of its time-consuming operation and expense.

APPENDIX F

"1995" BUICK QUESTOR


1995 BUICK


MARVEL OF FUTURISTIC AUTOMOTIVE TECHNOLOGY
GRAPHIC CONTROL CENTER


1995 "QUESTOR," BUICK EXCELLENCE EMBODIED IN A
Light-sensitive
exterior without outside
mirrors or even door handles

APPENDIX G

"Electronics in the Passenger Compartment,"

Radio Electronics, September 1985

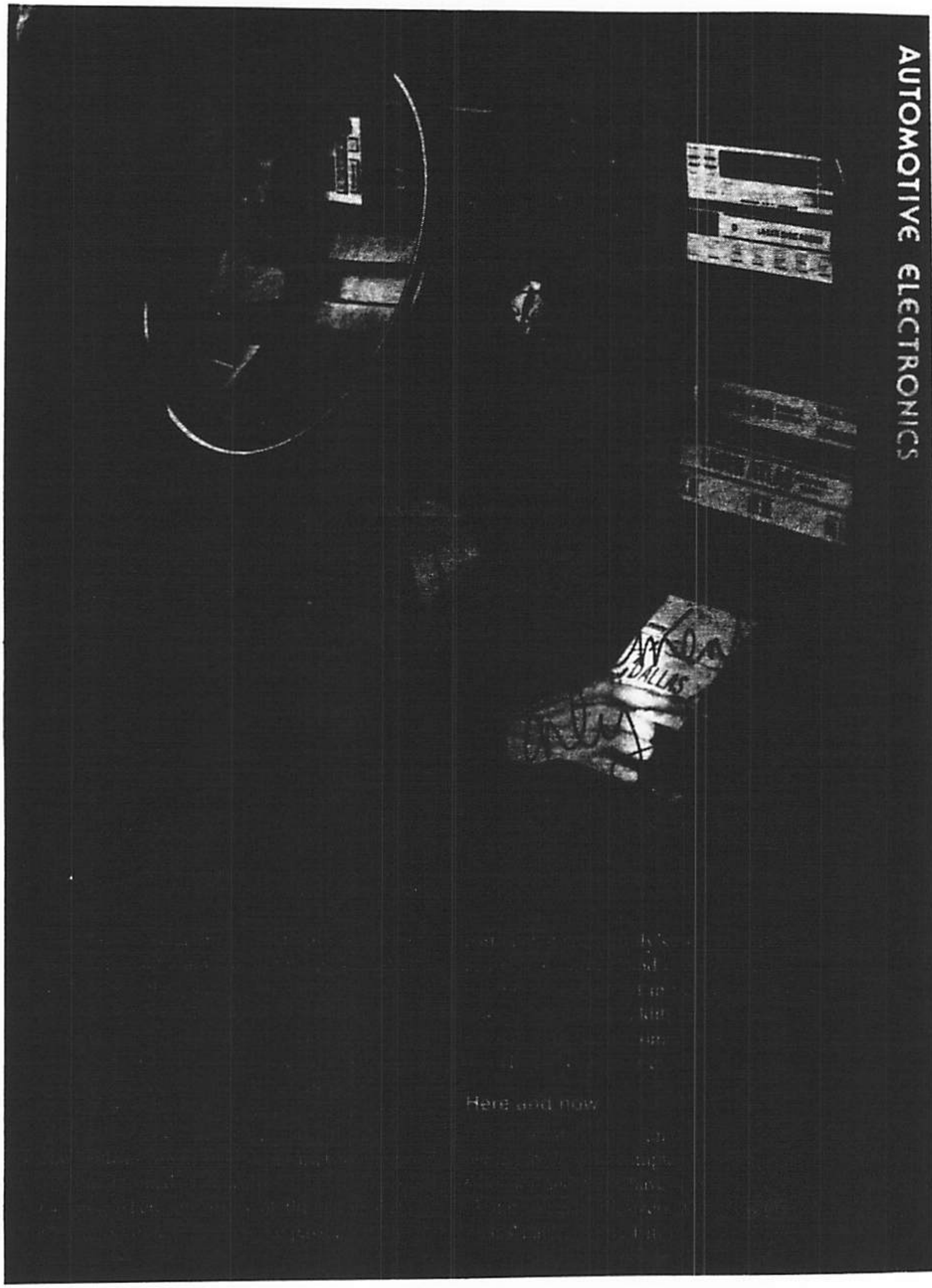

AUTOMOTIVE ELECTRONICS
Here and now

FIG. 3—THE QUESTOR is a concept car from the Buick division of General Motors. It is being used as a test bed for systems that Buick hopes to incorporate in its products over the next decade.

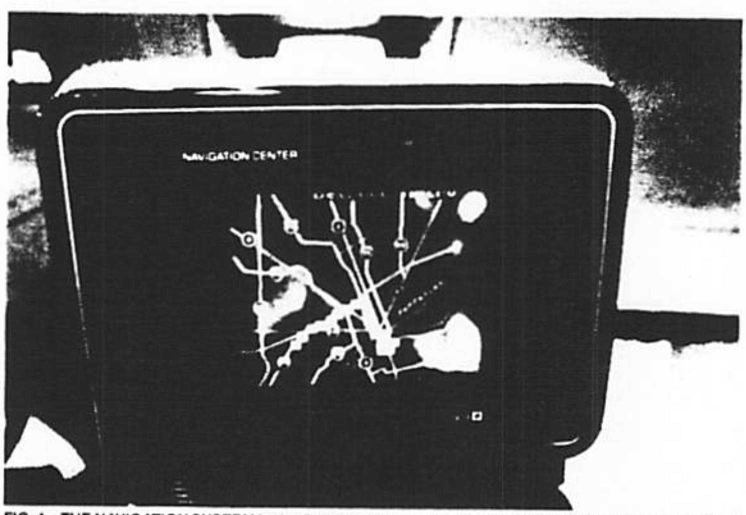


FIG. 4—THE NAVIGATION SYSTEM in the Questor can display area, region, or state maps on one of the vehicle's center-console CRT's.

future. That car uses a barometric sensor in the manifold air-pressure-sensing system. But that same sensor could also be used to detect changes in air pressure that aren't related to engine variables; such changes would be signaled by a change in air pressure that differs from the normal system parameters. A microprocessor receiving such information could even be programmed to interpret the reading to forecast changing weather conditions!

That information could be relayed to the driver via the car's display system, and passed on to other systems in the car. One microprocessor-controlled system could be in charge of altering the car's handling characteristics to accommodate the impending change in road conditions. Another might tune the car radio to the National Oceanographic and Atmospheric Administration's frequencies so the driver could have a weather update.

The future

The current move to electronics in the automobile is but a preview of things to come. Already, many of the major automakers, both here and abroad, have developed what are called "concept" cars. Those are automobiles that showcase the features that automakers hope to be incorporating in their products within the next 5 to 10 years. Among those concept cars are Buick's Questor, Ford's Continental Concept 100, Chrysler's Stealth, Nissan's NRV-II, and Mazda's MX-02. Also, Saab recently unveiled its 900 Turbo EV-1.

The Buick Questor (see Fig. 3) is an idea car from GM. It is being used as a test bed for planned future systems. For example, the Questor features 14 microcomputers and has such features as a "laser key" entry system (an infrared transmit-receive system for vehicle entry); an automatic level, attitude, and spoiler control system; a "systems sentinel" (which monitors the status of the various systems within the car); a line-of-sight display for the speedometer and gauges (located at the top of the instrument pod); a map and navigation system; automatically aimed headlights; a theft deterrent system; a voice-actuated radiotelephone; a road surface traction monitoring system; a television rear-view mirror system, and a touch command center for entertainment, comfort and convenience functions.

The "heads-up," line-of-sight display is an interesting concept. It works much like the prompters used by public speakers. A specially angled screen, that is always in view of the driver, even while he is looking straight ahead at the road, is used to display information. Even though the screen is directly in the driver's line of sight, it doesn't block his view of the road because, like the displays used in jet fighters, it is transparent and appears as an overlay to the scene ahead. It is the first application of this type of technology to automobiles.

Also, Questor is one of the concept cars that features a navigation system. The Questor's navigation system can display area, region, or state maps on one of two display screens mounted in the center control console. (See Fig. 4.) In the navigation mode, a dot on the screen shows the location of the vehicle and moves when the vehicle moves. An electronic compass display gives the directional heading at all times.

The Chrysler Stealth concept car features the Chrysler Laser Atlas Satellite System (CLASS). This system, shown in Fig. 5, makes use of data from orbiting navigational satellites. Currently, there are five such NAVSTAR satellites in orbit; ultimately there will be a network of 18. Maps are stored on optical discs, touted for their high-density data storage capabilities. It is claimed that the system will be able to display your vehicle's position to within 300 feet.

Mounted in the trunk of the Stealth is a NAVSTAR receiver. As the NAVSTAR satellites circle the globe, they continuously transmit positional information. The CLASS receiver uses positional information from four of those satellites to continuously update the system microprocessor. From that information, and information stored in the system's ROM, the microprocessor is able to determine the car's position at all times. That information is displayed in map form on a nine-inch CRT.

The optical-disc storage system uses eight-inch discs that are capable of storing up to 25,000 images on a single side. That

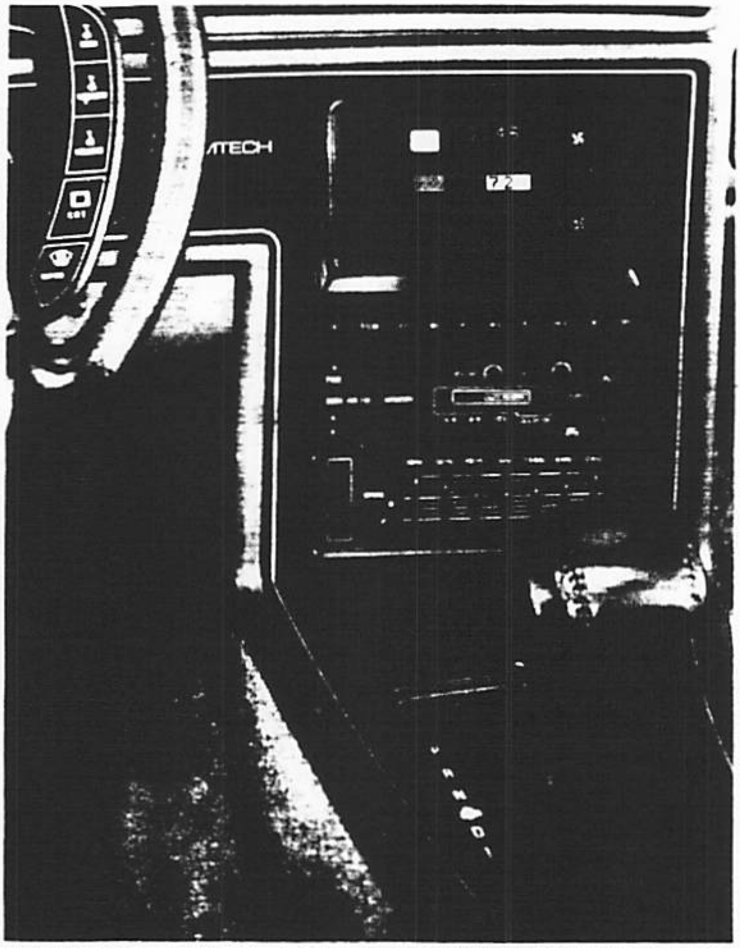


FIG. 1—A CRT WITH TOUCH-SENSITIVE SCREEN is used to replace traditional mechanical climate controls in this Mark VII Comtech, a limited-production vehicle from Ford.

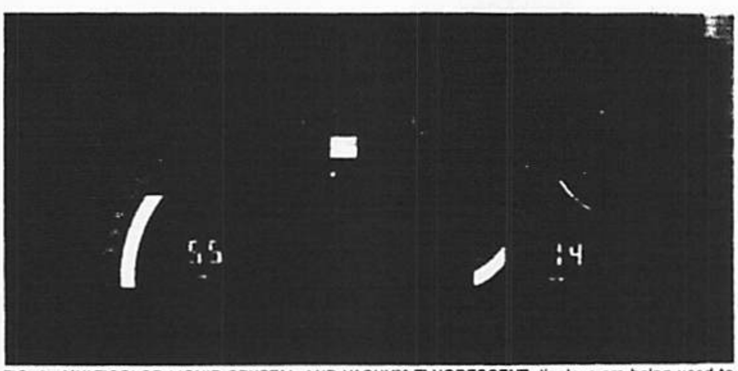


FIG. 2—MULTICOLOR LIQUID-CRYSTAL AND VACUUM-FLUORESCENT displays are being used to present driver information in several current production automobiles.

nology. First developed by Zenith in 1981, vehicular cathode ray terminals with touch-sensitive screens are actively being used in the Buick Riviera and Ford Comtech Mark VII, a limited production model (see Fig. 1). The CRT's are being used to replace traditional mechanical climate and entertainment controls, and multicolor, liquid-crystal and flat vacuum-fluorescent displays are being used for driver information. (See Fig. 2). Soon, expect to see cars equipped with navigational systems, using maps stored on compact discs, to help make sure that you never get "lost" again.

In fact the first such system is already available. It is the Etak *Navigator*. Manufactured by Etak, Inc. (1287 Lawrence Station Road, Sunnyvale, CA 94089), the system consists of a 1,024 × 770 pixel, high-resolution vehicular CRT; a cassette tape drive; compass, and the electronics package.

The heart of the system is the map database, designed by Etak, called EtakMaps. Those maps, stored on cassettes rather than CD's in this first commercially available system, are custom-designed to provide information down to individual addresses, the company says. Once the unit is installed, the owner can customize operation by selection of the appropriate map database.

The system uses a moving-map display to help you navigate. As you drive, your position on the viewing screen, marked by a small triangle, remains constant. Instead, it is the maps that move. The scale of the maps can be changed easily, allowing you to see your position in a neighborhood, a community, a city, or the country. The position of the vehicle relative to the maps is determined by the unit's special compass and sensor system, and is accurate to within 50 feet, on the average. Due to the nature of the system, correct positioning is automatically displayed as soon as the unit is turned on, no matter where the vehicle is located.

According to the company the system is easily installed in two or three hours. The display and the tape player are mounted at the driver's position, along with the tape player. The sensors are mounted at the wheels, and the electronics package located in the trunk. The cost of the system averages between $1,350 and $1,595, depending on the size of the CRT used. (There are two, one seven inches and the other 4.5 inches.) The tape player is designed for trouble-free use because it contains no capstan or pinch roller. The only moving parts are the motor driveshafts.

Microprocessors and the car

The key to all of those hi-tech automotive features is, of course, the microprocessor. For instance, the Buick Riviera uses two eight-bit microprocessors—custom-masked Motorola 6801's—to control that car's CRT display system.

At the moment, each microprocessor in a car is assigned one and only one task (controlling a car's display system, for instance). But automotive experts predict that the day is coming when all of the microprocessors in a car will communicate with each other and with a master control microprocessor designed to oversee the entire vehicle's condition and operation. The advantages of that become quite apparent if you look at the car as a complete system. Let's look at a hypothetical example.

Let's say we are driving a car of the

FIG. 5—CHRYSLER'S CLASS system uses a satellite receiver to obtain navigational information from a system of orbiting satellites.

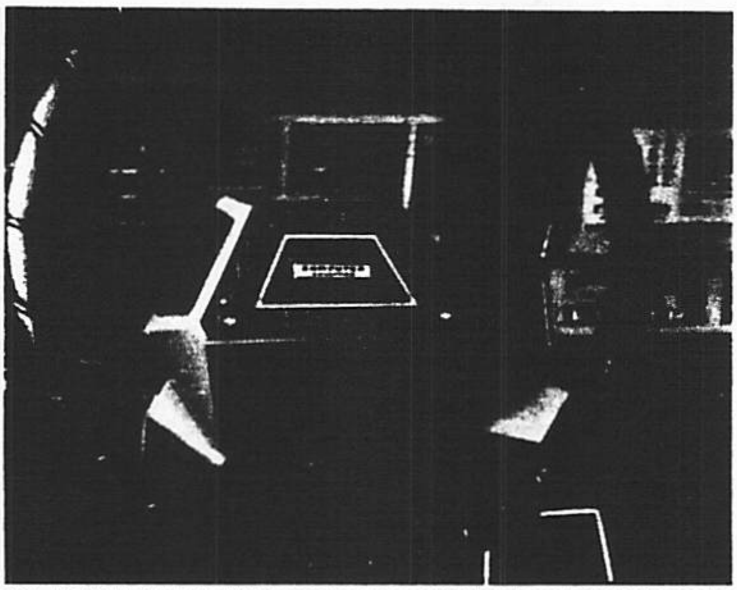


FIG. 6—IN THE CHRYSLER STEALTH concept car, many controls have been relocated to the steering wheel. In that vehicle, the traditional wiring harness has been replaced with a multiplexed wiring scheme.

is more than sufficient for the maps needed to adequately cover the U.S.; a demonstration version of the system contained 13,300 such maps. The leftover capacity could be used for a variety of applications, such as storing hotel, restaurant, and sightseeing information.

Like the system used in Buick's Questor, CLASS uses a moving icon to indicate the car's position on the map. The scale of the maps can be similarly varied, zooming in on a small area, or zooming out to accommodate an area as large as 1,600 square miles. Chrysler will be offering the CLASS system as an option when the NAVSTAR satellite system is fully operational.

Another interesting feature in the Chrysler Stealth concept car is the use of multiplexing for system controls. All controls have been removed from the instrument panel and placed at the hub of the steering wheel. (See Fig. 6.) However, instead of using separate parallel pairs of wires for each control, all the signals are multiplexed on a single bus.

There are many advantages to multiplexing. One is the elimination of heavy and unwieldy wiring harnesses. Also, a multiplexed system offers some unique advantages in the area of diagnostics. Information exchange between the bus-control microprocessor, and the microprocessors controlling the systems that the bus feeds is constant, and two-way. If a system should fail, that data is received by the bus-control microprocessor and either the driver can be informed, or, if possible, a back-up system activated.

Another automobile that makes use of multiplexing is the Nissan NRV-II. In that system, however, fiber optics rather than wires are used for data transmission.

For Placement Only

The NRV-II is noteworthy for a few additional reasons. For one, it is equipped with both voice-synthesis and voice-recognition systems. Voice-operated functions include the route-data input for the driver information system, speed warning settings, and control of exterior mirrors, interior lights and hazard flashers.

Another interesting innovation in the Nissan car is a "drowsiness" alert. For that, a microprocessor is used to monitor various functions, such as how the steering wheel is used, to look for signs that the driver might be getting drowsy. If any of those functions vary from the norm, the system sounds an alarm.

As you can see, the electronics revolution has finally reached the passenger compartment of your family's car. But it won't be limited to just that part of the car. Indeed, the role that electronics is, and will be, playing in the engine compartment is at least as important, if not more so. To find out more about the electronics revolution that is occurring "under the hood," turn to the next article in this section. **R-E**

APPENDIX H

Control Systems

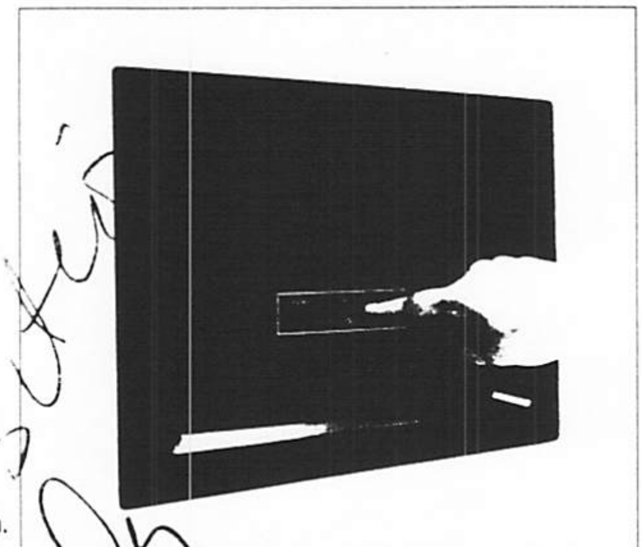
ALPS

position control

TRANSPARENT TOUCH PANEL

ALPS ELECTRIC (USA), INC.

FEATURES



1

Low cost.

2

Simple I/F circuit.

3

Low power consumption.

4

Available cylindrical shape and any size.

5

Free from any dust problem.

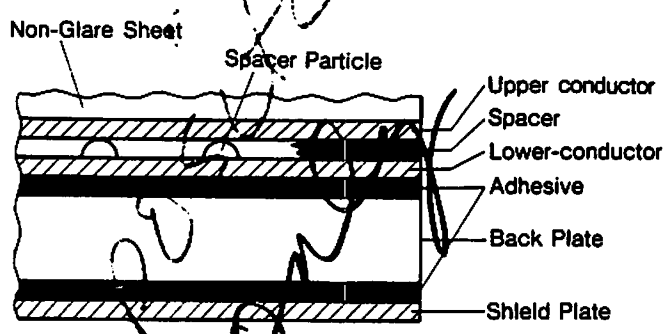
DESCRIPTION

TRANSPARENT TOUCH PANEL is a TRANSPARENT MEMBRANE SWITCH, which consists of two pattened transparent conductive films. The spacer particle is located in between upper and lower conductor as the insulator.

When the key is depressed by finger, the upper and lower conductor make contact and can transfer the signal of X-Y location to the computer.

CONSTRUCTIONS (Fig. 1)

Basic construction is the backplate, lower and upper conductor films. Optionally the shield and antiglare sheet can be added.



(Fig. 1)

SPECIFICATIONS

MECHANICAL

●Operating force	Max. 100gf
●Transparency	60 ~ 75%

ELECTRICAL

●Power rating	5V DC, 0.5mA
●Contact bounce	10msec. Max.
●Insulation resistance	Min. 10MΩ at 25V DC
●Dielectric strength	25V AC for 1 minute

STORAGE

●Non operating	−40°C~85°C
●Operating	0°C~40°C
●Life	500,000 ~

ALPS

for Position only

CONTROL PANEL

ALPS ELECTRIC (USA), INC.

FEATURES

1

Less than 12mm thickness body.

2

Uniform surface illumination (low-noise electroluminescent device is used).

3

Good-feeling tact switch, slide control, permit easy, single-hand operation.

4

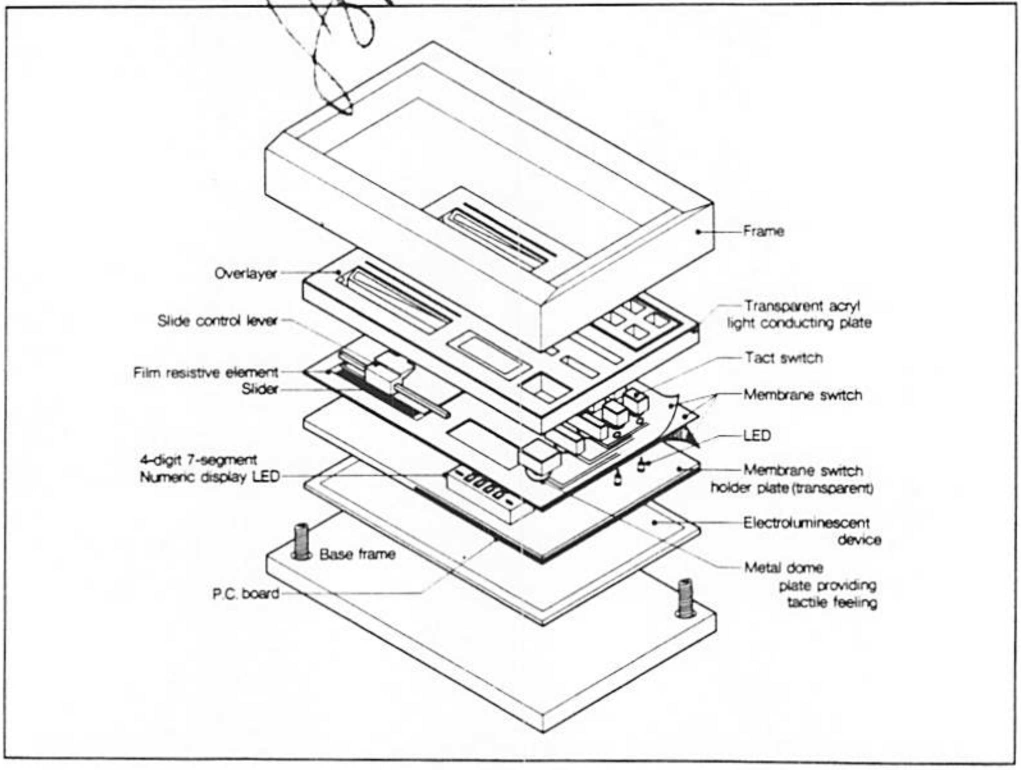
Point and 4-digit numerical representations by LED are possible.

5

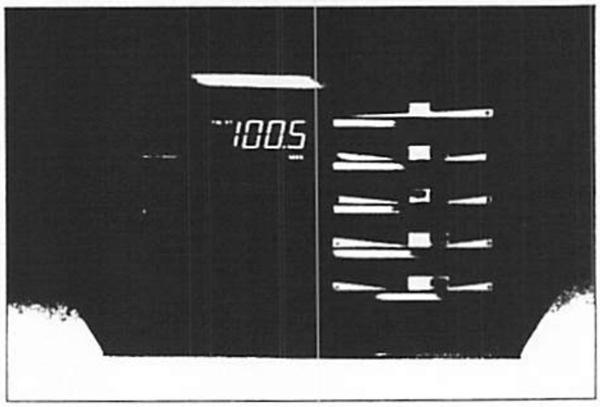
A wide variety of surface designs are affordable.

For Pos'n Only

PRINCIPLE OF OPERATION



ALPS



APPLICATIONS

● Center control panel for car radio, auto climate control etc.

SPECIFICATIONS

For position only

TACT SWITCH

Operating force	50~500 gf
Contact resistance	500Ω max.
Operating life	50,000 cycles min.

SLIDE CONTROL

Operating force	20~200 gf
Total resistance	Optional
Resistance taper	Optional
Operating life	10,000 cycles min.

ELECTROLUMINESCENT DEVICE

Luminance	10m cd/m^2 min.
Luminous color	Green, Blue, Orange
Current drain	90 mA max.
Stray capacitance	180 μF max.
Half-life period	5,000 hours min.

ALPS

OPTICAL TOUCH SCREEN

FEATURES

1

Non-mechanical contact type assures increasted durability and reliability.

2

Simple and trouble-free mechanism with superior resistance to vibration and shock.

3

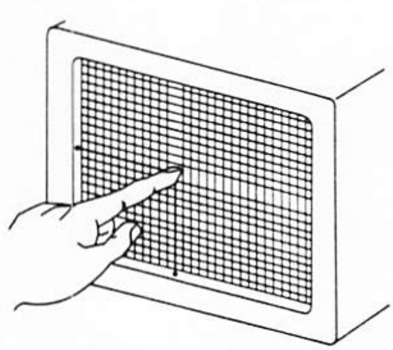
Provision of RS232C interface makes interconnection with a personal computer or office computer easily.

4

Finger-operated. No need for using a light pen.

FUNCTION

Light emitting diodes and photo-detectors are arranged around the CRT screen. LED light beams are of the matrix shape. When a light beam is intercepted with a finger, its touch position is detected according to the position of the intercepted beam.



APPLICATIONS

- **Personal computers for business use**
- **Video and audio controls**
- **Cashing services at banks**
- **Reservation services at hotels**
- **Personal computers for educational use**
- **Telephone sets**

SPECIFICATIONS

Format/Matrix	40×24
Screen size	12~14 inches
Resolution	X=Y≒7mm (min. 3mm)
Supply voltage	5V DC±5%
Temperature	Operating temperature 0°C~55°C Storage temperature −20°C~75°C
Humidity	5%~95% noncondensing
Interface	RS232C Serial Lines available ● RTS: Request to send ● CTS: Clear to send ● TX: Transmit data ● RX: Received data ● GND: Signal ground ● Parity bit: Disabled ● Start bit: 1 ● Stop bit: 2

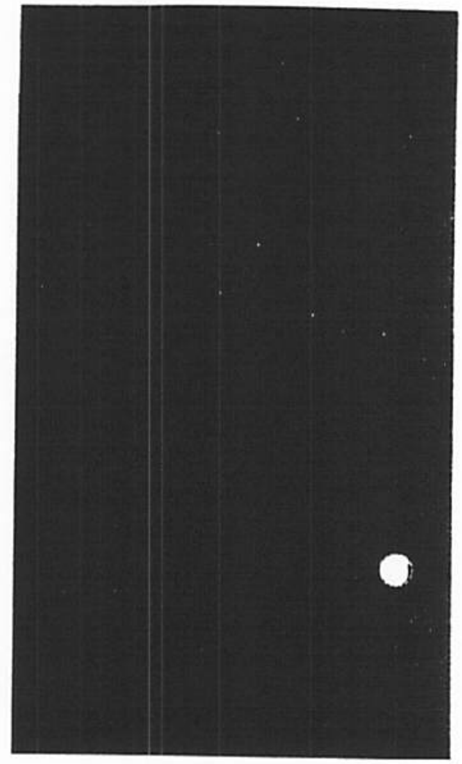
ALPS ELECTRIC (USA), INC.

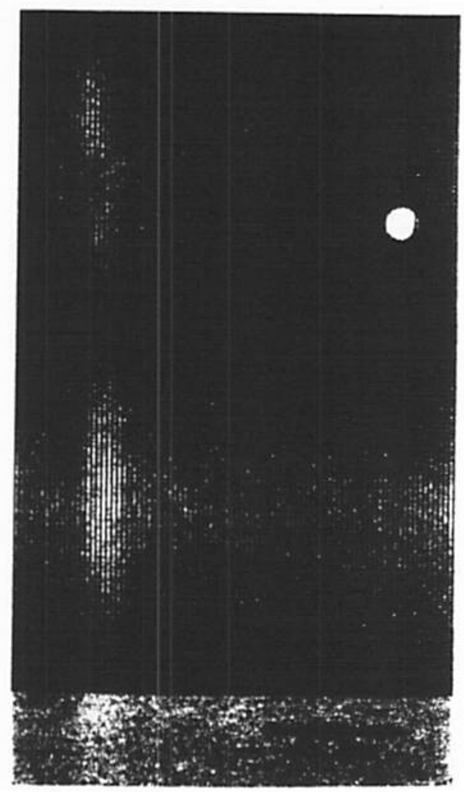
AUTOMOTIVE DIVISION:
1810 SOUTH LYNHURST DRIVE, SUITE X, INDIANAPOLIS IN46241
PHONE (317) 248-2577 TLX (23) 027-685

●HEAD OFFICE:
3553 NORTH FIRST STREET, SAN JOSE, CALIFORNIA 95134
PHONE (408) 946-6000 TLX 757061

●NEW YORK OFFICE:
100 NORTH CENTRE AVENUE, ROCKVILLE CENTRE, N.Y. 11570
PHONE (516) 766-3636 TWX (510) 211-6747

for position only





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