GENERAL MOTORS CORPORATION

PROGRESS IN AREAS OF PUBLIC CONCERN

GM PROVING GROUND

MILFORD, MICHIGAN

February, 1971

PRODUCED BY GM IN PENNY SHIPLER V GM

SHIPLER000000437

AUTOMOTIVE SAFETY

Louis C. Lundstrom

The safety provided by General Motors' cars, trucks and buses is important to us. Our engineers are very proud of their accomplishments in vehicle safety, which they know have been substantial—all criticism of such progress to the contrary. GM's work in safety is extensive, and I will provide you with an overview of such activities as they take place here at the GM Proving Ground, at our Technical Center in Warren, Michigan, as well as throughout the entire organization.

Because passenger cars have been around for the past 75 years, many people have the impression that we should know all there is to know about the automobile, and need only to apply this knowledge to make cars safer, stronger, and better than ever before. Quite frankly, we are still learning how to make them safer, stronger, and better.

In the 1920's and 1930's, we concentrated on enclosing cars in all-steel bodies and providing them with improved brakes and suspension systems that imparted a controlled but comfortable ride. In the 1940's and 1950's we perfected most of the power assist equipment common on cars of today such as power steering, power brakes and automatic transmissions. The late 1950's and early 1960's saw the beginnings of needed research into human tolerance to determine causes of injury resulting from vehicle accidents. This has led to a greater understanding of the second collision phenomenon in the automobile, resulting in such improvements as the energy-absorbing steering column, high penetration resistant windshield glass, energy-absorbing instrument panels, and other developments oriented toward occupant protection. In the 1970's, as we learn more about the nature and causes of accidents, we will design cars with further improvements that help the driver avoid accidents, or better protect the occupants if accidents do occur.

At General Motors, we are committed to this advancement of safety through sound engineering. We have demonstrated this commitment by introducing safety features whenever they have reached production stage, often in advance of our competitors. GM's safety research and development activities have, in various instances, led to data or breakthroughs utilized by the National Highway Traffic Safety Administration in formulating vehicle standards.

When our Safety Research and Development Laboratory was dedicated in the summer of 1968, Mr. Cole said, "We in GM will not be satisfied until our vehicles provide the greatest possible impact protection for occupants up to the limits of the physical laws of nature and of technological knowledge." We have not deviated from this course. These and other facilities give ample evidence of GM's dedication to seek continuing improvements in the occupant protection provided by our cars.

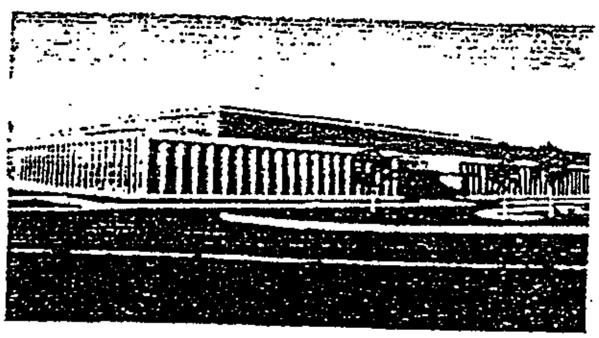


Figure 24

The GM Safety Research and Development Laboratory probably is the most extensive facility of its kind in the industry. (Figure 24) Here we have the great variety of equipment necessary to conduct tests that ultimately provide data leading to safety improvements, and that establish proofs of compliance for areas now covered by the motor vehicle safety standards.

We can simulate accidents which involve an entire vehicle or just a small part of one. Much work also is expended in maintaining these safety test machineries, and in taking care of our dummy simulators so that they can accurately record the experiences that a real person might undergo during an accident. Our photographic laboratory is comparable to many commercial studios. It provides us with a very vital means of graphically recording the movements of dummy occupants and vehicle components during an accident test.

Generally, an accident is over so quickly, that if you should blink at the wrong time, you would miss all its

PRODUCED BY GM IN PENNY SHIPLER V GM

SHIPLER000000438

essential points. With high speed photography, we can make a few seconds of accident test time last for a number of minutes on a screen as we study what took place.

Another workshop is responsible for the upkeep of sophisticated sensing devices that are placed inside dummies or attached at various parts of the car body structure. These instruments, hooked into magnetic tape pickups, record the speed as well as the severity of the collision. With movie footage and magnetic tape we then can go about reconstructing every little movement that took place during a simulated test collision, and plan how to make these collisions less severe to the occupants.

One of the more important functions of the Safety Laboratory is to study records of thousands of actual accidents involving new cars each year as reported to us by the Motors Insurance Corporation, a GM subsidiary that underwrites auto insurance. These accidents are coded and placed into a computer accident bank after being evaluated. (Figure 25) They provide evidence to help us determine how well any given improvement may perform in actual, real-life situations. And once the data bank is complete we can ask questions of the computer that might pinpoint accident patterns not previously suspected. Also, by plotting the frequencies with which different parts of the car exterior or car interior might be struck, the computer can help us to determine which areas might better be improved through design.

The computer search also has enabled us to study 160 cases on file where the occupants involved in an accident had been wearing lap and shoulder belts. This has been the largest such study made to date. It revealed that there were no fatalities for the people wearing the full restraints as long as the passenger compartment had remained intact during the accident.

For component safety tests we have invented and installed machinery such as a roof crusher, instrument panel head impactor, and a simulated side impact test ram—which was devised as a static test for the increased door strength side-guard beam, introduced as an industry "first" by GM on some 1968 models, and now on virtually all GM cars. The NHTSA is presently considering a performance standard based in great part upon this innovation.

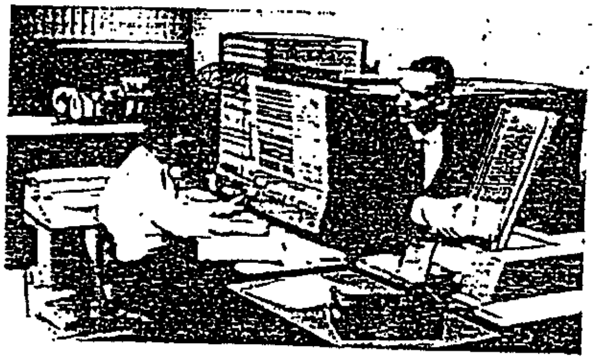


Figure 25

There is a mini-sled test fixture used for steering wheel and column development and compliance testing. We have upgraded it by substituting the upper torso of an actual dummy in place of the crude dummy fixture specified in the Federal standards, and have requested the NHTSA to adopt this change as an improvement over the existing requirement. The main test fixtures in the Laboratory are two impact sleds, either of which can propel a car body at speeds up to 70 miles-per-hour to simulate a variety of accidents. About 915 such tests were conducted last year.

The result of utilizing these different kinds of safety test devices as well as inventing new ones is that we have GM cars that are second to none in overall safety. Our energy-absorbing steering column, for example, has much greater performance than required by Federal safety standards, and its success in real-life accidents has been well documented by independent accident investigators and the Federal government. Present instrument panels, seat backs and other interior components also are much superior than minimum standard requirements, and are performing very well in real life.

As I indicated earlier, today's cars are capable of drastically reducing the highway death toll if full restraint systems would be worn by everyone. Unfortunately, they are not. The improvements we have made in the vehicle thus far have not interfered with our normal usage of the vehicle. However, it is becoming an increasingly difficult challenge to continue adding major vehicle improvements without affecting vehicle utility.

PRODUCED BY GM IN PENNY SHIPLER V GM

SHIPLER000000439

I should also mention a special group located at the Safety Laboratory with the responsibility for developing product proposals and design guidelines to reduce crash damage and the cost of repairs. Repair shops are being canvassed and car-to-car impacts conducted to determine what areas are most vulnerable to impact damage or are very difficult to repair. Based upon these investigations, the group hopes to recommend future changes in design that might overcome potential service problems.

The great majority of safety work we do here at the Laboratory is directed primarily at occupant protection. The rest of the Proving Ground, with its 85-miles of varied road systems, tests and evaluates the performance, durability and reliability of our vehicles so that they can enable the driver to avoid accidents, if at all possible. (Figure 26) GM safety work takes place in many other locations as well: at the Technical Center in Warren, Michigan and at the various divisional engineering locations. For example, the central headquarters for my own group, Automotive Safety Engineering, is the Technical Center. It is where our communication center for vehicle safety exists. From this central vantage point, Automotive Safety Engineering can work more closely with other staffs and car divisions on matters affecting the safety of our vehicles.

In addition to the Automotive Safety Engineering function the Technical Center is the location for many safety projects such as the air cushion development program now taking place under the supervision of Fisher Body Division. The Engineering Staff also is headquarters for the Experimental Safety Vehicle program being done under a one dollar contract with the NHTSA. This program is on schedule and we will be delivering two cars to the NHTSA in October, 1972. A "preliminary design package," defining the GM design approach, was delivered to Washington in December, 1970. We are not in a position to divulge the contents of the "package." With more than 100 Engineering Staff men working on the program, not counting the divisional personnel and resources that are aiding in various design, development and test projects, we are well along in the design. We will be fabricating components later this year for testing.

At the GM Research Laboratories, passenger com-

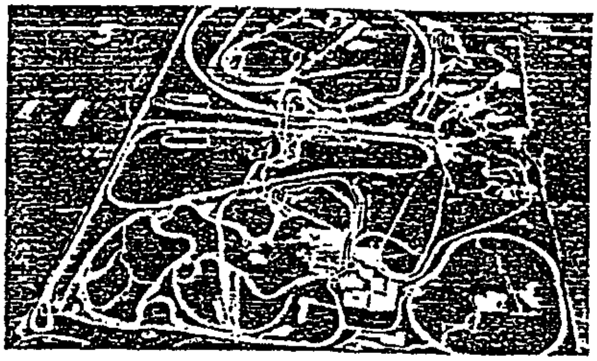


Figure 26

partment integrity is being studied by a new analytic-experimental technique for predicting barrier impact performance of a new car design. This program utilizes computer simulation, a giant static car crusher, and an elastic model of a car's passenger compartment.

GM research programs attempt to fill the knowledge gap that exists in human tolerance to injury—both in the laboratory and in the field. Professor Lawrence Patrick, Wayne State University, under our sponsorship, simulates collisions in the laboratory, using both cadavers and dummies. Meantime, Professor Donald Huelke of the University of Michigan reports monthly on crashes that

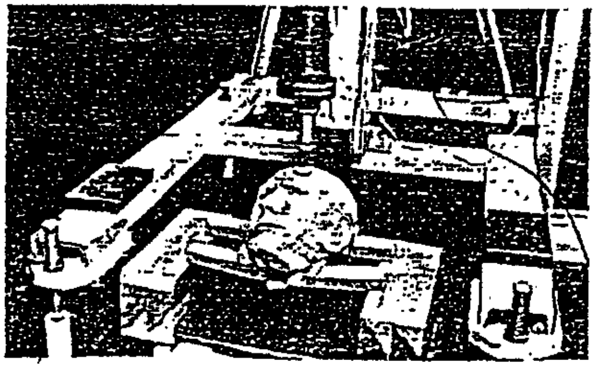


Figure 27

occur in the field. Also our Research Laboratories are studying the impact tolerances of various sections of the human body, for which GM designed a drop test machine. (Figure 27)

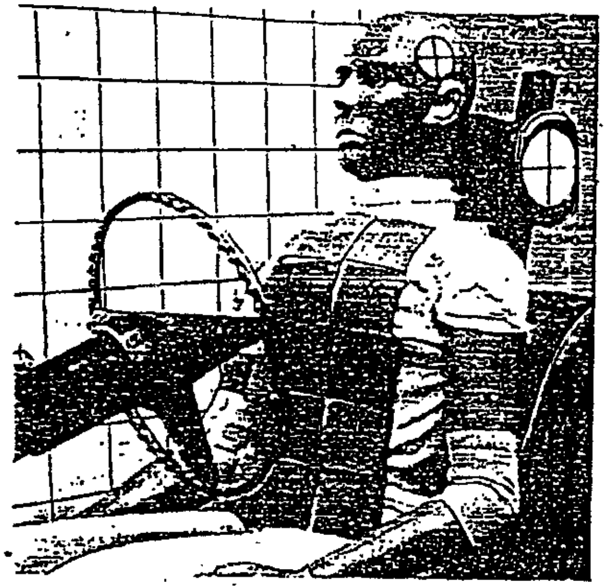


Figure 28

Associated with such work is development by GM Research Laboratories of a fibrous metal material called MetNet which is placed between colliding objects to provide a consistent depth of imprint for measurement and translation into impact pressure values. (Figure 28)

The System on Automotive Safety Information, established in conjunction with the GM Research Laboratories, is considered one of the world's most complete repositories of safety information. Intended originally as a GM information search and retrieval activity, SASI now is providing copies of its index cards to the NHTSA for expansion of its information base and incorporation into an international announcement service.

A new in-depth program located at the Technical Center to improve vehicle safety utilizes advanced electronic systems to incorporate analytical studies of vehicle control and impact factors, influence of highway factors,

Figure 29

and driver capability. Present programs cover air cushion sensor development and a physiological tester to prevent people from driving when alcohol or drugs impair their abilities.

At the GM Styling Staff, studies are taking place in anthropometrics, glare and vision, driver work space, reflection, and other forms of human factors testing. Some of this work is aided by the highly sophisticated GM driving simulator developed by Engineering Staff and now in its second generation of design. (Figure 29) This simulator can provide all of the stimuli of actual driving experiences, while trained researchers record responses of the drivers. The driving compartment resembles the interior of an actual car, and will pitch when the brakes are applied or roll when the steering wheel is turned in response to simulated situations shown on screen.

GM car and truck divisions also have extensive safety facilities and programs of their own, and responsibility for the exploration of practical improvements in vehicle safety. The GM Engineering Staff is responsible for coordination of all divisional and corporate safety programs. This, then, is a broad outline of the safety work conducted within General Motors for improving accident avoidance and occupant protection.

Discussion Period

A questioner asked if there was any way to simulate in GM's crash tests the fact that human beings react differently from test dummies during an accident. Mr. Lundstrom said this is difficult to do today, but that in a high speed crash—the type that is likely to produce serious injury and death—the forces are beyond human capability. On low-level impacts, he said some persons can bend the steering wheel so GM knows humans can resist injury and will do all they can to do so. Mr Cole added that comparisons of GM's test work with actual accidents indicate that human beings do anticipate an accident, position themselves for it, and that the level of actual survivability may be higher than tests with dummies demonstrate. He also noted that it is difficult to develop test dummies which correlate with human behavior.

In reply to another question, Mr. Lundstrom said General Motors had done considerable work in accident avoidability, including development of a defensive driving obstacle course which tests the skills of drivers in avoiding accidents. He pointed out that each individual reacts differently in an accident situation, and that General Motors is trying to incorporate in its vehicles systems which are in line with the capability of most drivers.

A person noted that General Motors and the automobile industry had made a major effort to support national safety programs in areas such as the upgrading of traffic courts, and the upgrading of traffic accident record maintenance and analysis. He also mentioned the American Bar Association's Traffic Court program which was supported by the automotive industry through the Automotive Safety Foundation, and the Traffic Institute of Northwestern University which was started with funds from the automotive industry. He praised the industry, particularly General Motors, for its efforts in these areas, and said they helped to reduce highway deaths to the level cited earlier by Mr. Roche. Mr. Lundstrom added that the vehicle-road relationship was recognized some time ago by General Motors, and that the road network at the Proving Ground was constructed with a view toward reducing road-related accidents. Mr. Lundstrom pointed out that General Motors has tried to emphasize the importance of removing roadside obstacles, and that the government has now recognized how essential this is to highway safety.

An individual asked about the Corporation's budget expenditures in these areas. Mr. Richard C. Gerstenberg, Vice Chairman of General Motors, said that U.S. expenditures of $124 million are forecast for 1971 for automotive emissions research, engineering and related activities. He said GM will spend another $64 million for controlling air and water pollution from plants, an expenditure almost four times as large as three years ago. He pointed out that these figures do not include the cost of automotive emission control hardware being installed on GM models. As for safety, Mr. Gerstenberg said the estimated expenditures for 1971 are over $400 million. Mr. Cole also pointed out that General Motors' level of spending was such that even if more money were available the results could probably not be increased. This is due, Mr. Cole said, to the fact that innovations cannot be scheduled, and that GM currently was employing sufficient people and resources to get the job done. Even if the effort was doubled, he doubted whether a great improvement in output would result.

Another person said he had read that a large proportion of total vehicle accidents involve drivers who were under the influence of alcohol, and asked what General Motors could do in this matter. Mr. Cole answered by describing GM's experimental physiological tester, a device which inhibits the starting of an automobile when the driver's control capability is impaired. He also pointed out that the physiological tester had been made available to the Federal government for evaluation.

Another individual recalled that the Presidential Task Force on Highway Safety found alcoholic intoxication the number one cause of serious highway accidents. He said there should be a massive attack upon the problem of alcoholism in the United States because of its effect on the nation's social fabric. Mr. Cole agreed, stating that this is one of the reasons for GM's development of the physiological tester.

Stating that a Chicago judge received satisfactory results over the holidays by promising a week in jail for any driver involved in an accident or traffic violation while under the influence of alcohol, a questioner asked Mr. Cole's opinion of such a prevention technique. The GM President replied that based on the experiences of Sweden and England, effective traffic law enforcement and efficient processing of violators by the courts help to decrease highway accident rates.

PASSIVE RESTRAINTS

David D. Campbell

About two months ago, the National Highway Traffic Safety Administration issued a Federal standard requiring all new cars manufactured for sale in the United States after July 1, 1973, to be equipped with passive restraints for all front seat passengers. Similar devices will be required for rear seat passengers one year later.

In a recent speech in Detroit, Douglas Toms, Director of the National Highway Traffic Safety Administration, repeated that the adoption of passive restraints is the topmost item on the Administration's priority list. What are these passive restraints? How do they work, and what are they supposed to do? We'd like to give you some answers to these and other questions.

As many of you may know, a passive restraint is one that requires absolutely no action on the part of the driver or passengers to be effective. It's always there, but it works only in the case of an accident. This is in contrast to restraints such as seat belts. These are classified as active and require the driver or the passenger to do something. In this case, buckle them up. Without question, lap and shoulder belts are effective. The big

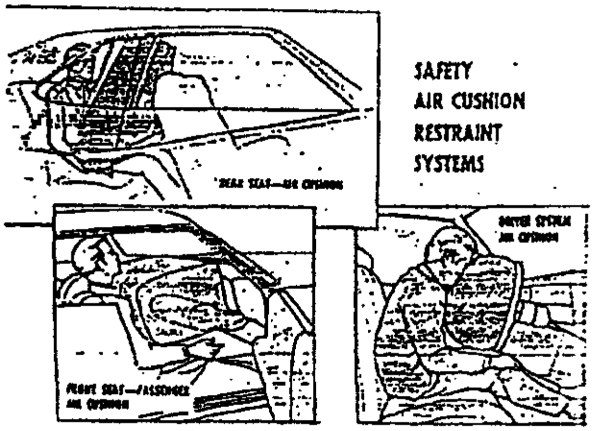


Figure 30

problem is that many people never use them. Only about 30% of lap belts are ever used and about 4% of shoulder belts are ever buckled.

Public apathy toward seat belts is the real reason behind this planned move toward the far more expensive and complicated passive restraints. We have worked on many other devices including padding, nets and blankets, and we intend to continue this research. But, our experience with the air cushion indicates that this system, if it can be proven feasible, has potential advantages over any other we know about. (Figure 30)

Now, I think we should take a look at what the air cushion is expected to do. A car equipped with passive restraints must be submitted to three types of tests in order to meet the new Federal standard 208.

These are:

- A 30-miles-per-hour crash straight into a barrier.
- A 30-miles-per-hour crash into a barrier at a 30-degree angle.
- And, a side impact with a 4,000-pound mass moving at 20-miles-per-hour.

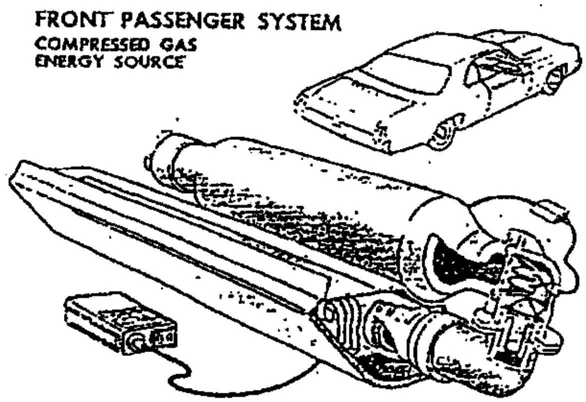


Figure 31

(At this point, a film showing a car being crashed into a barrier for each of these three tests was viewed.)

These tests simulate very severe accident conditions. In fact, head-on plus angular impact collisions cause nearly 60% of auto occupant fatalities each year.

On the surface, the air cushion looks like a pretty simple device. That assumption is far from the truth. Its components include: (Figure 31)

- An electronic device which signals the crash to the rest of the system. This component must discrim-

PRODUCED BY GM IN PENNY SHIPLER V GM

SHIPLER000000443

inate between crash and non-crash situations and also monitor the entire system for readiness. If the sensor finds any component malfunctioning while monitoring the system during non-crash conditions it turns on a red warning light on the instrument panel to indicate the system needs servicing. This area of design is one in which we have done considerable work in the hope that it can eventually find practical application in the event the air cushion is adopted.

- A container of air compressed to 3,500-pounds-per-square-inch.
- A diffuser which is nothing more than a long tube to distribute the air.
- A torso bag which is rolled and folded in front of the diffuser tube.
- And, a knee bag which is inside the torso bag and serves to protect the passenger's legs. The addition of a knee bag is another GM innovation which has solved a number of the technical problems that plagued early air cushion designers.

In operation, the air is held in the container by a steel diaphragm. When the sensor detects a crash, this diaphragm is broken. The breakage releases the air and inflates the cushion.

(At this point, a film showing the deployment of the front seat air cushion was viewed.)

The whole sequence takes only 60-thousandths of a second—or fast enough to happen 16 times in a single second. Although our current program has been underway for almost three years, we do not have a production version that we are satisfied with yet.

So far, we have been talking only about the front seat device. Now let's examine the air cushion for the rear seat. When we began, we thought it would be a matter of simply locating the rear seat air cushion in the back of the car's front seat. But, this created unforeseen problems. In tests we found that unrestrained rear seat passengers could generate as much as 25,000-pounds of force against the seat structure. This would mean that the front seat would have to be strong enough to support a weight equivalent to five Cadillacs. The impracticality of this is apparent, so a new approach was definitely needed. Our choice was a cushion that deployed from

ROOF MOUNTED AIR CUSHION SYSTEM
(REAR SEAT PASSENGER)

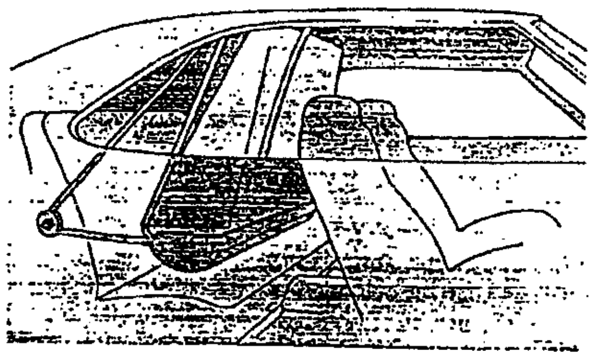


Figure 32

the roof and which hopefully could restrain the rear seat occupants before they collided with the front seat. (Figure 32) We are now in early stages of development of such a cushion.

Many of our engineers working on passive restraints have spent a great deal of time trying to make use of the air cushion to prevent ejection from the car during rollover accidents. Field surveys show that the chief cause of death in a rollover comes from passenger ejection through broken side windows.

One approach to solving this problem is a system we are developing that uses the rear seat air cushion to stretch and hold a net over the side windows during the accident. (Figure 33) Once the bag deflates, the tension is released and the net can be easily lifted for exit from the car.

(At this point, a film showing the deployment of the rear seat air cushion was viewed.)

While a good deal of technical progress has been made by GM in developing an acceptable air cushion system, we still have a long road to travel before we can say we are ready to install them in our cars. Up to now, no human being has been subjected to the many static tests, road tests, and noise tests that we feel we must perform in order to get the data that will tell us if we are on the right track and heading for production, or if we must go back and re-design.

On this subject of human testing, we are now able to

PRODUCED BY GM IN PENNY SHIPLER V GM

SHIPLER000000444

report that there is a government sponsored program underway at Holloman Air Force Base using volunteers to find out more about air cushions and their effect on people. General Motors is providing the automotive material for these tests. We feel that this program is especially critical because any failure here might deal a severe setback to our own air cushion program. In the same way, new progress or information achieved in these activities will contribute to our own efforts.

Yet another problem of great importance is reliability. We absolutely must develop an air cushion system that works when its needed—and *only* when its needed. The seriousness of this reliability problem cannot be over-emphasized. As an example, I am sure that you are all aware of the elaborate preparations that preceded the Apollo 14 moon flight to make certain, as far as humanly possible, that each component and system functions exactly as it was designed. It is not unrealistic to say that a high degree of reliability in air cushions is just as critical for the occupants of GM cars as it is in the equipment used by the astronauts.

We recognize that some safety features, such as seat belts and head restraints, involve some element of risk for occupants if the device is not used as the manufacturer intended. With air cushion systems representing a virtually new field of endeavor, and one involving space age technology at that, the risk is multiplied, particularly with respect to the occupant and the manufacturer's potential liability.

In this area, our concern is centered on such problems as:

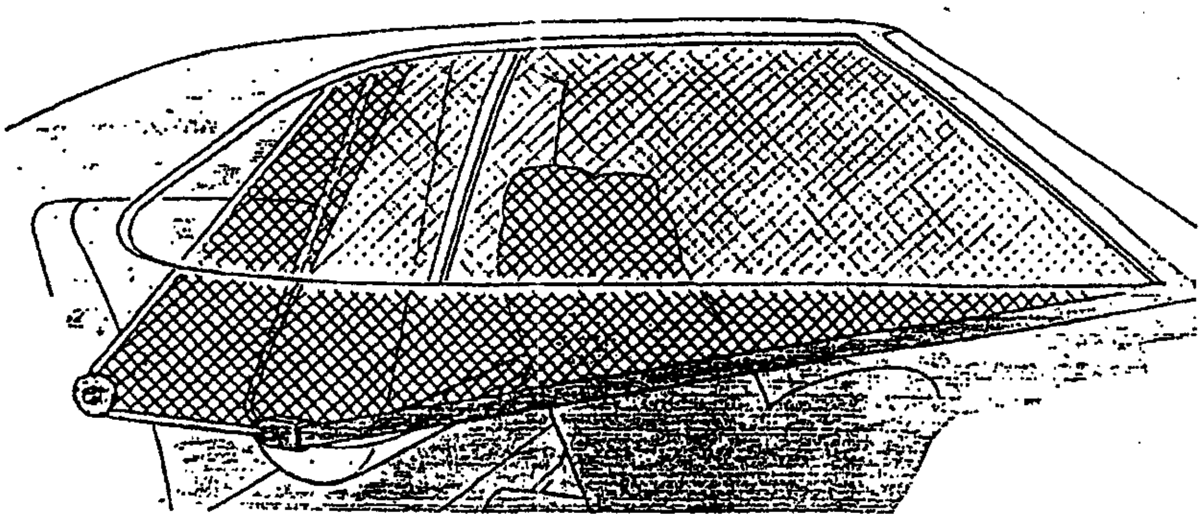
- Inadvertent deployment.
- Failure to deploy when needed.
- Or, delayed deployment.

These are by no means the only unresolved questions regarding system reliability and the manufacturer's possible liability. Another is, how long should a highly complex system like this be required to last before being replaced? Two years? Five years? Ten years? Life of the car?

Then, too, there are the out-of-the-ordinary cases. I am thinking of an accident where the level of severity would be so high that it was beyond the capability of the air cushion. As the effective date of the new Federal standard draws closer, and as we approach commitment for production tools, plants and equipment, each of these problems becomes more critical and of more concern to us.

(At the conclusion of this presentation, the deployment of a prototype air cushion installed in a passenger car was demonstrated.)

Figure 33. REAR SEAT AND SIDE WINDOW NET SYSTEM . . .



PRODUCED BY GM IN PENNY SHIPLER V GM

SHIPLER000000445