Shipler v. GM

Plaintiff's EXHIBIT

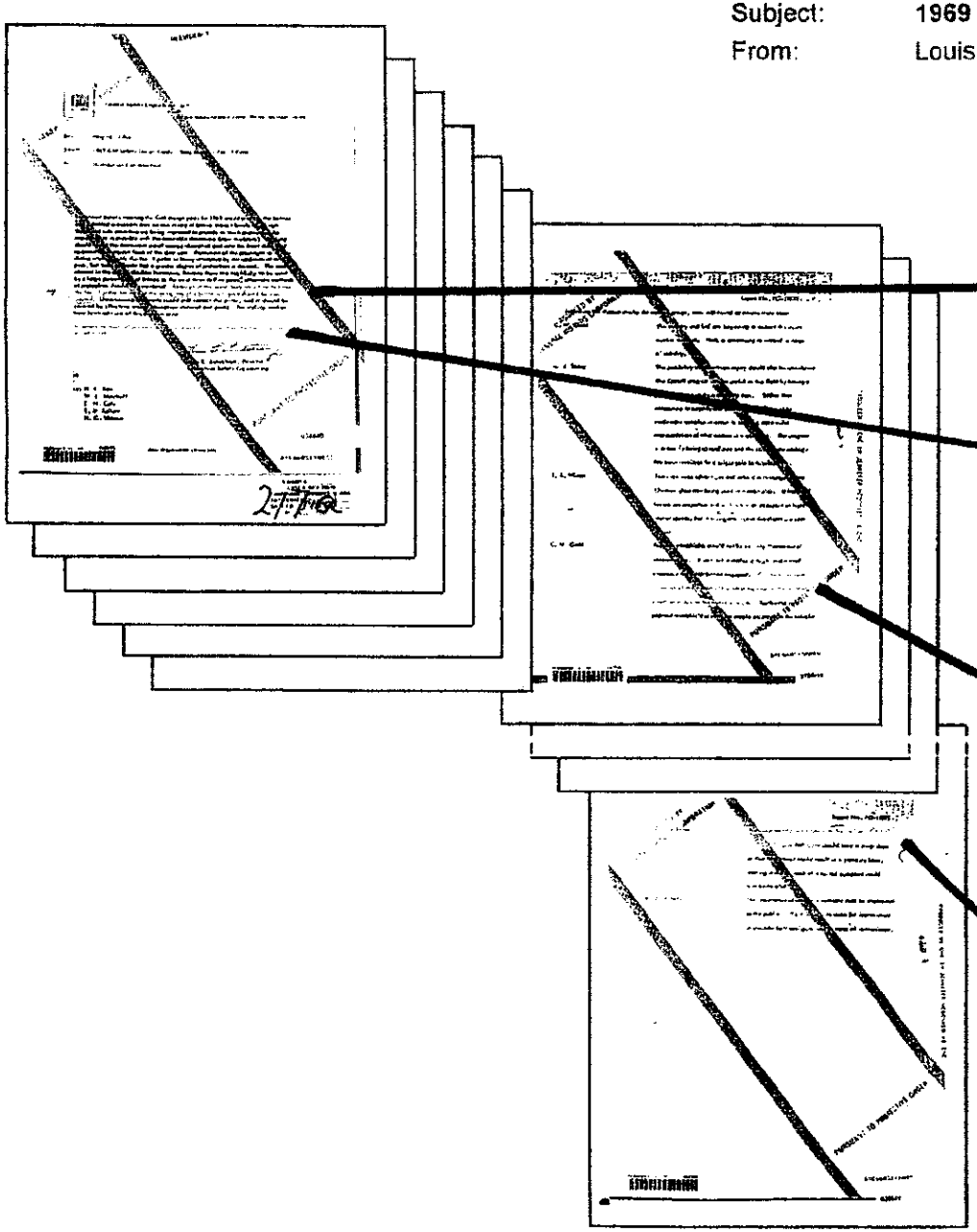
General Motors Engineering Staff

BLOW-UP EXHIBIT #50A

Date: May 16, 1966

Subject: **1969 Safety Design Goals - Body Design - No. 1 Pillar**

From: Louis C. Lundstrom, Director - Automotive Safety Engineering



Redesign of the upper body structure to keep the No. 1 pillar forward of the swingline of a belted occupant should be considered. Unrestrained occupants would still contact the pillar, and it should be covered by effective energy absorption material (not pads). The styling studios have been advised of this problem area.

Alternative methods of accomplishing increased protection from the No. 1 pillar are solicited.

Report No. PG-21773

Page 6

C. W. Gadd: **Pop-out windshields should not be entirely thrown out of consideration. A pop-out wind-shield might allow head clearance for a lap-belted occupant. On the other hand, retention of the windshield is advantageous in the event of a roll-over due to added roof strength.**

Page 9

Lundstrom: **<u>We are presently in trouble with the "A" or Number 1 pillar.</u> Perhaps it should have a steep slope so that any impact would result in a glancing blow. Moving it out of reach of a belted occupant would also be helpful.**

General Motors Engineering Staff

General Motors Technical Center, Warren, Michigan 48090

Date: May 16, 1966

Subject: 1969 GM Safety Design Goals - Body Design - No. 1 Pillar

To: Distribution List Attached

Instrument panels meeting the GM design goals for 1969 would protect the belted and unbelted occupants from serious injury at barrier impact levels of 30 mph. Doors and side structure are being improved to provide as much protection for occupants as is possible with the available dimensions (door thickness). Styling should blend the instrument panel energy absorption pad into the front door pad to avoid high impact loads at the door jam. Protection of the passenger or driver during impacts with the No. 1 pillar is being attempted by the addition of thin pads, but tests indicate that a greater degree of protection is desired. The most obvious is the use of shoulder harnesses; because these are not likely to be used by a large percentage of drivers in the next three to five years, alternate methods of protection should be considered. Redesign of the upper body structure to keep the No. 1 pillar forward of the swingline of a belted occupant should be considered. Unrestrained occupants would still contact the pillar, and it should be covered by effective energy absorption material (not pads). The styling studios have been advised of this problem area.

Alternate methods of accomplishing increased protection from the No. 1 pillar are solicited.

Louis C. Lundstrom

Louis C. Lundstrom, Director
Automotive Safety Engineering

jc

cc: H. F. Barr
W. L. Mitchell
E. N. Cole
E. D. Rollert
H. G. Warner

Inter-Organization Letters Only

May 16, 1966
1969 GM Safety Design Goals - Body Design - No. 1 Pillar

Distribution

Messrs.	L. ' . Kinrigh	Buick Motor Division
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	A. F. Underwood	Research Laboratories
	P. Kyropoulos	Styling Staff
	J. S. McDaniel	Styling Staff
	K. A. Pickering	Styling Staff

May 17, 1966
General Technical Committee

Automotive Safety Engineering Items

I. Fisher Body Report - 1967 Rearview Mirror

II. Areas of Responsibility and Program Coordination

III. Vehicle Energy Absorption (Front and Side) Versus Interior Energy Absorption

IV. Steering Wheel Designs - 1968 Models

V. No. 1 Pillar Location and Protection

VI. Foreign Car Impact Tests

VII. General Services Administration Items for 1967

VIII. Bumper Requirements

* * * * *

General Motors Proving Ground
Safety Test Engineering
May 9, 1966

ANALOG SIMULATION OF A SIDE IMPACT COLLISION

The model used in the analog simulation is shown in Figure 1. It consists of a 4400 lb bullet car traveling at 30 mph impacting into the side of a 3700 lb target car restrained by tire friction force of 2500 lbs ($\mu = .67$). An occupant is inside the target car a given distance from the inside of the door.

The crush rate of the bullet car is a representative curve determined from barrier tests. The exterior of the target car has a crushable structure and the interior is provided with energy absorbing crush material. Both the exterior and interior crush rates are of a square wave nature, that is, both crush with a constant load until they bottom out. When they do bottom out the crush rates are assumed to change from square waves to that of stiff linear springs with spring rates of 100,000 lb/in. for the exterior and 30,000 lb/in. for the interior.

To facilitate analysis the exterior and interior crush distances are kept separate by an interface. This interface prevents the external deformation from altering the interior occupant-door geometry. While this is not true in an actual side impact with present vehicles it does approximate the preferred case of no penetration.

The occupant is simulated by a 90 lb block torso and hence the quoted acceleration values best correspond to what would be lateral chest accelerations. This simulation of course precludes any consideration of the head and its interaction during the collision.

GTC660517.00000058

ANALYSIS OF A SIDE IMPACT

Initially the target car is at rest with the occupant some given distance from the door. At impact the target car is accelerated sideways. Neglecting seat friction, the occupant remains stationary as the car is accelerated out from under him. A few milliseconds later the car door contacts the occupant. At this time, the target car has some velocity which is dependent upon the occupant's original distance from the door. The greater the distance the larger the velocity at impact (Figure 2). This impact velocity is the major factor in high occupant accelerations (a minor portion is due to the continuing acceleration of the target car itself). Reducing the occupant distance from the door results in lower acceleration values but after a point it is not practical. Even at one inch from the door the velocities are such that the acceleration values remain above general human tolerance levels.

The next solution is to formulate the crush rate of the exterior structure such that the velocity of the target car at occupant-door impact is a minimum. This should result in minimum occupant acceleration. Unfortunately, with reasonable exterior crush distances, the peak occupant acceleration is not appreciably altered. Increasing the crush distance from 1 in. to 12 in. reduces the peak occupant acceleration by only about 15%, probably not enough to insure occupant protection (Figure 3). The side friction and inertia of the target car prevent it from moving any significant distance before the exterior structure bottoms out. Increasing the force level of the exterior crush, such that the structure does not bottom out, is equally ineffective. The required crush rate is so high that all advantages of a crush structure are lost.

The best solution appears to be energy absorbing material on the inside of the car. The presence of proper energy absorbing padding can reduce the peak occupant acceleration to tolerable levels (Figure 4)[1]. However, this padding, to be effective, must be of the proper stiffness. If it is too soft, readily permitting the occupant to bottom out, then the g load goes up as the depth of the padding is increased (Figure 4). This is because soft padding serves only to increase the effective occupant distance from the door, resulting in a correspondingly higher impact velocity. The lowest crush level at which the occupant will no longer bottom out is the optimum value. Increasing the stiffness of the padding beyond this level again increase the g load because now full use is not being made of the available crush distance.

[1]The load values of interior crush referred to in Figure 4 are total values corresponding to approximately 20 psi for the side area of an average upper torso if the entire side is supported.

CONCLUSIONS

1) For reasonable distances of external crush (twelve inches or less) external energy absorbing structure is ineffective in reducing peak occupant acceleration.

2) Moving the occupant closer to the door reduces the peak occupant acceleration.

3) Proper interior energy absorbing material can reduce the peak occupant acceleration to tolerable levels.

4) Interior energy absorbing padding which is too soft can contribute to high occupant acceleration values by bottoming out and thus effectively increasing the occupant distance from the door.

J. E. Lahiff
Safety Test Engineering

GTC660517.00000061

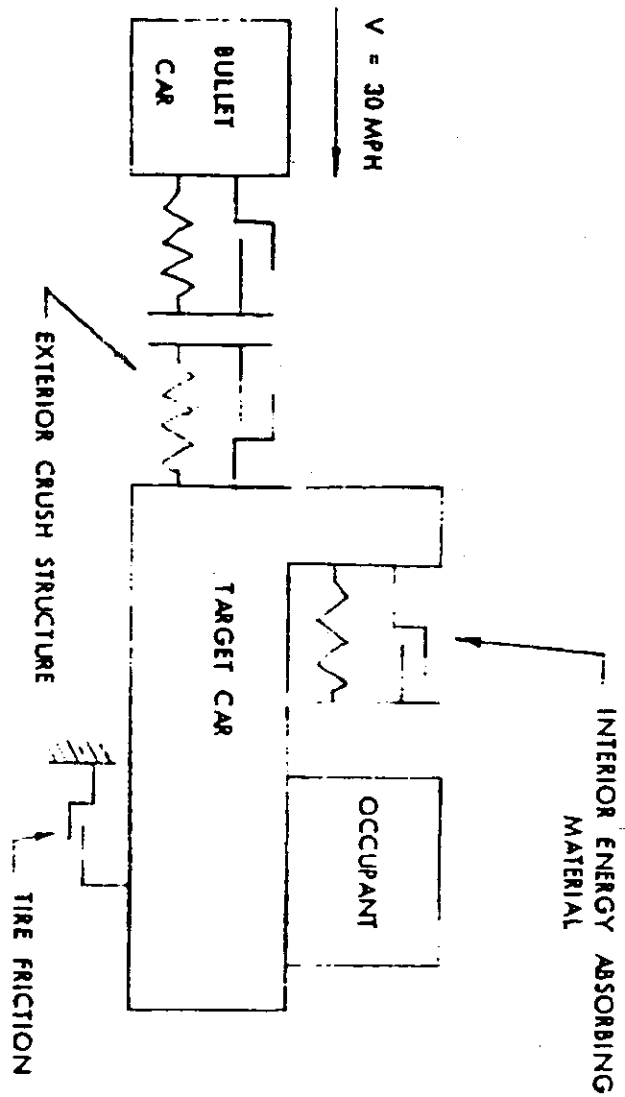

FIGURE 1

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GTC660517.00000062

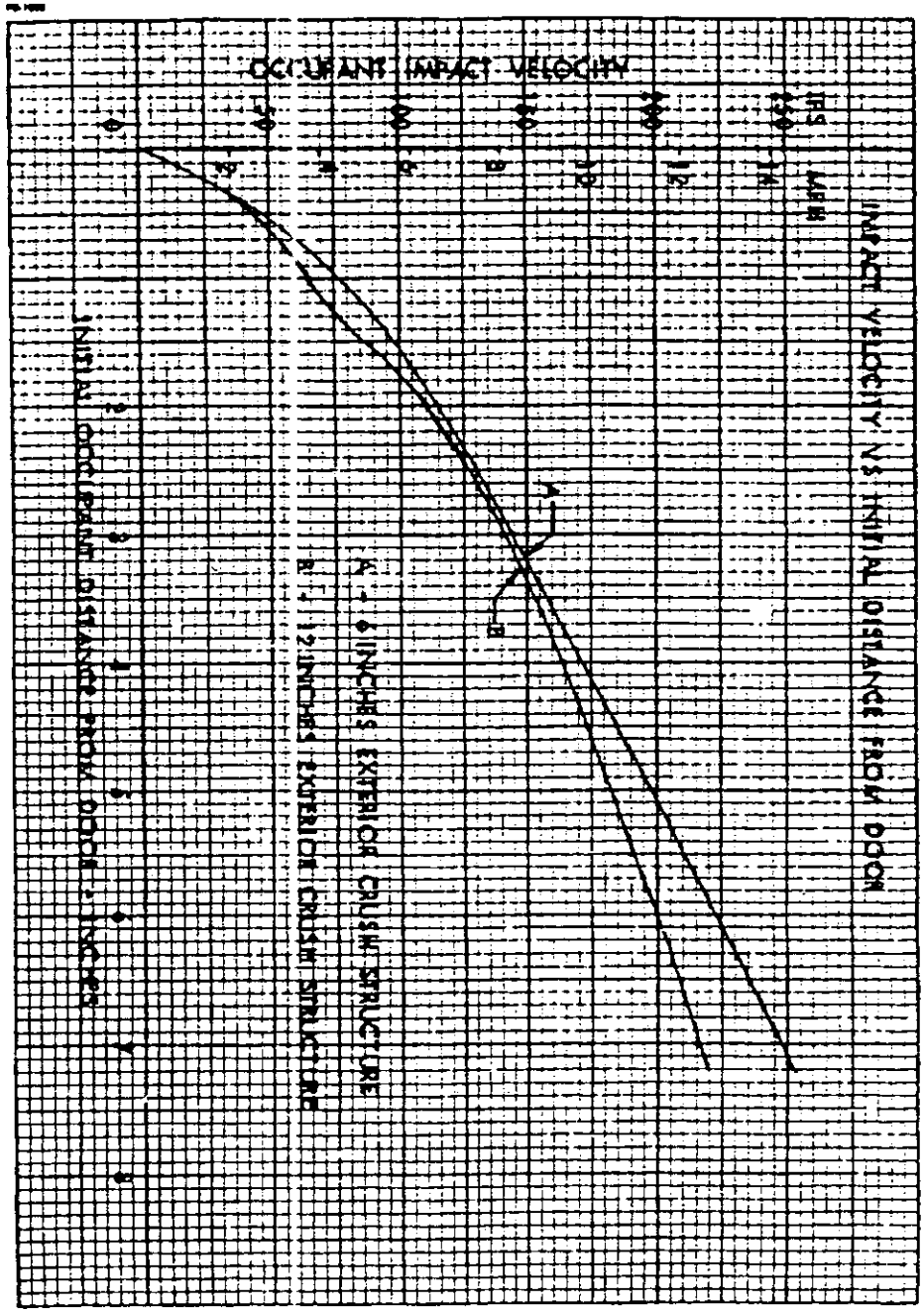


FIGURE 2

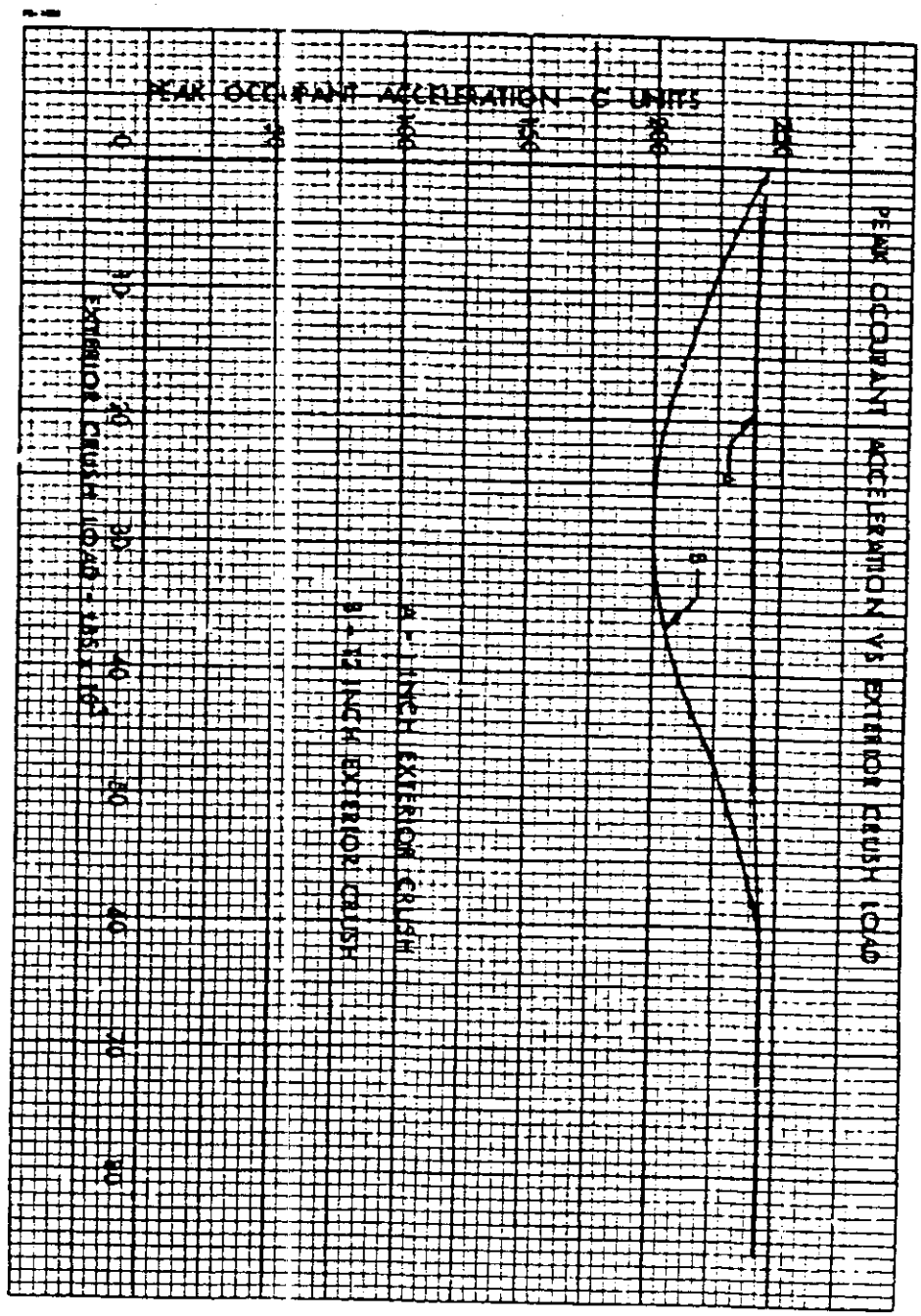


FIGURE 3

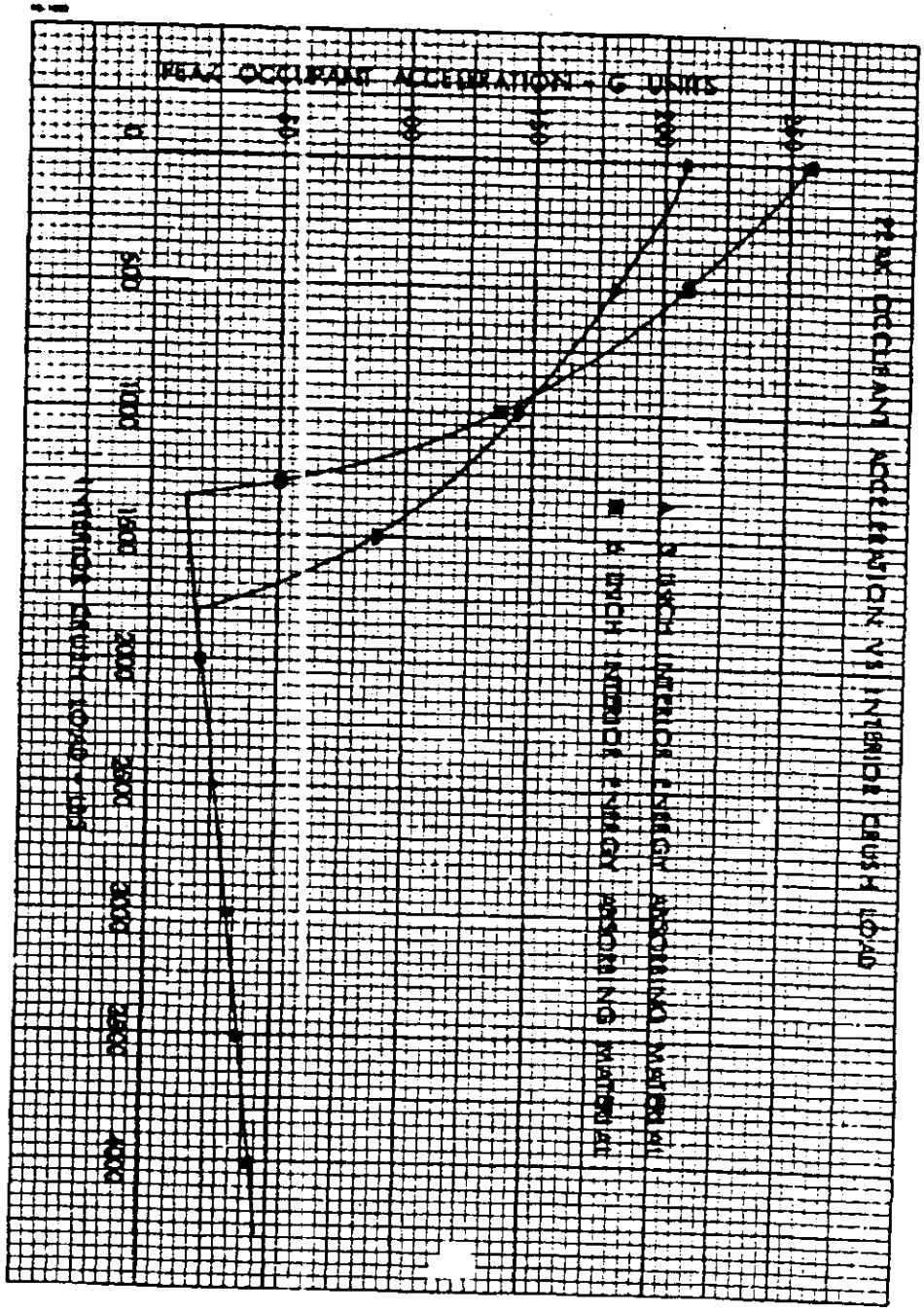


FIGURE 4

GM

Date: 5-13-66

Time:

To: Ken Brooker

From: Bill Kolbe

I hope this will serve your purpose for the General Technical Committee minutes. If not please let me know

GTC660517.00000066

BIMETAL ACTUATED VACUUM REGULATOR

FOR AUTOMATIC TEMPERATURE CONTROL

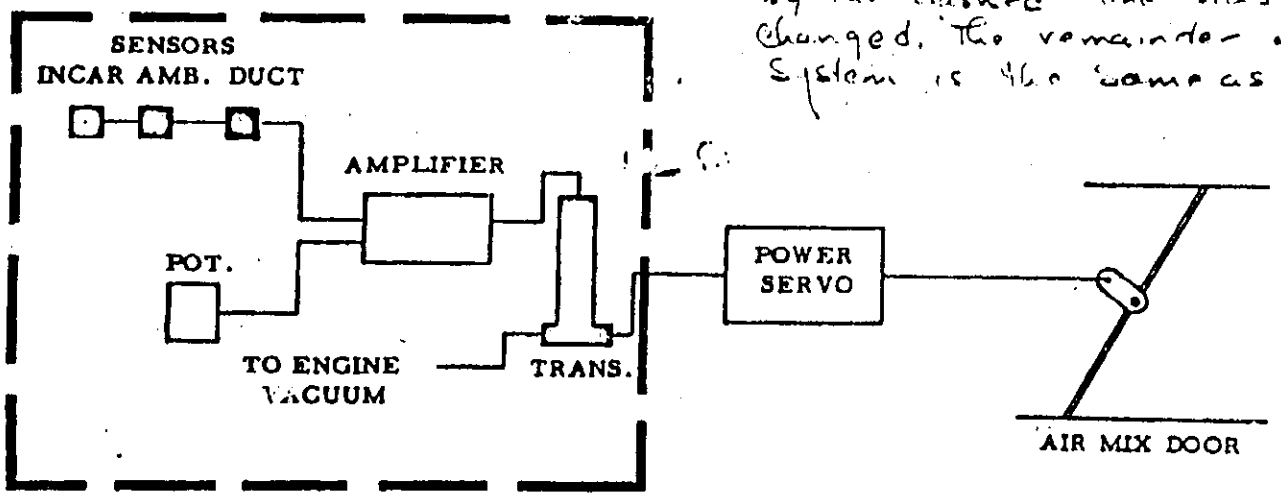
AIR CONDITIONING SYSTEMS

SLIDE #1

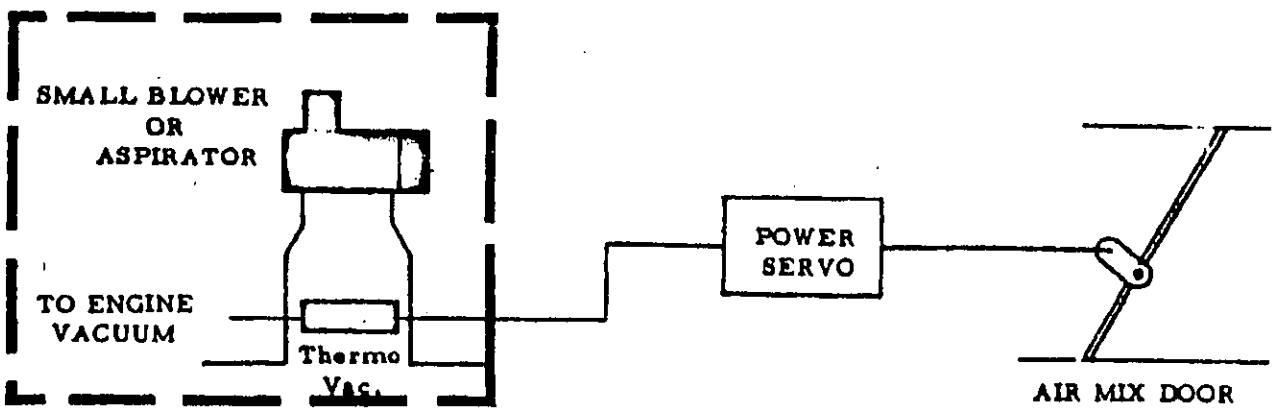
GTC660517.00000067

AUTOMATIC TEMPERATURE CONTROL
PRODUCTION SYSTEM

Note: Only the sensing circuit outlined by the dashed line has been changed. The remainder of the system is the same as production



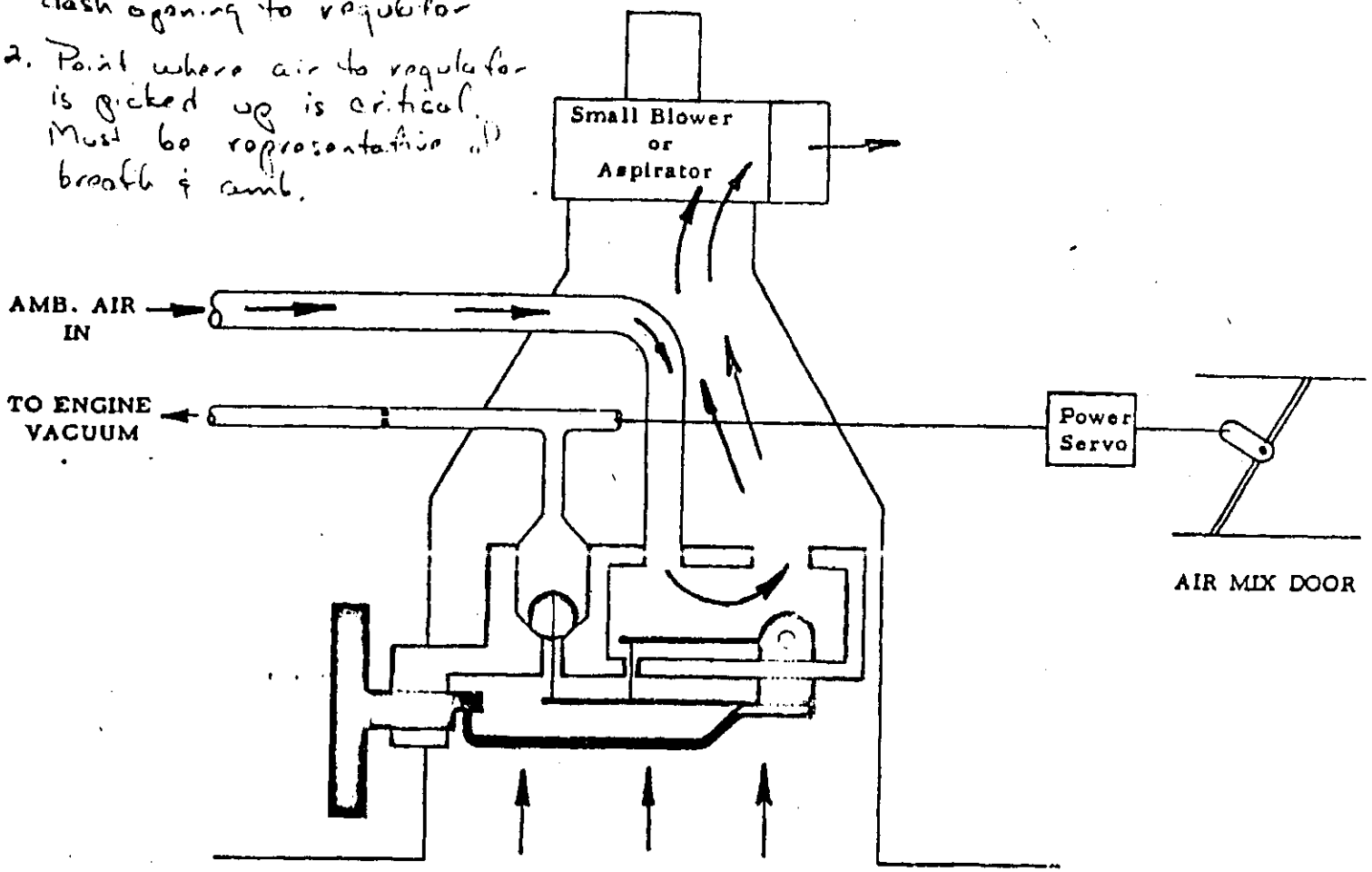
EXPERIMENTAL SYSTEM
BIMETAL ACTUATED VACUUM REGULATOR



Items: 1. Mounting is flexible - can be mounted at control head with insulated tube from dash opening to regulator

2. Point where air to regulator is picked up is critical. Must be representative of breath & amb.

AUTOMATIC TEMPERATURE CONTROL
THERMO-VAC



Sheet #3

ADVANTAGES OVER PRODUCTION SYSTEM

- LOWER COST
- SIMPLER
- REDUCED WARRANTY
- IMPROVED PERFORMANCE

(By) Fewer parts, simpler wiring harness and control head. – estimate $3 to $6/car depending upon whether a blower or aspirator is used – est. prod @ 300,000 units this year. $1.5 million savings to corp.

→ through simplicity, more understandable unit and service circuit in one package.

→ Eliminates the flare to high blower when the system is started and for in car temperature is 72°F to 75°F.

SLIDE #8

STATUS

- CAR TESTS
- ACCESSORY DIVISIONS

→ Car tested in Detroit, Florida, Colorado & Phoenix Ariz temperature range from -10 to +98° & altitude from sea level to Pikes Peak

Cadillac & Harrison representatives who participated in the test trips said the system was as good or better than the production system.

→ Development turned over to Harrison & Delco Radio — Both have development programs in process. Harrison Radiator, Delco Radio & Engineering Staff have cars at the DPG to demonstrate to the A. Committee Subcommittee

Slide #5

Neils Muench

SUMMARY: A new heat treatment was described which eliminates the upper yield point from rimmed sheet steel (GM grade 1E) and gives it the drawing characteristics of premium grade, 5E, (aluminum-killed) steel at considerably reduced cost. Subsequent aging results in improved strength of parts made from treated low grade steel as compared to parts made from aluminum-killed steel.

GTC660517.00000072

FROM THE DESK OF
V. D. Polhemus
Engineering Staff

FOR YOUR INFO ☐
IN REPLY ☐
PLEASE ANSWER ☐

Date 5-17-66

TO Mr. J. Brooker

Copies of Mr. Polhemus'
notice — G.T.C. 5/17/66

Eileen

GTC660517.00000073

(1)

One BOP Division has requested permission to discontinue the use of 6.95-14" tires on all "A" body vehicles — replacing those used with 7.35-14". This would apply primarily to the 6-cylinder non-air-conditioned vehicles -- as most V8's and airconditioned models are already on 7.35-14" tires.

This request is based on an anticipated increase of from 40 to 50 pounds in the 1967 vehicle weight; this addition is the result of —

1. Increased body weight
2. Additional safety items
3. Modification of option requirements.

With this anticipated weight increase added to all "A" body vehicles presently on 6.95-14" tires, then each division would have to upsize as follows:

Pontiac	56%	of their models
Buick	72%	" " "
Olds	20%	" " "
Chevelle 6	none	" " "
Chevelle V 8	50%	" " "

This upsizing would then comply with the T & SA requirements.

GTC660517.00000074

ED LINE TIRES

Even though the red line tire question has been settled for the time being, the Tire Task Force of the VSSC was asked to formulate a recommended policy for optional tires.

The subcommittee voted unanimously to recommend that no division supply as an option on any particular vehicle a lower performance rating tire than the base tire.

GTC660517.00000075

ED LINE TIRES

Even though the red line tire question has been settled for the time being, the Tire Task Force of the VSSC was asked to formulate a recommended policy for optional tires.

The subcommittee voted unanimously to recommend that no division supply as an option on any particular vehicle a lower performance rating tire than the base tire.

1965 6 [illegible] & [illegible] ASSOCIATION YEAR BOOK

PROPOSED REVISION NO. 3 — TIRE LOAD TABLES, PAGE T-02

EAC.

Maximum cold inflation pressure of 4 ply rating tires is 32 psi and of 8 ply rating tires is 40 psi. For sustained high speed driving – over 75 mph – cold inflation pressure must be increased 4 psi, but not to exceed the maximum of 32 psi for 4 ply rating tires and 40 psi for 8 ply rating tires. Where the 4 psi pressure adjustment for sustained high speed with maximum vehicle load would require inflation pressures above the maximum allowable, speed must be limited to 75 mph.

EAC.

1. TIRE WEAR INDICATOR

2. NO CALCULATIONS TO BE REQUIRED AT ANY LEVEL OF TIRE WEAR

3. RECOMMENDS THAT NO CALCULATIONS BE REQUIRED ON ANY TIRE INSTALLED AS A FACTORY OPTION.

DISCUSSION: STATIC TIRE WITH MAX. LOAD CAPACITY [illegible] MAY BE USED TO ELIMINATE [illegible]

GTC660517.00000077

GTC660517.00000078

1967 GM ORIGINAL EQUIPMENT TIRE SUMMARY

[illegible]

Date	Released for Production	Ride & Handling [illegible]	Ride & Handling Pending	High Speed Approved	High Speed On Test	High Speed Ordered	Durability Approved	Durability On Test	Durability Ordered
5-16-66	3	33	24	4	12	16	3	22	6

6

GTC660517.00000078

GTC660517.00000078

General Motors GM Proving Ground

- ☐ For your information
- ☐ For necessary action
- ☐ Please review and comment
- ☐ In accordance with your request
- ☐ For your files
- ☐ Please return

To: KEN,

THIS COVERS MY TOPIC AT GTC

Ed Wilson

GTC660517.00000079

FOREWORD

On May 13, 1966, a meeting was held to review energy absorption work currently being conducted within General Motors.

The following people were in attendance:

G. Bailey	Buick Motor Division
D. H. Bratton	Chevrolet Motor Division
E. DeFusco	Chevrolet Motor Division
R. G. Rhoton	Chevrolet Motor Division
V. D. Valade	Chevrolet Motor Division
J. Anderson	Defense Research Laboratories
A. Rydquist	Defense Research Laboratories
K. R. Vincent	Defense Research Laboratories
H. A. Wilcox	Defense Research Laboratories
T. M. Fisher	Engineering Staff
O. K. Kelley	Engineering Staff
L. C. Lundstrom	Engineering Staff
K. A. Stonex	Engineering Staff
F. J. Winchell	Engineering Staff
D. Clark	Fisher Body Division
F. C. Skeels	Proving Ground
D. L. Veenstra	Proving Ground
R. A. Wilson	Proving Ground
J. P. Danforth	Research Laboratories
C. W. Gadd	Research Laboratories
L. Johnson	Research Laboratories
W. F. King	Research Laboratories
D. E. Martin	Research Laboratories
W. M. Spreitzer	Research Laboratories
G. Barrett	Styling Staff
L. L. Howson	Styling Staff
K. B. Kelly	Styling Staff
P. Kyropoulos	Styling Staff
B. Martens	Styling Staff
R. McLean	Styling Staff
A. J. Sobey	Styling Staff

DISCUSSION

The serious groups represented discussed current analytical and experimental work in energy absorption.

Styling Staff - (A. Sobey)

The development of safety computer programs at Styling has proceeded to the point where it is possible to predict and illustrate in graphic form the movement of the passenger during frontal collisions of specified severity. These programs are being used in studies of alternate shapes for the 1969 "B" series dash and instrument panel.

Present activity is directed toward the completion of the "Level 1" capability for the program. This essentially consists of modifications to the program purchased from Cornell in September, 1965. The present goal is to develop a production tool for the use of design studio engineers. Improvement of output representation includes graphical display of the occupant and his trajectory using either a digital drafting machine or the CRT plotter on the IBM 7094 at Research Laboratories. A movie film clip was shown to demonstrate the latter. Present work on the program also includes simplification of the input and improvement of the representation of both the occupant and the vehicle interior.

Experience with the program has indicated the need for additional information concerning the properties of typical dashboard materials and construction techniques under dynamic load. Additional information on the physical characteristics of human subjects is also needed. Specifically, the data required is:

1. Crash Characteristics - Crush rate of overall vehicle, change in attitude of seat, rate of deceleration.

2. Materials - Force-deflection relationships for various typical materials (constant velocity during impact), loading and unloading characteristics.

3. Structures - Force-deflection relationships versus rate of impact for typical dash construction.

4. Human resistance forces - Joint friction, braced and unbraced grip forces, hand on wheel.

5. Injury Limits - Bone breakage forces, internal injury force limits.

Defense Research Laboratories - (A. Rydquist, J. Anderson)

For the area of energy absorption, the Defense Research Laboratories are primarily involved in the investigation and development of experimental devices and materials, individually and in aggregates. Specifically, devices and materials under consideration are:

1. Water-filled bumper
2. ~~Inner-tube~~ INVERTIBE
3. Polyurethanes
4. Honeycombs

As an aggregate, an arrangement using a water bumper and ~~inner-tube assembly~~ INVERTIBE should adequately absorb energy for impacts below 10 mph. For impacts below 5 mph, the bumper dissipates energy without any permanent deformation; between 5 and 10 mph, the ~~inner tubes~~ invert and must be replaced, but no other part of the car is damaged. An energy absorbing aggregate such as this, requires a much stiffer vehicle frame than is presently used.

An impact testing machine is scheduled for installation by the end of May, 1966. It will be capable of impacts at speeds up to 60 mph or loads up to 5000 lbs.

Mathematical models of energy absorbers are being formed. The model for the water bumper shows that there is considerable design freedom in choosing cross-sectional shapes and holes.

A permanently inflated instrument panel was considered as an energy absorber, but upon analysis, it appears that such an arrangement would store energy instead of dissipating it.

The Cornell occupant simulation computer program was used to evaluate complete restraint systems (lap and shoulder belts). Belt loads resulting from a 30 mph barrier collision may be reduced 30% by changing the front crush characteristic from the present production condition to a constant deceleration level. The advantage of the constant deceleration decreases with decreasing impact speeds; there is no advantage at 15 mph, and the constant deceleration gives higher belt loads at speeds below 11 mph. Belt loads may also be reduced 50% by allowing the anchorages to yield at about 1500 lbs.

Research Laboratories (D. Martin, J. Danforth)

Research Memorandum 34-1527 discusses the potential advantage of altering the vehicle structure to provide a constant deceleration crush characteristic instead of a linearly increasing deceleration characteristic. For a 30 mph barrier impact, an unrestrained or lap-belted occupant will experience a 4% reduction in head impact velocity with the constant level; a completely restrained occupant will experience a 25 to 30% reduction in belt load. The ~~study failed to indicate~~ [revised] study indicates realistic conditions under which constant deceleration would be disadvantageous to the striking car. However, severe intrusions will be imposed on the ~~struck car~~ [side] [struck] car by a car whose front end has been stiffened for constant deceleration, ~~unless the side of the struck car has also been stiffened~~. As a result, current engineering knowledge does not justify an immediate and radical redesign of the vehicle. The tailoring of exterior crush characteristics should be approached cautiously and should begin with the side structure.

The Wayne State University impact sled facility has been used to verify the Cornell computer program using cadavers.

Crush characteristics of instrument panel elements have been evaluated by dropping a headform on the panel. A thin covering of soft padding was found to increase possible injuries by enlarging the area of contact and thereby requiring a larger total force to deform the panel.

Work is being continued to extend the range of validity for calculation of injury numbers beyond the present 2 to 50 millisecond pulse duration. An injury number program is now available on the GE-265 time-sharing computer (GADDNO++)

Direct digitizing of acceleration-time curves is available using the DAC facility. FORTRAN programs using this digitized information are now being written.

Proving Ground - (R. Wilson)

An analog computer study has been made to determine how to best protect the occupant in side impacts, assuming that there is no penetration into the target car. Within reasonable size limitations, peak occupant accelerations may be reduced only 15% by utilizing external crush. Greater gains may be realized with a stiff exterior and a padded interior. Interior padding should be stiffer than necessary to insure that it does not bottom out. Padding which is too soft effectively increases the distance of the occupant from the door and allows him to gain a higher relative velocity before contacting the solid surface.

The Proving Ground has also been working with the Cornell occupant simulation program. An energy absorbing steering column has been included, and work is presently proceeding on improving the model of the man and adding a model for a steering wheel.

The modified Cornell program has been used to study the effects of various types of front crush characteristics. For a totally restrained passenger, a constant vehicle deceleration was found to be the best. The cases involving an unrestrained or lap-belted passenger are more involved, however. With present interior geometry and front structure, the car is stopped

when the occupant strikes something. Therefore, it does not matter how the car is stopped. This situation could be improved by extending the time duration of the impact or by positioning the contact surfaces closer to the occupant. A way of extending the duration of the impact without increasing the total crush distance is to give the car a high initial acceleration to get the occupant moving relative to the car and then a low acceleration rate while he meets the car and rides the car to a stop. There may be some problems in low speed impacts with high initial acceleration, but they should be no worse than under the present condition.

Present automobile structure appears to be adequate for front impacts, provided the passenger compartment geometry is not altered by the impact. Interior crush initially is much more valuable than alteration of exterior characteristics.

Fisher Body Division - (D. Clark)

Current work in energy absorption is experimental and is mainly directed toward compliance with the General Services Administration requirements. Areas of activity include material evaluation, instrument panel energy absorption, and shoulder restraint. Some experimental work is also being done with shoulder belt anchor location.

Inland Manufacturing Division is also involved in material and instrument panel evaluation. Contact Bob Forward at Inland for experimental force-deflection data of materials which have been tested.

Following the discussions by the various groups, some additional comments were made:

C. W. Gadd — The industry and SAE are beginning to accept the injury number concept. Work is continuing to extend its range of validity.

A. J. Sobey — The possibility of pedestrian injury should also be considered. The Cornell program can be useful in this field by having a proposed shape strike a standing man. Rather than attempting to simplify the Cornell model, it must be made more complex in order to obtain a more valid representation of what occurs in a collision. The program is presently being streamlined and the integration package has been rewritten for a slight gain in running time.

R. A. Wilson — There are some advantages and some disadvantages to the Chemcor glass now being used in windshields. It has good laceration properties and will retain an occupant at higher impact speeds, but it also gives higher decelerations upon impact.

C. W. Gadd — Pop-out windshields should not be entirely thrown out of consideration. A pop-out windshield might allow head clearance for a lap-belted occupant. On the other hand, retention of the windshield is advantageous in the event of a roll-over due to the added strength. Furthermore, a pop-out windshield is poor for people external to the vehicle.

R. A. Wilson, D. L. Veenstra

A high initial front crush rate should be no worse at low impact speeds than the present condition. Perhaps a strain rate sensitive material is needed to reduce the severity of low-speed impacts. All divisions are not presently involved to a great extent in energy absorption work. Buick has been doing experimental work with structure and engine motion. W. E. McCarthy of Buick Motor Division has been investigating child restraint systems.

L. C. Lundstrom

It appears that front and side structure collapse rates should be made compatible.

O. K. Kellay

Side structure will be greatly improved by 1968 or 1969. It might be worthwhile to consider an exterior front design which would have the effect of changing a frontal impact to a glancing blow. There seems to be no reason for a revolutionary change in frame design; changing interior design would be much more valuable.

F. J. Winchell

A present criterion for bumper designs is that there should be no sheet metal deformation for straight-on or quartering impacts at speeds of 2 mph or less. Although this does not seem very severe at first, in actuality, it has been found to be very strict.

P. C. Skeels — Perhaps an instrument panel is needed which would be soft for light impacts but which would become stiff for higher velocity impacts.

C. W. Gadd — If the instrument panel were to be positioned nearer to the passenger, it would be possible to take advantage of the additional collapse distance available. In addition, the knees can take impact.

L. C. Lundstrom — Knee contact tends to force the body upward. On the other hand, considerable deflection in the contacting surface could force the body downward while absorbing energy.

[illegible] — No great breakthrough on front structure is seen for 1969. Fisher Body is presently working on side door strength.

O. K. Kelley — Door padding appears important, and work is presently being done in this area.

R. A. Wilson — It was the consensus of opinion of the group that met in the morning that more communication is needed among the people working on energy absorption. Consequently, it was decided that it would be a good idea to have meetings continued at six-week intervals.

O. K. Kelley — A fixed front seat may not be ready for 1969. Instrument panel structure will be improved.

Report No. PG-21773

L. C. Lundstrom

We ~~presently in trouble with~~ the "A" or Pillar

~~No~~ ~~Perhaps it~~ should have a steep slope so that any impact would result in a glancing blow. Moving it out of reach of a belted occupant would also be helpful.

V. D. Valade

The importance of complete restraint must be emphasized to the public. There is definite room for improvement in shoulder belt configurations in terms of convenience.

GTC660517.00000089