Automobile seat belt and injury reduction

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THE AUTOMOBILE SEAT BELT AND INJURY REDUCTION

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TABLE OF CONTENTS

I.	Introduction	1
II.	Accident Facts	5
III.	Epidemiology of Auto Accidents	32
IV.	Injury Cause	36
V.	Seat Belt Development	40
VI.	Seat Belt Effectiveness	49
VII.	Use of the Safety Belt	58
VIII.	Present Belts Versus Automatic Belts	64
IX.	The Seat Belt Syndrome	72
X.	Standards and Specifications	76
XI.	Seat Belt Ratings	80
XII.	Misconceptions and Questions	88
XIII.	Summary	91
XIV.	Conclusion	95
XV.	Bibliography	97

INTRODUCTION

Starting as a novelty at the turn of the century, the automobile has advanced from a toy for the rich to an indispensable adjunct to American family and industrial life. But within the past two decades, it has assumed another and more sinister significance.

It is now recognized as the most lethal instrument not forbidden by law in the hands of the United States public. It takes a toll in mained bodies, human lives and property damage unequaled by war or natural clamity. In the crucial age group of 5 to 24, it is America's number one killer. Yet this epidemic on the highways which has destroyed one and a third million lives, permanently crippled four million, robbed the nation of $90 billion in property loss and forebodes another million fatalities in the next 15 years if the present rate continues unabated. While there has been much research, comparatively little of it -- by the scientific criteria demanded by medicine -- is definitive or controlled. Outside of punitive measures for speed regulation, little effective legislation has been passed.

This current epidemic of traffic accidents should be viewed within the concept of preventive medicine. Man's perception of preventive medicine is dependent on the period of time and the geographic location in which he lives. It is also dependent upon his culture or subculture since different cultures exhibit wide variations in their concept of ability to control the obvious threats to health and life.

In the development of preventive measures, there are essentially three stages:[19] the stage when no scientific knowledge is available, the stage when there is scientific knowledge available but it is not being applied by a significant number of the population and the stage when there is scientific knowledge which is being effectively applied.

Until recent years we were in the first stage in respect to poliomyelitis. Today we are still in the stage of not having the scientific means of preventing deaths from such diseases as pancreatic cancer, most leukemias, multiple sclerosis and many others.

The primitive reaction to such situations is either the adoption of a completely fatalistic attitude with the hope that the threat will not strike or the use of various mechanisms prevalent in the culture such as symbolic objects to ward off the danger. Such attitudes and actions are not inappropriate to the first stage when there is really no effective measure for dealing with the hazard.

Such behavior, however, is entirely inappropriate when a society is in the second stage, when there is knowledge which is not being effectively applied. This is the situation in which we find ourselves today in regard to automobile accidents. We are both the perpetrators and the victims of a cultural lag. A scientifically proved preventive measure, the seat belt, is not being applied and as a result there is needless loss of lives and occurrence of disabilities. The psychological attitude of fatalism and the acceptance of a feeling of helplessness in auto accidents contributes to the death toll and reinforces the attitude of fatalism, thus creating a vicious cycle.

If there were 5,500 needless deaths annually from polio, medicine would take action immediately. When motor vehicle accidents are reviewed, however, it becomes apparent that not only the average person driving his car along the nation's highways, but we in the field of medicine who practice in the prevention of disability and disease seem to share the fatalistic approach to this common hazard to health and life. By our own inaction, we have shown surprising apathy and lethargy in setting an example of effective leadership in preventive medicine. It is the responsibility of medicine to provide leadership in the community toward moving from stage two to stage three.

One of the first things to recognize about highway safety is that it involves a staggering complexity of interrelated factors. Swarming over the 350,000,000 miles of the U.S. primary and secondary roads are 70,000,000 machines operated by 82,000,000 drivers.[6] Each of them is capable of behaving under a constantly changing kaleidoscope of circumstances in an unpredictable manner.

Although the analysis of the human factor in highway safety is complex, one safety authority finds one thing encouraging in that there are only two models of the human body currently available with no immediate prospects of a new design; therefore, any findings in this research should provide permanent standards.[32]

The human factor, however important, is only one element in the intricate configuration of automotive crashes. Many investigators insist that too much stress is laid on human variables, often so subtle as to defy analysis or so intangible as to preclude control. Design failure they believe, plays a greater part than is commonly known. How well, they ask, is the standard American vehicle designed to minimize the possiblity of mishap? Could it not be built to make driving less susceptible to human failure? Or, when collision does occur, how effectively does it protect occupants against trauma?

The automobile industry is the only one whose product can still be sold after killing thousands and injuring millions of its customers each year. They design the cars and then tell the occupant to adapt himself to them as best he can. It is with one of the methods of his efforts to adapt that this thesis in concerned — the automobile seat belt.

ACCIDENT FACTS

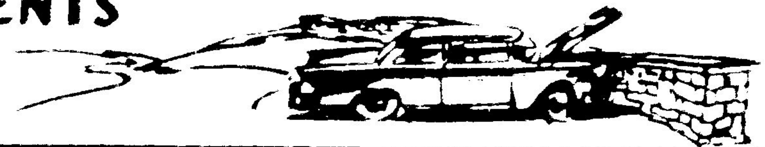
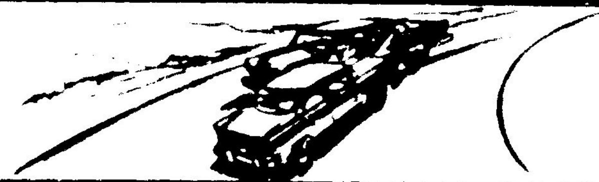
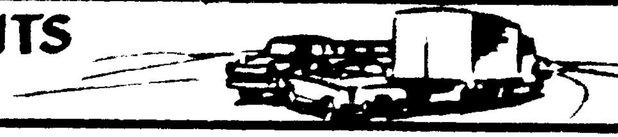
Since 1953 Automotive Crash Injury Research (ACIR) of Cornell University has collected, processed and analyzed approximately 25,000 case reports on automobiles involved in injury-producing accidents. These data have been collected as a part of a continuing interstate program to determine the cause of injury in automobile accidents so that ultimately those injuries might be prevented or mitigated through the design of safer cars.

The following information was based on data collected through random sampling plans designed to provide representative injury-producing accident data from a number of states. Tabulations are based on a total of 11,892 cars involved in injury-producing accidents; 1,807 collected between 1953 to 1955 and 10,085 collected during the period 1956 to 1959.[14]

The most significant figures gained from this study (Fig. 1-13) are:

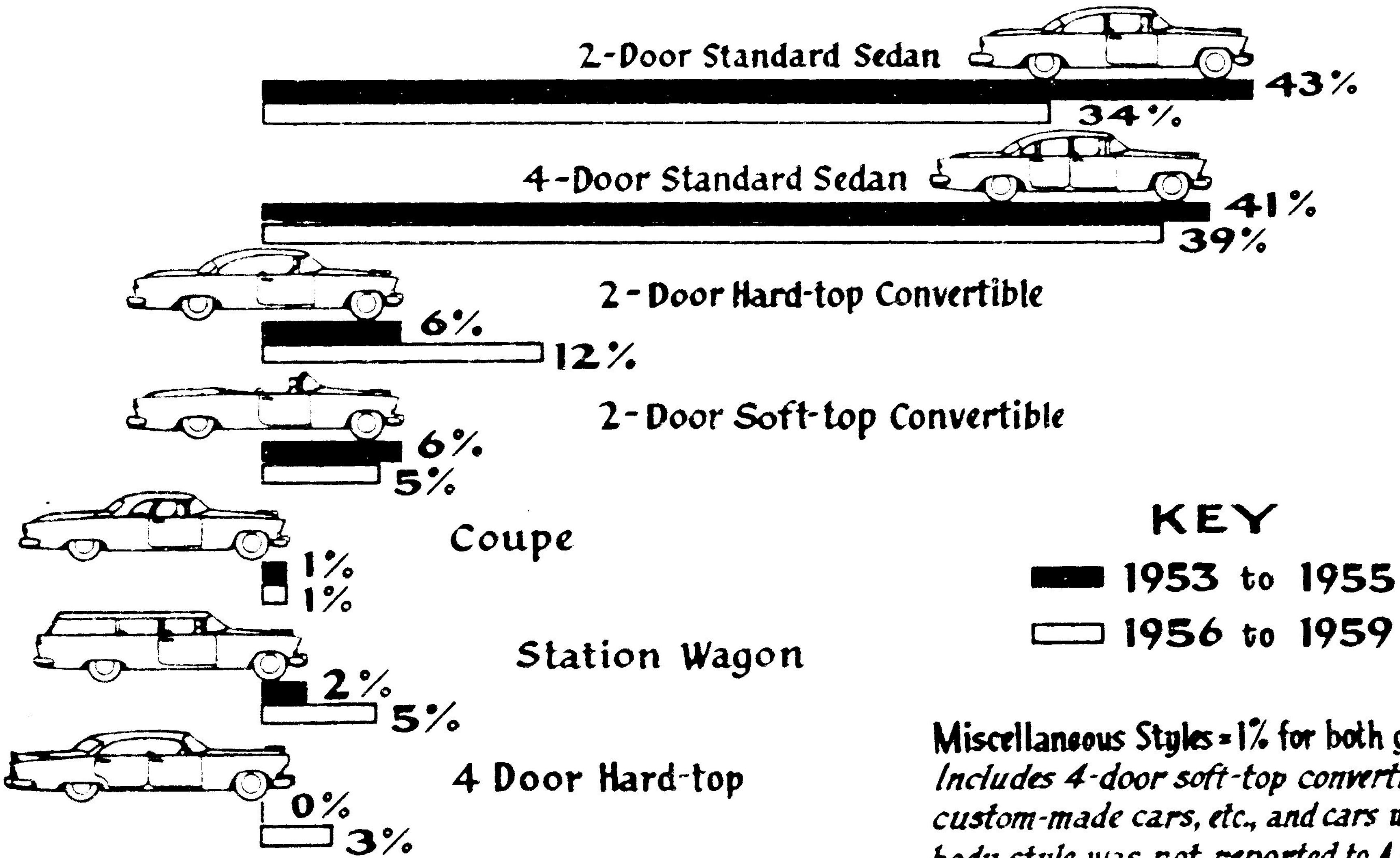
1. 52% of the accidents were one-car accidents.
2. The average traveling speed was between 45 and 50 mph.
3. One or more doors was jolted open in 45% of the collisions.
4. Passenger or driver ejection was present in 45% of the accidents.
5. The head and chest were the most frequently injured body regions.
6. The injury ration of ejectees to non-ejectees was about 5:1.

Type of Accident

Type of accident		1953 to 1955	1956 to 1959
***One* CAR ACCIDENTS**			
Collision with immovable object		16%	17%
Collision with partly movable object		5%	6%
Rollover without collision		26%	25%
Rollover after collision with object		3%	3%
Other (miscellaneous) *one* car accidents		3%	1%
***Two* CAR* ACCIDENTS**			
Car to car simple collision		35%	38%
Car to car or vehicle-complex collision		8%	5%
***Three or more* CAR* ACCIDENTS**		4%	5%

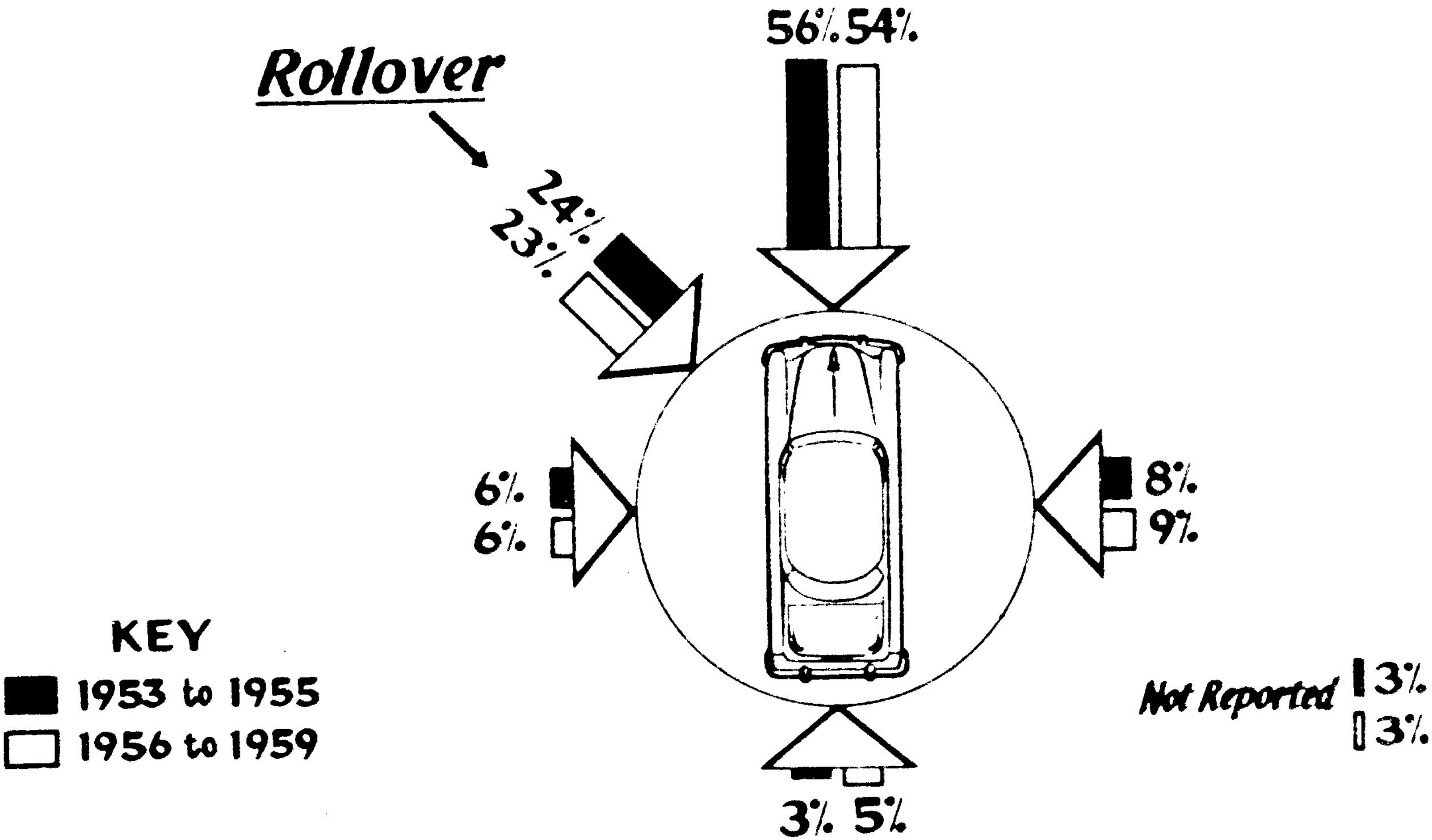
* *Each injury-producing accident studied involved at least one car, some of the accidents involved collision of car with car(s) or car with vehicle(s) such as trucks, busses, etc.*

Body Style of Cars

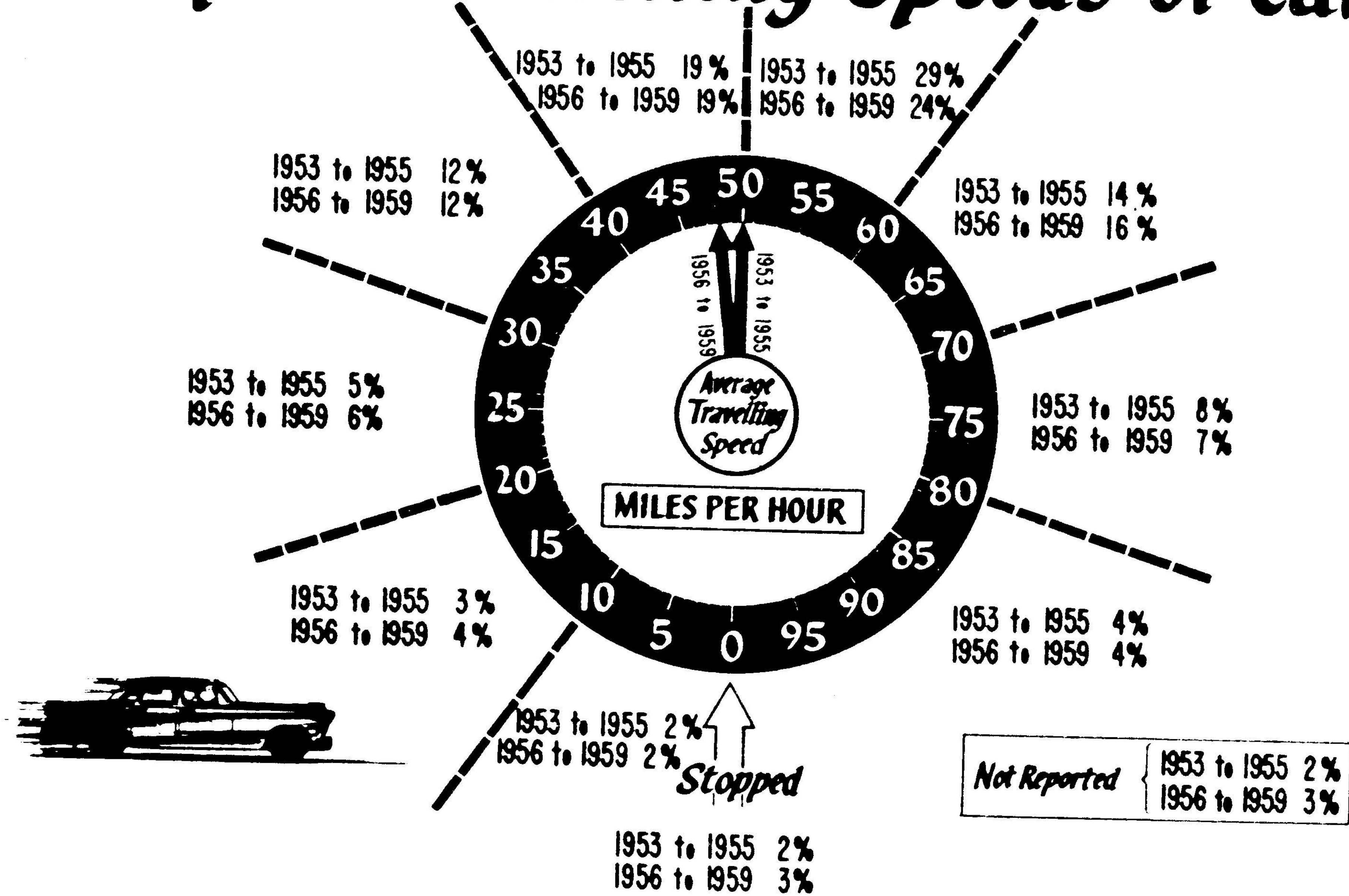


Miscellaneous Styles = 1% for both groups.
Includes 4-door soft-top convertibles, custom-made cars, etc., and cars whose body style was not reported to A.C.I.R.

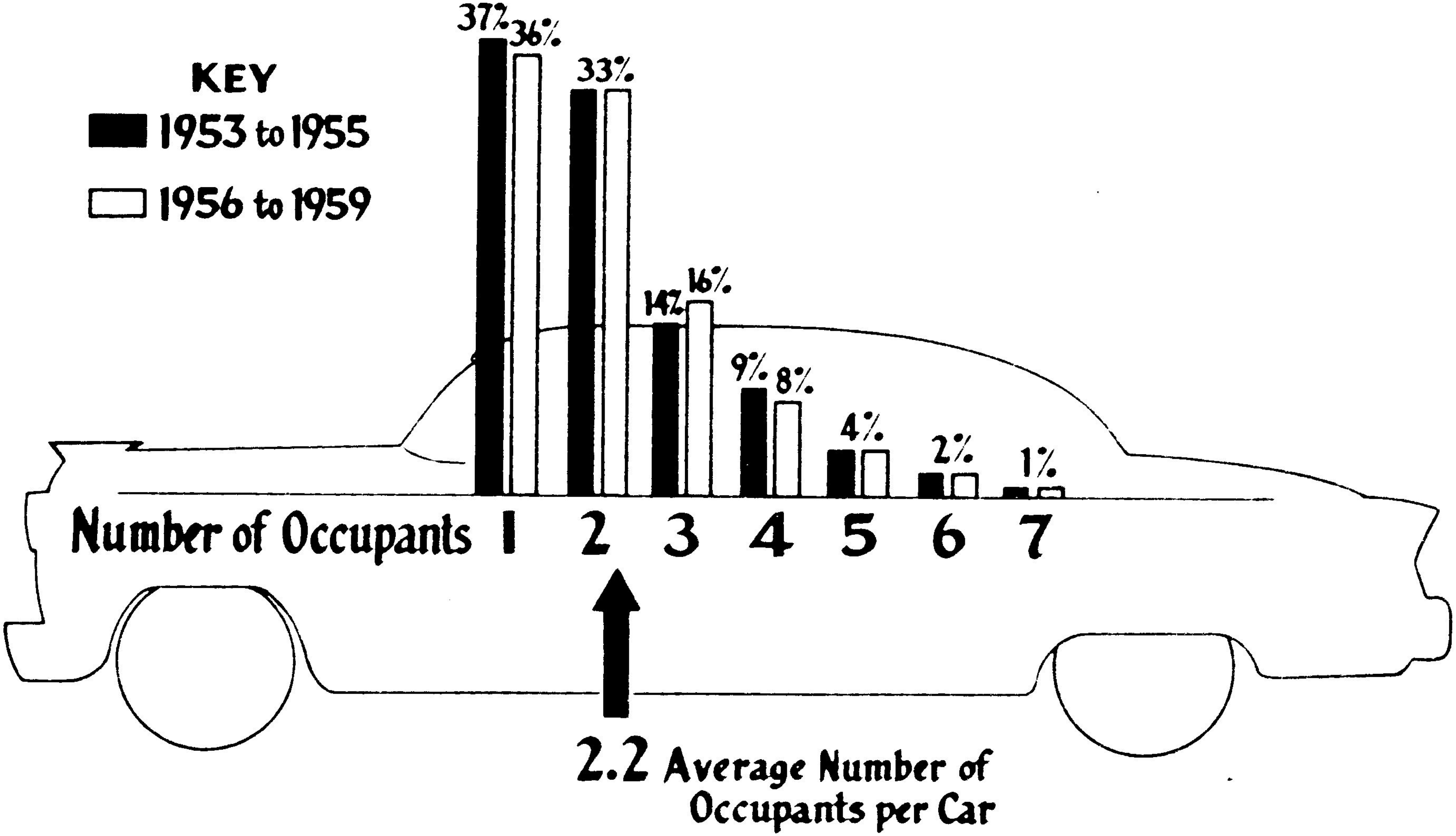
Direction of Principal Impact



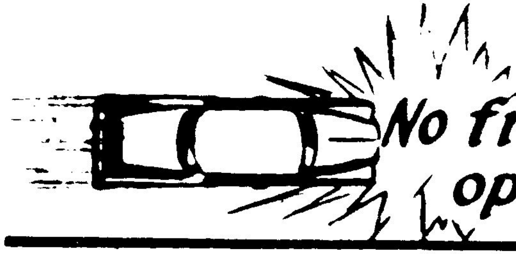
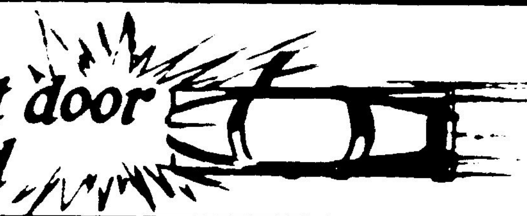
Reported Travelling Speeds of Cars



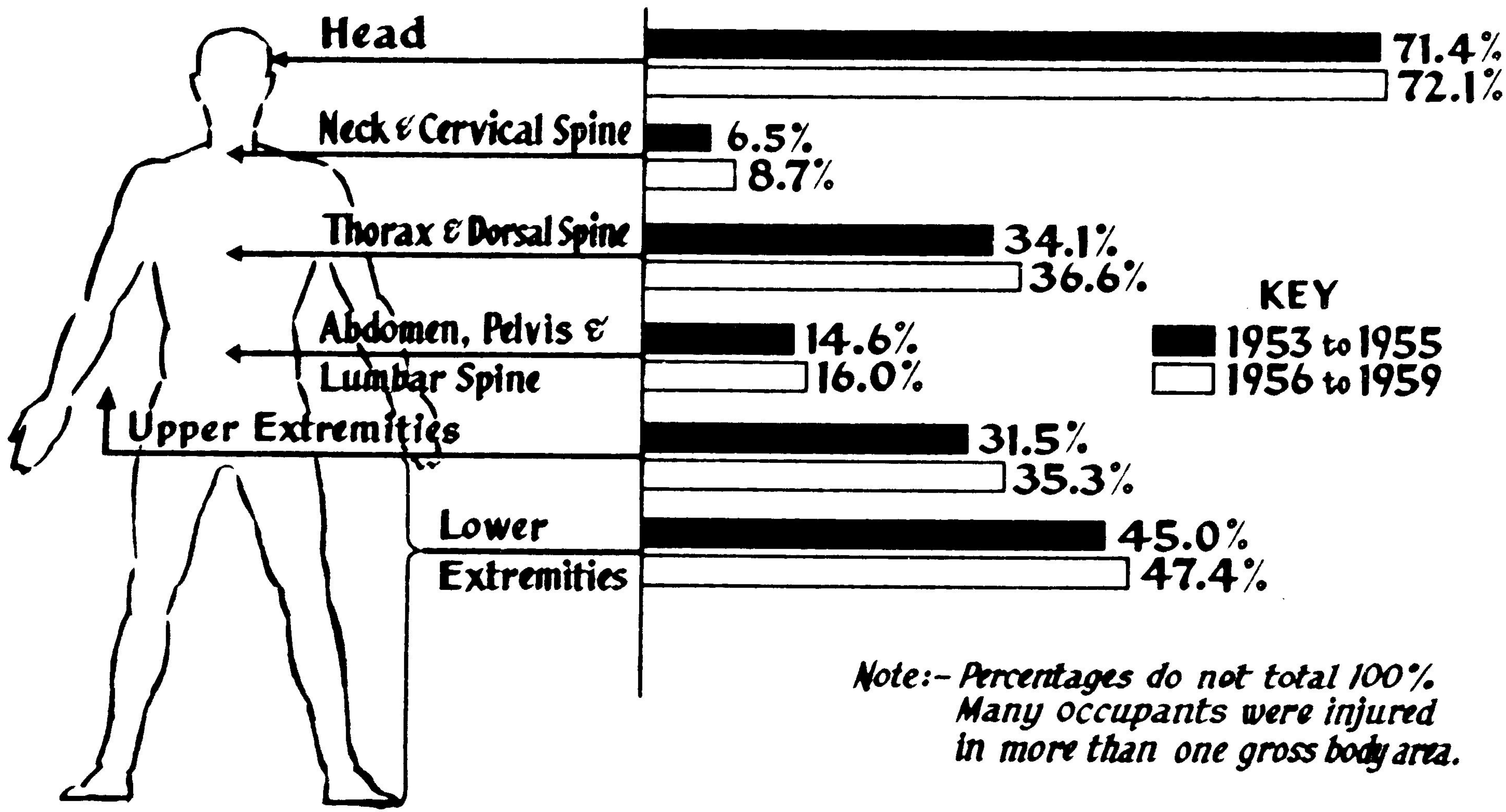
Number of Occupants in Cars



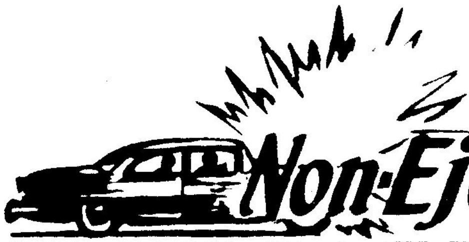
Frequency of *Front* Doors Opening under Impact Conditions

	2-Door Standard		4-Door Standard		2-Door Hard-top	
	1953 to 1955	1956 to 1959	1953 to 1955	1956 to 1959	1953 to 1955	1956 to 1959
 *No front doors opened*	48%	50%	51%	55%	47%	51%
 *One front door opened*	32%	29%	29%	28%	30%	30%
 *Two front doors opened*	15%	15%	15%	12%	18%	14%
Not reported	5%	6%	5%	5%	5%	5%

Frequency of Injury to Gross Body Areas



Risk of Injury as Related to Ejection or Non-Ejection



	% of Occupants with: Moderate-Fatal Grade		Severe-Fatal Grade		Dangerous-Fatal Grade		Fatal Grade	
	1953 to 1955	1956 to 1959	1953 to 1955	1956 to 1959	1953 to 1955	1956 to 1959	1953 to 1955	1956 to 1959
Non-Ejectees**	23.9	25.8	9.9	12.3	5.5	6.0	2.6	2.2
Ejectees*	49.9	54.7	36.4	37.3	26.6	25.3	13.3	12.2
Injury Ratio, Ejectees to Non-Ejectees	2.1:1	2.1:1	3.7:1	3.0:1	4.8:1	4.2:1	5.1:1	5.5:1

* *Occupants completely ejected from doors opened under crash conditions.*

** *Occupants who remained inside.*

Major Causes of Injury

1953 to 1955

% of Occupants Injured to:	Any Degree	Moderate-Fatal Degree	Dangerous-Fatal Degree
Steering Assembly	29.4	8.4	2.5
Ejection	14.6	6.9	3.2
Instrument Panel	20.6	4.2	.7
Windshield	16.9	4.6	.6
Backrest of Front Seat (Top Portion)	11.0	2.4	1.1
Door Structures	7.7	2.4	.5
Backrest of Front Seat (Lower Portion)	15.1	2.5	0
Front Corner Post	2.0	1.2	.7
Flying Glass	3.0	.5	.02
Top Structures	1.2	.6	.2
Rear View Mirror	2.2	.6	.02

7. The 5 most lethal parts of the car in order of their importance are:
    a. Steering wheel and column
    b. Ejection
    c. Instrument panel
    d. Windshield
    e. Back of the front seat

Each year in the United states for the past twenty years something over 38,000 people have been killed by the auto and something over 1,500,000 injuried annually. Stated otherwise, the auto has killed 64,000 more people in the fifty years of its existence than have all our wars put together. During the years of the Korean conflict, many more people were killed and injuried at home than became casualties in Korea. The Navy Department lost more men from off-duty auto accidents in Korea than they did from enemy fire. A life is lost due to the auto every fifteen minutes around the clock, day and night and every one-half minute someone is injuried here in the United States.[5]

For twenty seven years, the Travelers Insurance Company has published accident facts which have reflected the bare statistics that lie behind the pain, suffering and death that each year blanket the nation's highways. And each year these statistics have shown an increase in the evergrowing list of casualties. The year 1960 from which the following information is taken was no exception (Tables 1-14).

The increase in injuries during 1960 was up 7% over 1959 to a total of 3,078,000. Deaths increased by 1% over 1959 to a total of 38,000. More than 3,116,000 men, women and children were injuried or killed, a tremendous human and economic loss because the suffering and death of these three million Americans advanced no cause, served no purpose or taught no lesson. They occurred soley through a lack of concern for others through negligence, carelessness and indifference to traffic regulations and auto safety devises.[17]

This deadly reckoning of 1960 shows:

1. 38,000 deaths.
   400 more than 1959.

2. 3,078,000 injuries.
   208,000 more than 1959.

3. More than 1,000,000 casulties
   from speeding.

4. 14,900 deaths occurred on weekends.
   Almost 40% of the total.

5. More than 34% of the drivers involved
   in fatal accidents were under 25 or
   over 65 years.

6. Almost 84% of the dasualities occurred
   when the weather was clear.

7. More than 95% of the vehicles involved
   were in apparently good condition.

8. Saturday was the most dangerous day
   of the week.

The most significant figures form this data concern injuries rather than deaths. In 1960, deaths increased by 1% while injuries increased 7%. Thus while deaths remain fairly stable within a few hundred each year, injuries continue to mount topping 3,000,000 annually for the first time in 1960.

It has been the contention of many safety and medical authorities that the total number of casualties rather than the number of deaths should be the criterion by which the seriousness of this situation should be judged. Judging by deaths alone does not take into consideration the ever increasing number of injuries and the consequent suffering and economical loss. It is to be remembered that the apparent leveling off of the number of deaths has come about, not because of the motorist but in spite of them. Eighty-five percent of personal injury accidents still involve driving violations and the fact that deaths have not risen sharply in recent years is due largely to better and more prompt medical care, national educational programs and increased use of safety devices rather than care on the part of the drivers.

Table 1 — Types of accidents resulting in deaths

	Persons Killed	Per Cent	Persons Killed	Per Cent
COLLISION WITH:				
Automobile	15,000	39.5	13,720	36.5
Non-Collision	9,000	25.0	9,250	24.6
Pedestrian	7,600	20.0	8,200	21.8
Fixed Object	4,050	10.7	4,700	12.5
Railroad Train	1,300	3.4	1,150	3.1
Bicycle	430	1.1	500	1.3
Other Vehicle	80	.2	40	.1
Miscellaneous	40	.1	40	.1
TOTAL	38,000	100.6	37,000	100.0

The casualty count is riding high,
It's often the innocent that die.

Table 2 — Types of accidents resulting in injuries

	Persons Injured	Per Cent	Persons Injured	Per Cent
COLLISION WITH:				
Automobile	2,305,400	74.9	2,112,300	73.6
Non-Collision	304,700	9.9	278,300	9.7
Pedestrian	255,500	8.3	241,000	8.4
Fixed Object	147,700	4.8	175,100	6.1
Bicycle	52,300	1.7	51,700	1.8
Railroad Train	6,200	.2	5,800	.2
Other Vehicle	3,100	.1	2,900	.1
Miscellaneous	3,100	.1	2,900	.1
TOTAL	3,078,000	100.0	2,870,000	100.0

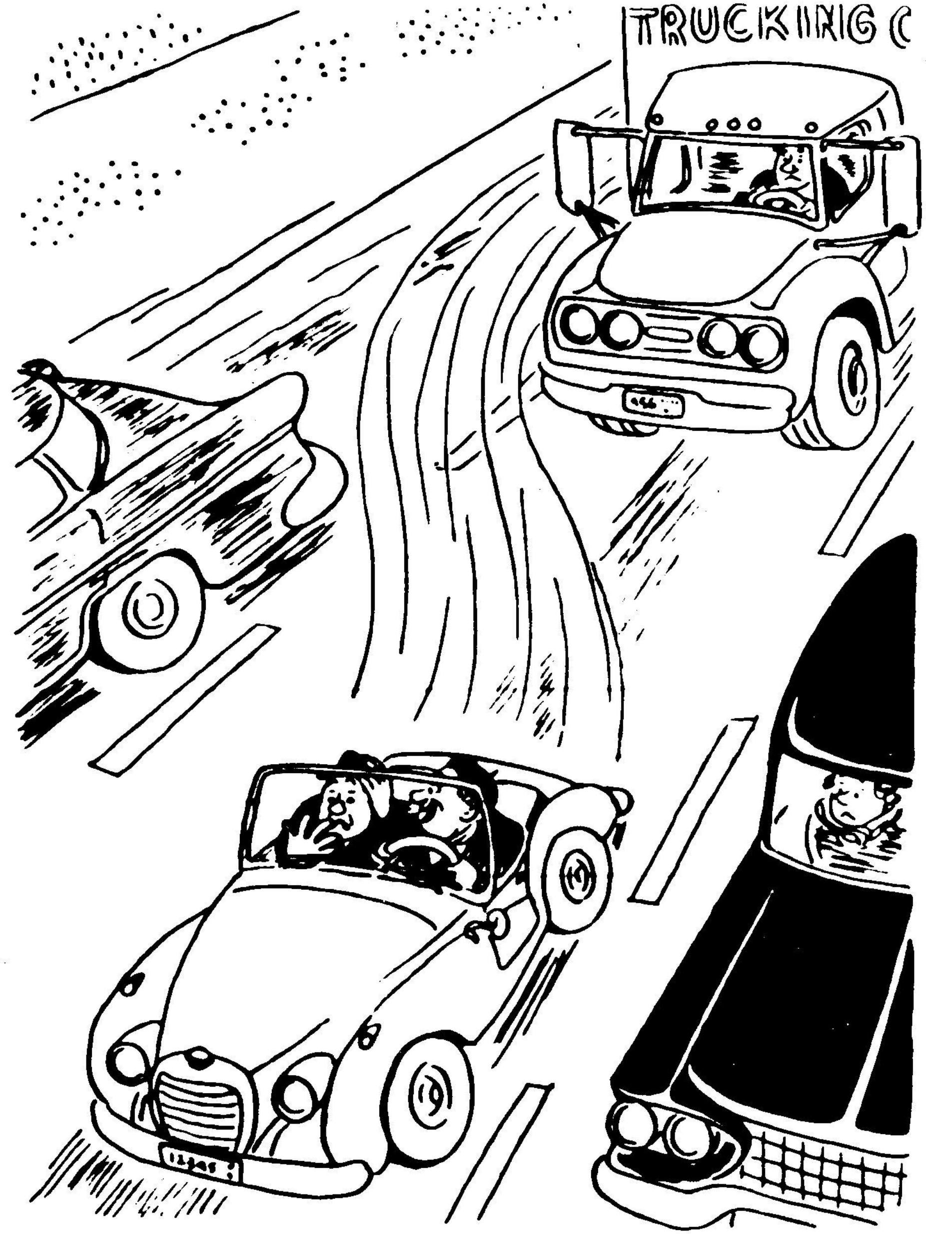
"Do you think bigger signs would help?"

Table 3 – Actions of drivers resulting in deaths and injuries

	Persons Killed	Per Cent	Persons Injured	Per Cent
Exceeding Speed Limit	10,970	36.1	1,001,000	38.5
On Wrong Side of Road	5,170	17.0	174,200	6.7
Did Not Have Right-of-Way	3,880	12.8	585,000	22.5
Cutting In	90	.3	78,000	3.0
Passing on Curve or Hill	90	.3	2,600	.1
Passing on Wrong Side	460	1.5	31,200	1.2
Failed to Signal and Improper Signaling	490	1.6	80,600	3.1
Car Ran Away No Driver			2,600	.1
Drove Off Roadway	5,050	16.6	215,800	8.3
Reckless Driving	3,800	12.5	351,000	13.5
Miscellaneous	390	1.3	78,000	3.0
TOTAL	30,400	100.0	2,600,000	100.0

Exceeding the limit is the biggest error,
Leading to pain and death and terror.

	Persons Killed	Per Cent	Persons Injured	Per Cent
Exceeding Speed Limit	12,980	43.1	901,710	38.8
On Wrong Side of Road	4,790	15.9	151,060	6.5
Did Not Have Right-of-Way	3,370	11.2	529,870	22.8
Cutting In	180	.6	81,340	3.5
Passing on Curve or Hill	180	.6	2,320	.1
Passing on Wrong Side	360	1.2	18,600	.8
Failed to Signal and Improper Signaling	480	1.6	74,370	3.2
Car Ran Away No Driver	30	.1	2,320	.1
Drove Off Roadway	3,840	12.1	178,950	7.7
Reckless Driving	3,580	11.9	336,900	14.5
Miscellaneous	510	1.7	46,400	2.0
TOTAL	30,300	100.0	2,324,000	100.0



"Maybe you're not the sports car type."

Table 5 – Age of drivers in accidents

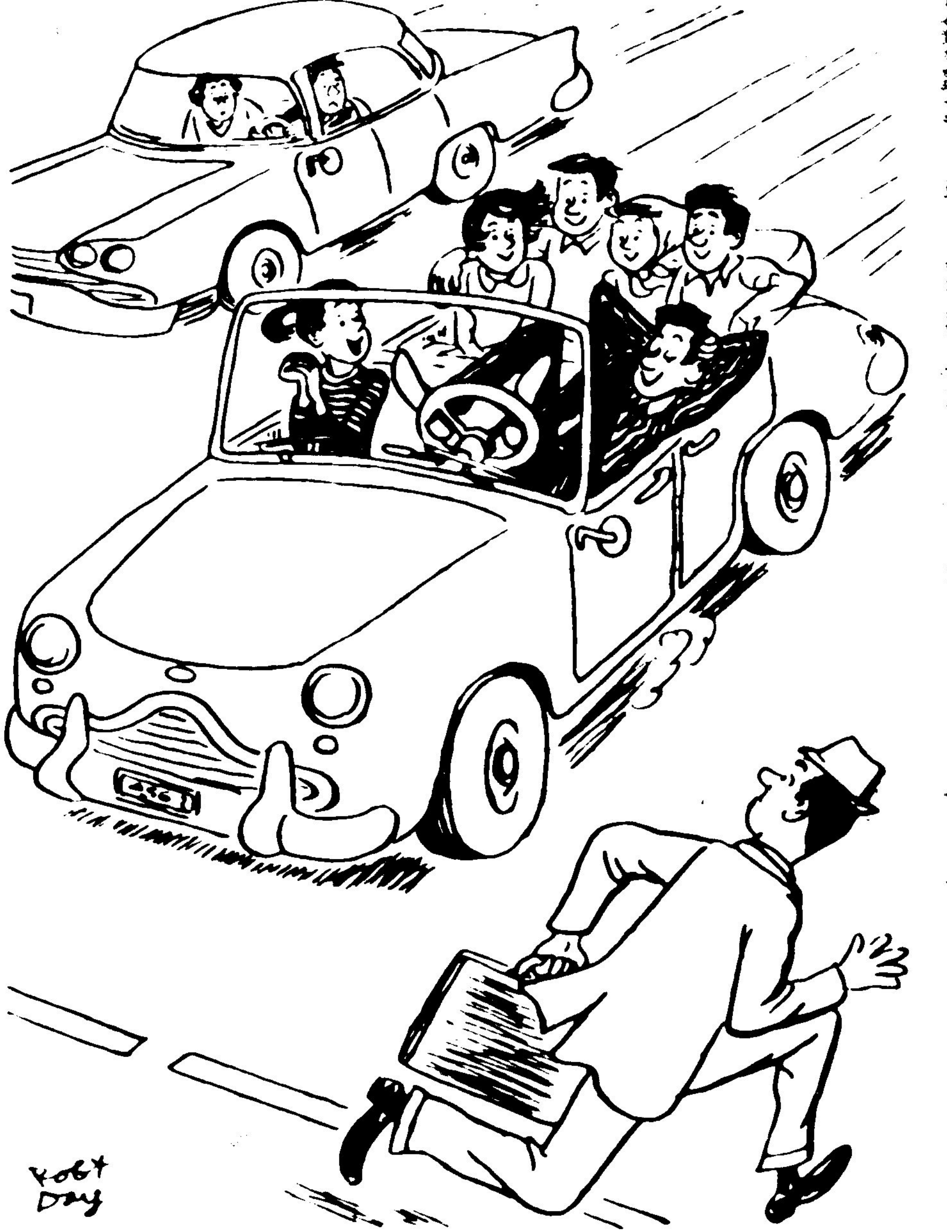
	Drivers in Fatal Accidents	Per Cent	Drivers in Nonfatal Accidents	Per Cent
Under 18 Years	2,270	4.8	123,300	3.6
18–24 Years	10,700	22.8	640,400	18.7
25–64 Years	31,100	65.9	2,531,070	73.9
65 and over	3,070	6.5	130,150	3.8
TOTAL	47,200	100.0	3,425,000	100.0

The middle years are a dangerous age,
As shown by the figures on this page.

	Drivers in Fatal Accidents	Per Cent	Drivers in Nonfatal Accidents	Per Cent
Under 18 Years	2,010	4.4	113,750	3.5
18–24 Years	11,130	24.3	588,250	18.1
25 64 Years	30,140	65.8	2,437,500	75.0
65 and Over	2,530	5.5	110,500	3.4
TOTAL	46,000	100.0	3,250,000	100.0

The overall record of young drivers improved in 1960 as compared to 1959, but the record of drivers under 18 years of age deteriorated. Drivers under 25 were involved in 27.6% of all fatal accidents in 1960 as compared to 28.7% in 1959. This improvement, however small, is encouraging. In 1960 the first of the bumper baby crop of the early 1940's became of driving age and this is reflected in the statistics. Drivers under 18 were involved in 4.8% of all fatal accidents in 1960 as compared to 4.4% in 1959.

In future years the proportion of drivers under 25 will become steadily larger, and if their records do not improve we can look forward to a steady increase in the number of casualties.



"Isn't Jeffie wonderful."

Table 6 – Operating experience of drivers in accidents

	Drivers in Fatal Accidents	Per Cent	Drivers in Nonfatal Accidents	Per Cent
Less Than 3 Months	190	.4	41,100	1.2
3-6 Months	430	.9	30,830	.9
6-12 Months	610	1.3	65,070	1.9
1 Year or More	45,970	97.4	3,288,000	96.0
TOTAL	47,200	100.0	3,425,000	100.0

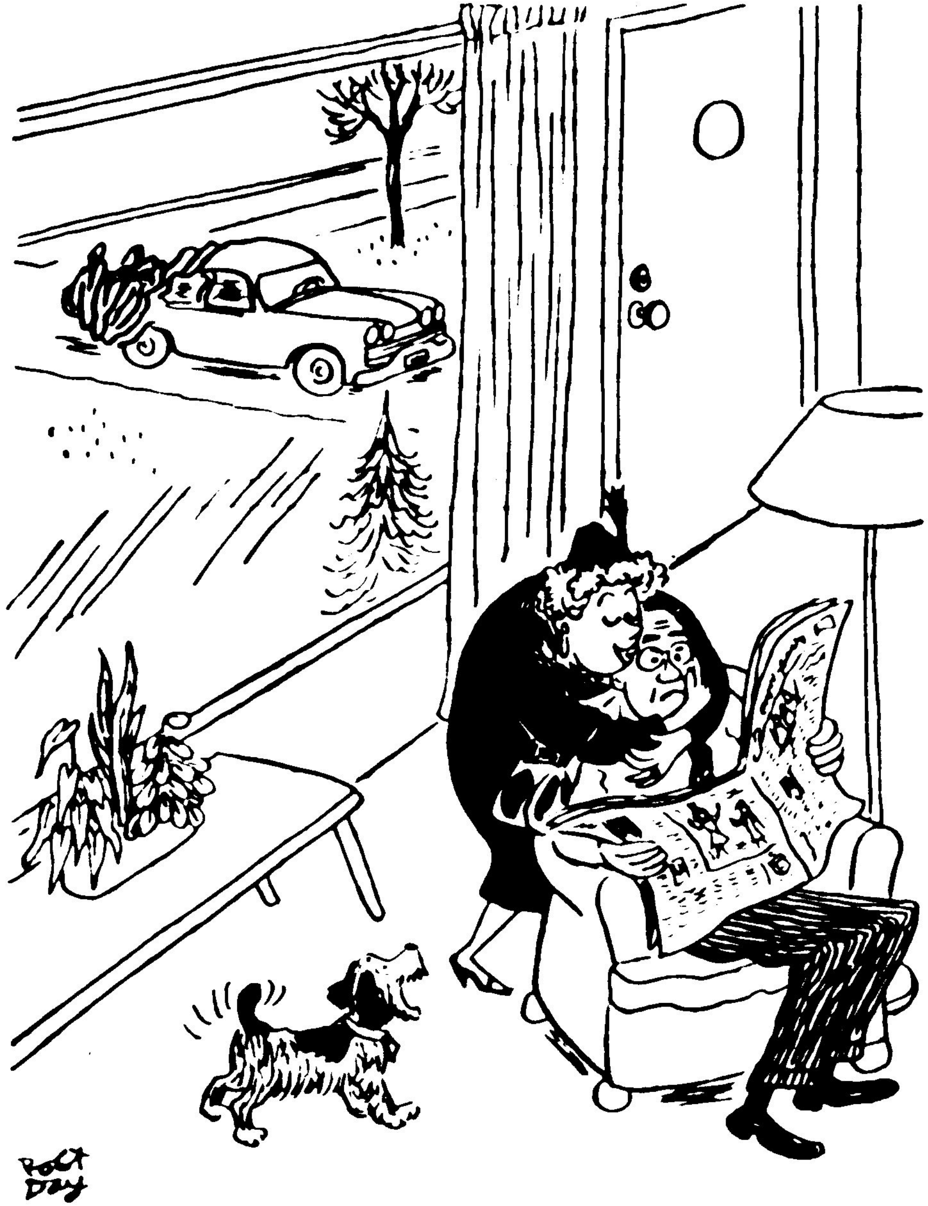
Experience is usually hard to beat;
But obviously not in the driver's seat.

	Drivers in Fatal Accidents	Per Cent	Drivers in Nonfatal Accidents	Per Cent
Less Than 3 Months	320	.7	39,000	1.2
3-6 Months	410	.9	26,000	.8
6-12 Months	410	.9	55,250	1.7
1 Year or More	44,660	97.5	3,129,750	96.3
TOTAL	45,800	100.0	3,250,000	100.0

Table 7 – Sex of drivers in accidents

	Drivers in Fatal Accidents	Per Cent	Drivers in Nonfatal Accidents	Per Cent
Male	41,350	87.6	2,784,520	81.3
Female	5,850	12.4	640,480	18.7
TOTAL	47,200	100.0	3,425,000	100.0

	Drivers in Fatal Accidents	Per Cent	Drivers in Nonfatal Accidents	Per Cent
Male	40,170	87.7	2,652,000	81.6
Female	5,630	12.3	598,000	18.4
TOTAL	45,800	100.0	3,250,000	100.0



"Malcolm, dear, I can't get the trunk open."

Table 8 – Types of vehicles involved in fatal and nonfatal accidents

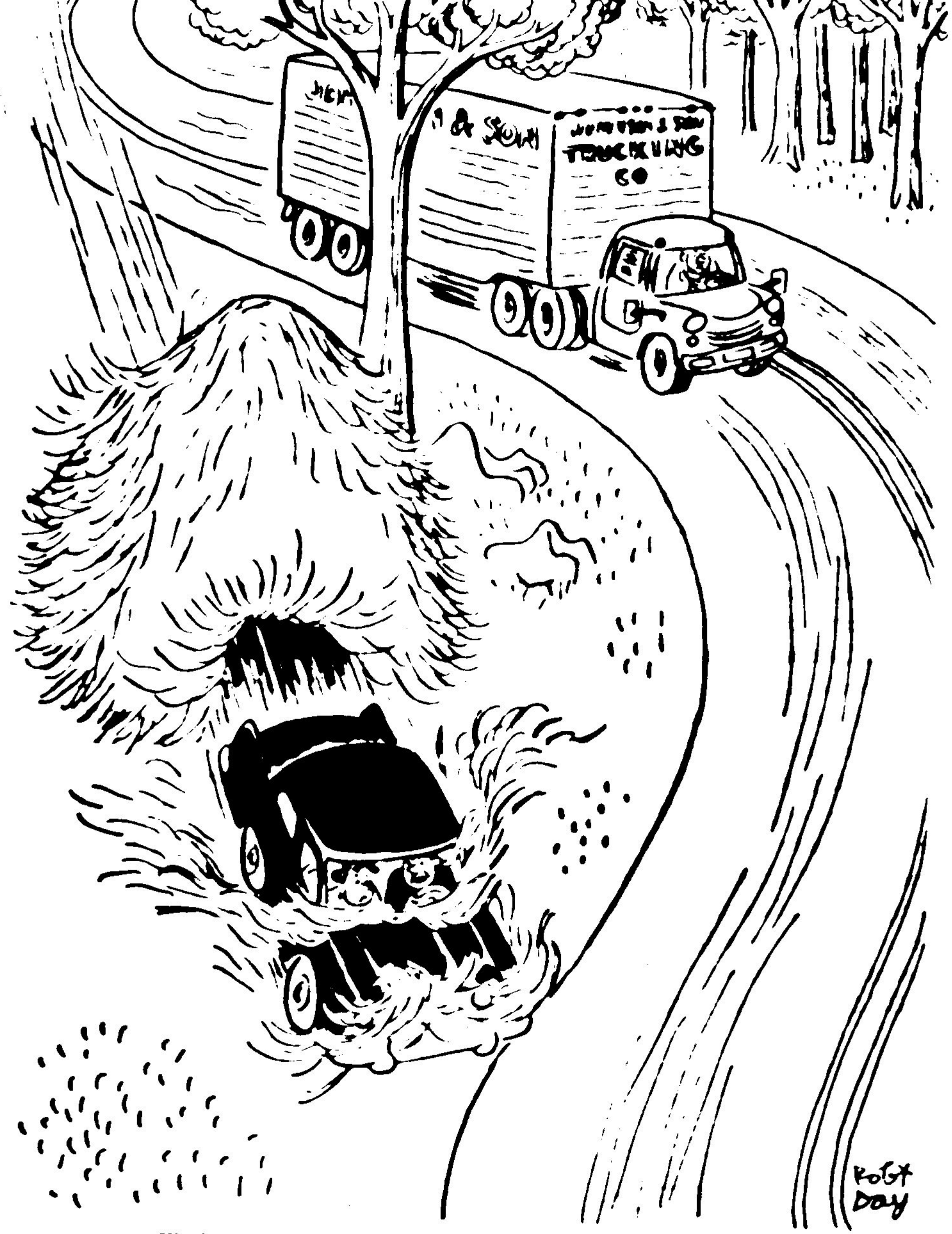
	Vehicles in Fatal Accidents	Per Cent	Vehicles in Nonfatal Accidents	Per Cent
Passenger Car	37,600	79.0	3,006,740	86.9
Commercial Vehicle	8,190	17.2	297,560	8.6
Taxi	190	.4	51,900	1.5
Bus	480	1.0	38,060	1.1
Motorcycle	810	1.7	31,140	.9
All Others	330	.7	34,600	1.0
TOTAL	47,600	100.0	3,460,000	100.0

**It's not the car that is the killer;
But the driver who holds the tiller.**

	Vehicles in Fatal Accidents	Per Cent	Vehicles in Nonfatal Accidents	Per Cent
Passenger Car	36,250	78.8	2,850,700	87.1
Commercial Vehicle	7,640	16.6	278,200	8.5
Taxi	230	.5	49,300	1.5
Bus	600	1.3	36,000	1.1
Motorcycle	780	1.7	29,460	.9
All Others	500	1.1	29,460	.9
TOTAL	46,000	100.0	3,273,000	100.0

The passenger car as usual was involved in almost 80% of all fatal accidents and more than 85% of the non fatal accidents. We might suspect that because there are more than four times as many passenger cars as there are commercial vehicles, it follows that passenger cars should have the most accidents. That this is not so can be demonstrated by the fact that the average commercial vehicle travels four times as many miles as the average passenger car; thus, the exposure is equal.

We must conclude that the better record possessed by the commercial vehicle operator denotes driving skill of a higher order and reflects the training and safety instructions that he has had. A person who drives for a living needs a license, and so must drive carefully to preserve it.



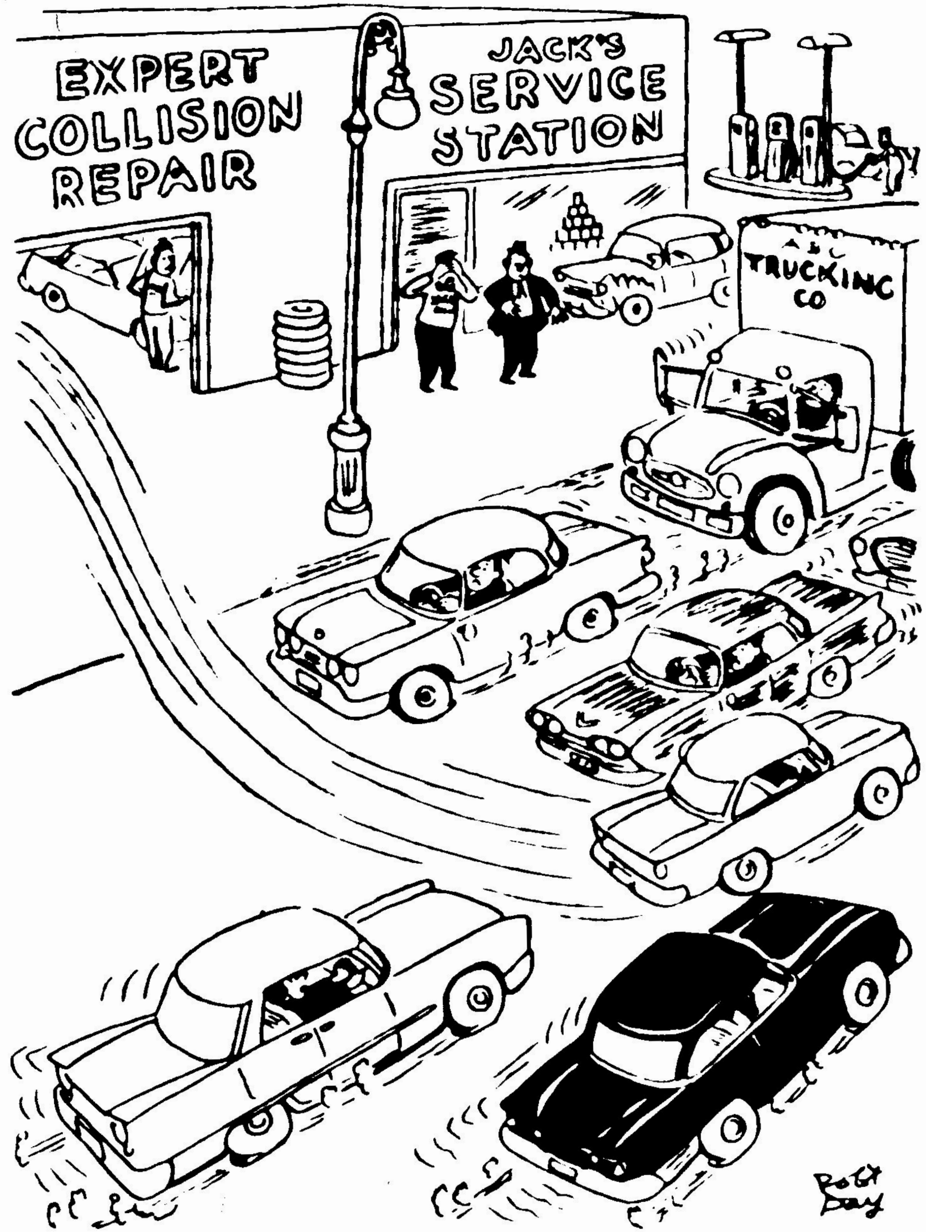
"What are you crabbing about? I didn't pass the truck on a curve, did I?"

Table 9 – Condition of vehicles involved in fatal and nonfatal accidents

	Vehicles in Fatal Accidents	Per Cent	Vehicles in Nonfatal Accidents	Per Cent
In Apparently Good Condition	44,790	94.1	3,318,140	95.9
Brake Defective	810	1.7	79,580	2.3
Steering Defective	100	.2	6,920	.2
1 or 2 Lights Out	140	.3	6,930	.2
Tail Light Out or Obscured	100	.2	3,460	.1
Other Defects in Equipment	1,140	2.4	31,140	.9
Puncture or Blowout	530	1.1	13,840	.4
TOTAL	47,600	100.0	3,460,000	100.0

Keep your car in good repair,
But depend on care to get you there.

	Vehicles in Fatal Accidents	Per Cent	Vehicles in Nonfatal Accidents	Per Cent
In Apparently Good Condition	43,610	94.8	3,161,740	96.6
Brake Defective	830	1.8	55,640	1.7
Steering Defective	90	.2	6,540	.2
1 or 2 Lights Out	180	.4	3,270	.1
Tail Light Out or Obscured	90	.2	3,270	.1
Other Defects in Equipment	1,020	2.2	32,730	1.0
Puncture or Blowout	180	.4	9,810	.3
TOTAL	46,000	100.0	3,273,000	100.0



"Oh! Oh! There goes a whole week's work."

Table 10 – Weather conditions prevailing in accidents

	Persons Killed	Per Cent	Persons Injured	Per Cent
Clear	33,200	87.4	2,582,450	83.9
Fog	460	1.2	21,550	.7
Rain	3,420	9.0	326,300	10.6
Snow	920	2.4	147,700	4.8
TOTAL	38,000	100.0	3,078,000	100.0

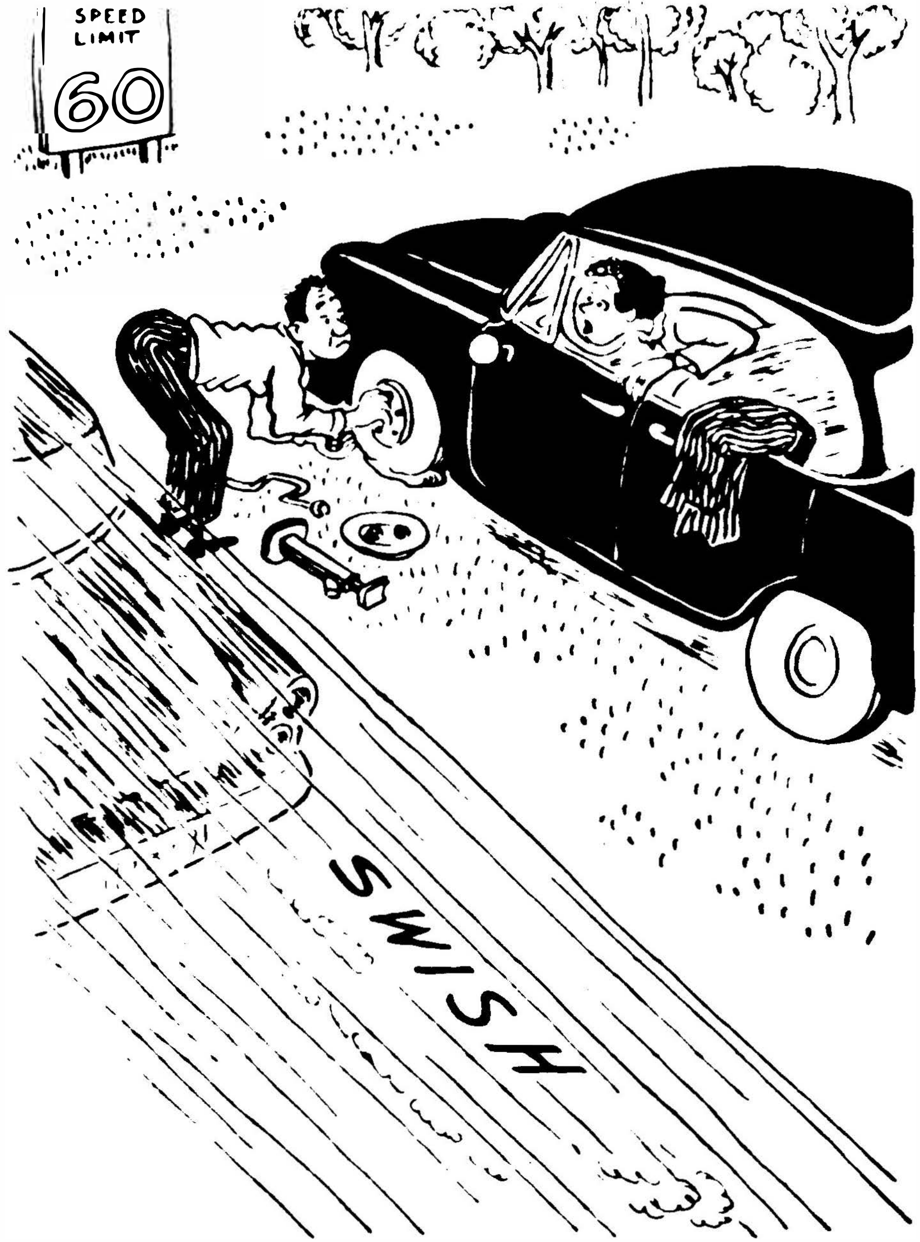
	Persons Killed	Per Cent	Persons Injured	Per Cent
Clear	32,600	86.7	2,339,050	81.5
Fog	680	1.8	28,700	1.0
Rain	3,380	9.0	378,840	13.2
Snow	940	2.5	123,410	4.3
TOTAL	37,600	100.0	2,870,000	100.0

Fog, rain, snow, can cause us woe;
But there's usually sun when the damage is done.

Table 11 – Road conditions prevailing in accidents

	Persons Killed	Per Cent	Persons Injured	Per Cent
Dry	30,100	79.2	2,200,770	71.5
Wet	5,740	15.1	507,870	16.5
Snowy	1,060	2.8	178,520	5.8
Icy	1,100	2.9	190,840	6.2
TOTAL	38,000	100.0	3,078,000	100.0

	Persons Killed	Per Cent	Persons Injured	Per Cent
Dry	30,350	80.7	2,103,710	73.3
Wet	5,150	13.7	505,120	17.6
Snowy	750	2.0	100,450	3.5
Icy	1,350	3.6	160,720	5.6
TOTAL	37,600	100.0	2,870,000	100.0



"Harry, stand in closer. You're wearing your brand new trousers."

Table 12 – Days of occurrence of accidents

	Persons Killed	Per Cent	Persons Injured	Per Cent
Sunday	6,730	17.7	467,860	15.2
Monday	4,370	11.5	415,530	13.5
Tuesday	4,410	11.6	375,520	12.2
Wednesday	3,990	10.5	372,430	12.1
Thursday	4,250	11.2	415,530	13.5
Friday	6,000	16.0	492,480	16.0
Saturday	8,170	21.5	538,650	17.5
TOTAL	38,000	100.0	3,078,000	100.0

The weekend holds a fascination,
For drivers to break a regulation.

	Persons Killed	Per Cent	Persons Injured	Per Cent
Sunday	7,140	19.0	419,020	14.6
Monday	4,700	12.7	390,320	13.6
Tuesday	3,600	9.8	358,750	12.5
Wednesday	3,990	10.6	344,400	12.0
Thursday	4,440	11.8	367,360	12.8
Friday	5,600	14.9	464,940	16.2
Saturday	7,970	21.2	525,210	18.3
TOTAL	37,000	100.0	2,870,000	100.0

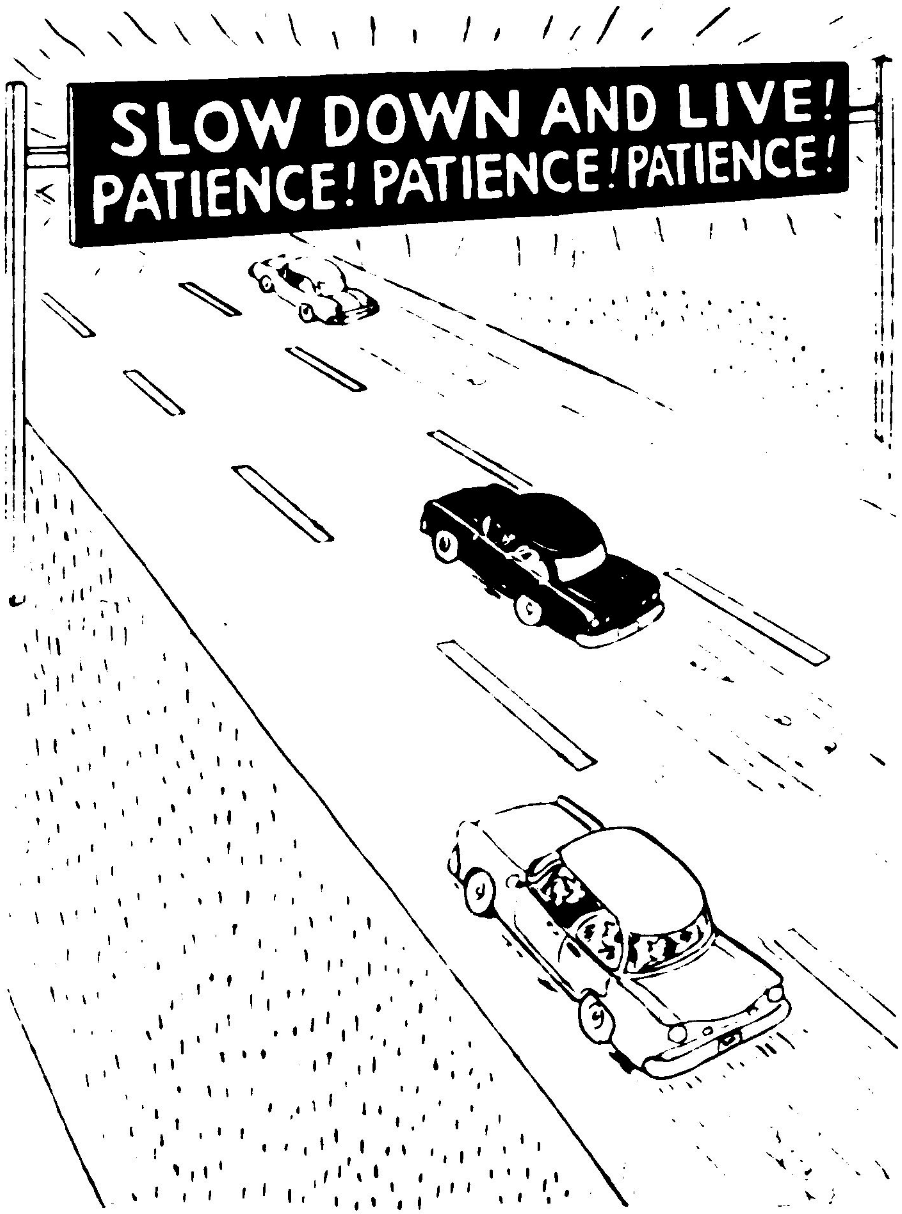
"Hey, Mac! Can we borrow an axe?"

Table 13 — Hours of occurrence of accidents

	Persons Killed	Per Cent	Persons Injured	Per Cent
12 to 1 a.m.	1,980	5.2	83,100	2.7
1 to 6 a.m.	6,500	17.1	252,400	8.2
6 to 7 a.m.	870	2.3	52,300	1.7
7 to 8 a.m.	1,060	2.8	129,300	4.2
8 to 9 a.m.	910	2.4	141,600	4.6
9 to 10 a.m.	800	2.1	101,570	3.3
10 to 11 a.m.	1,100	2.9	120,040	3.9
11 to 12 a.m.	1,180	3.1	132,350	4.3
12 to 1 p.m.	1,330	3.5	144,670	4.7
1 to 2 p.m.	1,290	3.4	150,820	4.9
2 to 3 p.m.	1,560	4.1	175,450	5.7
3 to 4 p.m.	1,900	5.0	233,930	7.6
4 to 5 p.m.	2,240	5.9	280,100	9.1
5 to 6 p.m.	2,240	5.9	261,630	8.5
6 to 7 p.m.	2,510	6.6	181,600	5.9
7 to 8 p.m.	2,280	6.0	166,210	5.4
8 to 9 p.m.	1,900	5.0	138,510	4.5
9 to 10 p.m.	2,170	5.7	140,040	3.9
10 to 11 p.m.	2,170	5.7	110,810	3.6
11 to 12 p.m.	2,010	5.3	101,570	3.3
TOTAL	38,000	100.0	3,078,000	100.0

Early hours and speed don't mix;
Most deaths occur 'twixt one and six.

	Persons Killed	Per Cent	Persons Injured	Per Cent
12 to 1 a.m.	1,840	4.9	77,490	2.7
1 to 6 a.m.	6,620	17.6	235,340	8.2
6 to 7 a.m.	830	2.2	45,920	1.6
7 to 8 a.m.	1,010	2.7	114,800	4.0
8 to 9 a.m.	1,010	2.7	123,410	4.3
9 to 10 a.m.	900	2.4	91,840	3.2
10 to 11 a.m.	1,010	2.7	109,060	3.8
11 to 12 a.m.	1,090	2.9	120,540	4.2
12 to 1 p.m.	1,130	3.0	140,630	4.9
1 to 2 p.m.	1,320	3.5	143,500	5.0
2 to 3 p.m.	1,390	3.7	169,330	5.9
3 to 4 p.m.	1,960	5.2	218,120	7.6
4 to 5 p.m.	2,370	6.3	264,040	9.2
5 to 6 p.m.	2,330	6.2	249,690	8.7
6 to 7 p.m.	2,560	6.8	177,940	6.2
7 to 8 p.m.	2,330	6.2	154,980	5.4
8 to 9 p.m.	2,140	5.7	129,150	4.5
9 to 10 p.m.	1,920	5.1	109,060	3.8
10 to 11 p.m.	2,000	5.3	100,450	3.5
11 to 12 p.m.	1,840	4.9	94,710	3.3
TOTAL	37,600	100.0	2,870,000	100.0



"The top sign lights up when there is no traffic and the bottom one when it's bumper to bumper."

Table 14 – Direction of travel of cars involved in accidents

	Persons Killed	Per Cent	Persons Injured	Per Cent
Going Straight	29,140	76.7	1,911,440	62.1
Turning Right	610	1.6	61,560	2.0
Turning Left	1,100	2.9	166,210	5.4
Backing	610	1.6	58,480	1.9
Skidding	3,460	9.1	113,870	3.7
Car Parked or Standing Still	2,700	7.1	640,220	20.8
Slowing or Stopping	380	1.0	123,120	4.0
Miscellaneous			3,100	.1
TOTAL	38,000	100.0	3,078,000	100.0

Going straight may seem a snap;
But the careless driver takes the rap.

	Persons Killed	Per Cent	Persons Injured	Per Cent
Going Straight	29,210	77.7	1,722,000	60.0
Turning Right	600	1.6	63,200	2.2
Turning Left	1,470	3.9	163,500	5.7
Backing	600	1.6	57,400	2.0
Skidding	3,720	9.9	134,900	4.7
Car Parked or Standing Still	1,730	4.6	591,200	20.6
Slowing or Stopping	230	.6	134,900	4.7
Miscellaneous	40	.1	2,900	.1
TOTAL	37,600	100.0	2,870,000	100.0

"It has oversize pistons and dual carburetors."

THE EPIDEMIOLOGY OF MOTOR VEHICLE ACCIDENTS

One of the greatest difficulties in understanding the basic cause of accidents has been the lack of an over-all conceptional framework within which the results of different approaches and different kinds of data might integrated. In recent years it has been demonstrated that accidental injuries on the highway are amenable to study by methods evolved for the investigation of contagious and epidemic diseases and thus is the most promising method for overcoming the difficulties which have retarded effective study in the accident field.

The objective of the epidemiological method is to determine the laws and interrelated factors governing the occurrence of disease of other abnormalities in a specific population. In any community, various factors may be at work which give rise to disease or disability. An epidemiological approach thus involves the study of many influences, including all aspects of the host, agent and environment. A schematic presentation of epidemiology as a study of pathogenesis providing the data from which diagnosis and treatment, prevention and control are derived, is shown in Fig. 14.[40]

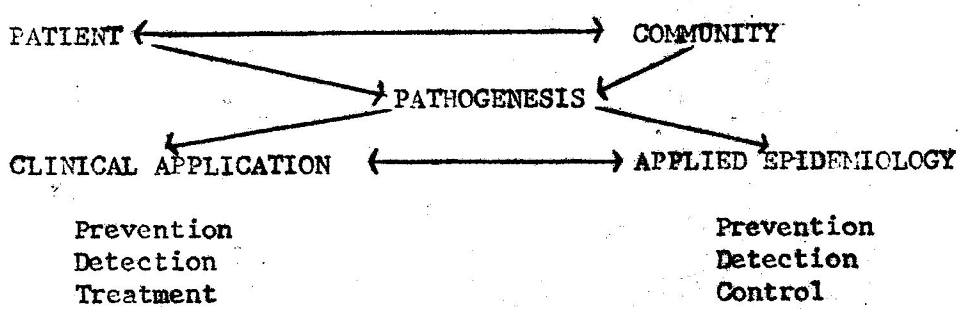


Figure 14

It is not generally appreciated that accidents exhibit some of the same biological and physical interrelationships as do disease processes. When the prevalance and incidence of accidental injuries have been analyzed in an epidemiological manner, it has been shown that accident distributions, like disease, show characteristic variations.

It is clear that there are specific variables which can be isolated and that the pathogenesis of accidental injury, as in the case of disease, arises in the presence of a susceptible host, a predisposing environment and an inciting agent. Thus, the etiology of such events involves a study of the interrelationships between host, the agent and the environment as they combine together in producing an accident.

In the various fields of medicine, it has been possible to control a disease once the agent has been clearly identified. In the field of highway safety, the agent is the automobile. It would be possible to reduce injuries and fatalities if the driver and passenger could be adequately protected during a crash either by restraining devices or by vehicles so designed that severe injuries would not be produced.

The automobile manufacturers have developed many features in their equipment which have contributed to safety such as power steering and brakes, improved lighting and improved door locks. Yet, only in the last few years have they made available the most important single, economically feasible device to control trauma associated with automobile accidents — the seat belt.

It seems obvious that basic research on human factors in automobile safety should be and could be expanded so as to provide convincing evidence for additional safety considerations in design. The Cornell ACIR project is contributing much toward this goal.

In the field of aircraft manufacturing all major companies have human engineering programs which have contributed greatly to survival in aviation crashes. It is of interest to note that auto companies are also developing human engineering programs. Some of the principal areas involved in this concept are:[20] (1) adequate dimensioning and adjustability of seats (2) location and design of controls for safe and efficient operation (3) windshield and window design for maximum visibility (4) design of instruments to give essential information rapidly and (5) design for crash protection for occupants.

In many instances, the control of accidents depends upon the identification of specific characteristics in the environment and some means of regulating the interaction between the driver (host factor), his vehicle (the agent) and the environment.

In summary, accidents on the highways now constitute one of the greatest threats to many segments of our population. The methods of epidemiology may be useful for study of accidental deaths and injuries. Auto accidents result from multiple causes and their control requires consideration of the interrelationships between the host (driver), the agent (vehicle) and the environment both physical and social. Host factors which have significant influences include age, experience, training and emotional adjustment. Alcohol, drugs, disease and physical defects are additional variables of great importance. The design of vehicles in terms of human capabilities and limitations offer another aspect of help in control. Protective features such as seat belts based on tolerance of the human body can reduce injuries. An understanding of the influences of environmental variables upon human performance is another requirement. Problems in this area such as high accident rates while driving at night or in low illumination provide clear examples of significant interactions between the host, agent and the environment.

INJURY CAUSE

It has been said that nothing happens by chance -- every occurrence has a cause from which it follows by necessity. This principle seems to be the basis for all of the present day efforts to curb the mounting traffic accident rate. Selective enforcement, driver education and highway engineering have focused attention on accident causes with the aim of their ultimate elimination.

Those who have worked in the enforcement, education and engineering phases of the traffic problem believe that if accident causes are eliminated, both accidents and injuries would cease. This is true, but taking into account the limitations of human beings and the man-made machines in which they travel at high velocities, it is doubtful if they will be able to eliminate all accidents causes. It seems apparent that all the efforts of enforcement, education and engineering throughout the years have been concentrated almost exclusively on accident cause. Little or no attention until recently had been given to why people are injuried in collisions.

It is evident that this reasoning has been faulty in assuming that accident cause and injury cause are synonymous. Since preventing an accident necessarily prevents injury, it has been tempting to conclude that the same cause is reponsible for both. This is not true. A blind intersection may be part of the cause of a collision, but the intersection does not cause a skull fracture. Injury cause is a separate entity. This type of reasoning leads to the question: if accident causes cannot be entirely eliminated, can anything be done to prevent injuries and deaths when accidents do happen?[15]

Although the physics of injury in collisions involve very elementary concepts, the exact physical circumstances have many complex variations. Eliminating those cases where a passenger is crushed within a collapsed passenger space, there are three main factors affecting a collision injury,[28] namely, (1) the speed from which the automobile and its occupants must stop (2) the distance in which the car and the people involved must stop and (3) the human body area that is struck during the deceleration. As soon as a velocity difference develops between the occupant and the car, the occupant collides with the interior of the car and sustains injury. The greater the difference, the greater the injury.

The actual circumstance, can best be understood by an example of a head-on crash. Let us assume that a vehicle collides with a solid fixed barrier at a speed of 30 mph. Let us assume further that the car is crushed in a distance of two feet. This means that the velocity of the car has decelerated from 30 mph down to zero in a distance of two feet. This represents a deceleration rate of 483 feet per second per second. Such a deceleration is 15 times the acceleration of gravity which is 32.2 feet per second per second. This unit of gravity is called the G. For convenience, we say that the car suffered a 15G crash.

As commonly used, G is the ratio of the deceleration (or acceleration) of an object to the acceleration of gravity. It is also the ratio of the impact force to the weight of the object upon which the force acts. For circular motion, the G is the ratio of the radial acceleration to the acceleration of gravity.[15] There is an equation which computes the mean G's that are acting in a given situation:[22]

$$G = \frac{MPH^2 \times .034}{\text{Stopping distance in feet}}$$

(The constant .034 converts mph to feet per second)

Referring back to the 15G crash, how does the occupant behave in such a crash? At the moment of impact he has the same velocity as the vehicle. As the car crashed to a full stop, he continues forward at almost the same speed of 30 mph and collides with the dash or some other component of the car interior. By the time his body reaches these objects, they are at rest or very nearly so. Assuming that the combined crashing of his body and car interior will reduce his velocity to sero in a distance of two inches, he will have suffered a deceleration of almost 176G's.[15]

Although the occupant might have survived without injury the 15G crash, he cannot excape injury or death from the 176G crash of his body against the car interior.

Thus, while the direct injury-producing factors are speed, distance and body area, the velocity difference previously mentioned is the first phase of the injury process.

The physics of injury tells something which seems paradoxical. If the occupant wore the car, as he would a suit of armor, the crashing of the car exterior in a collision would absorb tremendous amounts of impact energy and protect him from bodily harm. The occupant would be spared injury unless his passenger compartment became extensively crushed. However, for some unexplained reason, these teachings of physics have never been understood or accepted by the motorist, so rather than strap on the car with his belt and take advantage of its protective armor in a crash, the motorist watches the vehicle crash relatively slowly to a stop and then dashes himself violently to pieces against its interior.

SEAT BELT DEVELOPMENT

Man must move to live. When he starts to move he can stop only one of two ways. His alternatives are stopping normally under his own powers or the power of the vehicle he is using or stopping accidentally. If he stops normally, it may take a great deal of space to slow down or he may stop abruptly.

Man has always been in search of a more efficient and more rapid method of moving himself from one point to another. When he sought to turn to the air for the most efficient method of transportation, he found that he was now dealing with forces which could easily and quite often dislodge him form the means of controlling his vehicle.

As man learned to move faster and faster with better and better vehicles, it became apparent that his ability to move rapidly was accompanied by the hazard of sudden stoppage. For example, as the airplane became capable of aerobatics it became increasingly evident that a method of restraining the pilot to the seat was essential.

The translation of this knowledge to surface vehicles was very slow. During the mid-thirties and early forties no driver at the Indianapolis 500 Race would have used a seat belt. It is believed that the earliest translation of the knowledge of restraining the passenger to the package in the surface vehicular field followed the investigations of Hugh de Haven at Cornell in

1940. To investigate the question - why should moving human bodies be damaged or injuried when they are suddenly stopped - he was given a grant of funds by the office of Scientific Research and Development and the National Research Council under the sponsorship of Dr. Phillip DuBors, head of the Department of Physiology, Cornell University Medical College and chairman of the Committee on Aviation Medicine of the National Research Council.

Thus was established for the first time a scientific study on the problem of human tolerance to acceleration. This project became known as the Cornell University Crash Injury Research Studies. The first result of this grant was a paper which for the first time advanced the theory that man could absorb tremendous amounts of force (100 to 250 units of gravity) in stopping from a moving position if the force were applied through the transverse axis of the body and the force was not held for periods of time beyond those characteristic of impact (250 milliseconds).[7] Subsequent research by the US Air Force under supervision of Colonel John P. Stapp used rocket sleds to document the original scientific hypothesis of de Haven. These scientific experiments using animals and humans demonstrated that man could survive without loss of consciousness, at least 8,000 lbs. through the transverse axis for periods of 283 milliseconds. Forces of even higher levels can be survived with recoverable injury. Forces of even higher magnitude can be survived with moderate through critical ranges of injury.[32]

The conditions applying to this concept of packaging man were (1) the force should be applied through the transverse axis of the body, over the hips and shoulders and (2) it should be applied against structures which have the capacity of bending and yielding.

At this stage of development, it was noted that it was necessary to attach these restraining devices to structures which would support the loads imposed by the human body against the restraining devices. During the later part of the 1940's people involved with hazardous surface transportation such as race driving became aware of this knowledge and began to adapt to the military restraining solutions.

Gradually and without much notice from industry or government a number of informed individuals started to adapt the aviation concepts of seat belts to the automobile.

A number of physicians began to publish items in the medical literature which called attention to the frequency of injury to the head and face and the types of injuries associated with being thrown against interior components of the car. However, the general public still believed that its safer to be thrown clear.

In 1952 the Armed Forces Epidemiological Board of the Defense Department was advised that it had more hospital bed days arising from vehicular accidents that resulted from combat casualties in the Korean War. This board suggested that the Cornell group undertake a study of the causes of automobile injury in accidents which would parallel the methods used along with the Air Force in crash injury studies of aviation accidents.[21]

Thus, was undertaken the first mass epidemiological study of the mathematical relations between the host-agent-environment relationships. The efforts of Cornell were followed by similar programs at the University of California, Cornell Aeronautical Laboratory, Inc., and certain groups of the US Air Force at Holloman under the direction of Col. Stapp. From these combined resources came documentary evidence that (1) ejection from the vehicle doubled the risk of a hospitalizing injury and increased by five to one the risk of a fatal injury (2) 56% of the people injuried in auto accidents were injuried by colliding with the windshield, steering wheel, instrument panel or being thrown from the vehicle.[14]

The Cornell group using as its laboratory the highways of 18 states and 85 randomly selected sampling areas identified ejection as the most important single variable influencing the risk of and the degree of injury in auto accidents. This study also documented the frequency with which auto doors opened during accidents in which humans were injuried. The study examined the degree and difference in degree of restrained versus ejected occupants.

Before all this documentary evidence was available, Hickok Manufacturing Co., Inc. entered into a contractural arrangement with Cornell Aeronautical Laboratory, Inc. and the Cornell Crash Injury Research group. It was requested that they design and present to Hickok an automotive seat belt which met the criteria of the Civil Aeronautics Administration for seat belts in aircraft. This arragement led to the fabrication of a concept of an extrusion bar tied to the chassis but the cost of this configuration eventually priced this solution off the market. At this point of development there was no Society of Automotive Engineers standard or any other standard except the recommendations of the Cornell University group.[14]

The automobile industry, having access and prior planning conferences with this research group, took an active lead in suppling additional funds for the expansion of the Cornell study, the U.C.L.A. group and other research agencies studying this problem.

In the summer of 1955 it was announced by both Chrysler Corp. and Ford Motor Co. that scientific evidence now indicated the magnitude of the problem of ejection and that the auto manufacturers would now make available to their consumers at optional cost, seat belts.

For the first time the motoring public was given an opportunity to buy a device with the endorsement of ethical manufacturers. This device would reduce their hazard in case they had an accident while using the most common denominator of men in America, the passenger automobile.

At this point there was not in effect any criteria or standards to assure the manufacturing agencies or the public that the device offered would meet with known requirements of performance for protection of the buyer. Into this gap stepped the Society of Automotive Engineers with the establishment of a committee to make for the first time a set of performance specifications to guide the buyer and the general public about the problems of what seat belts should do and how they shoud be manufactured.

In the fall of 1955 the auto industry issued grants to Cornell to increase this investigation of property damage and injury producing highway accidents to document in a more refined degree the efficiency of new door locks, recessed steering wheel hubs, padded instrument panels and header strips as well as seat belts.[21]

At this point the only existing specifications for seat belts were those published by the C.A.A., the military services and the recommendations of Cornell University. The majority of seat belts being sold and installed in cars at this point met the C.A.A.'s requirements of 3,000 lb. loop load.[27]

The first appraisal of the efficiency of what seat belts could accomplish was reported before a Congressional Committee in Washington in 1957. By this time the Ford Motor Co. had offered with considerable advertising emphasis a safety package in addition to their normal vehicle performance and styling.

This national advertising campaign was accomplished with television programs showing seat belts and other safety devices for a period of many months beginning in September 1955. The public response to the Ford campaign resulted, according to later evaluations, in requests for many more seat belts than could be provided.[21]

From the period of September 1955 to January 1956, seat belts were in extreme short order. In the spring of 1956 the campaign advertising safety features was concluded. However, subsequent testimony by officials of Ford Motor Co. before Congressional Committees indicated that the concept of advancing safety devices was advantagous.

At this time the first data scientifically demonstrated the advantages of the seat belt for reducing injury and death was presented in professional journals and before Congressional Committees.

In 1958, the National Safety Council formally endorsed the concept of seat belts. During the period between the initial impact of the Ford advertising campaign of the fall 1955 and the early months of 1959, the seat belt issue entered a phase of lethargy. With the development of an Accident Prevention Division of the US Public Health Service in 1959, the endorsement of the National Safety Council and the increased activities of the Accident and Injury Medical Committee of the American Medical Association and the Committee on Trauma of the American College of Surgeons,[11] the problems of the use of seat belts began to attract more and more attention.

Additional hearings of the Roberts Committee on Motor Vehicle Safety in the spring of 1959 held in Washington introduced other legislation in the same field[34] and the special attention devoted by the Speno Committee on Joint Motor Vehicle Legislation in the State of New York[28] all combined to increase interest in seat belts as a special device for reducing the risk of injury and death in auto accidents.

By 1960 it was evident that the cycle and time for things to happen had arrived and the American public was under the prompting of all these nationally recognized agencies and was being encouraged to use seat belts. Definite programs to promote this concept were encourged in the latter part of 1960 by the Americal Medical Association, the US Public Health Service and the National Safety Council.[11] Formal educational material in mass quantities was prepared, automobile manufactures accepted leadership, public support groups undertook community programs and the seat belt issue becam a live issue. Controlling injury and death as a supplemental program to accident causation rather than a substitute for was accepted.

It appears that the concept of the seat belt is not very different than the concept of many other solutions developed in the history of medical and scientific research. Knowledge of improvement exists many years before there can be widespread public acceptance. This is not associated with public indifference or public stupidity as much as it is considered lack of communication between the using public and the scientific and research agencies which propose solutions.

The automobile manufacturing groups have expressed their willingness to make such equipment available if they could determine that the public is genuinely interested in using or buying equipment. The increased activities of the Society of Automotive Engineers Committee on seat belt specifications, the decision of many additional manufacturers to offer seat belts to their customers came about in the period between 1959 and 1962.

It is anticipated that the public will not lose its interest in seat belts and that in the next five to ten years we will see public acceptance of seat belts in much the same ways that they accept and use turn signal indicators and other safety devices developed in the past few years.

SEAT-BELT EFFECTIVENESS

In 1954, a major automobile accident problem area - ejection of passengers - was discovered when some of the relationships between door opening, occupant ejection and serious injury were brought to light. Prior to this time, there was a popular belief that being thrown clear of the car during an accident would generally save one's life. This early investigation by Moore and Tourin[23] indicated the fallacy of this concept as it showed that doors opened very often in accidents and that people were frequently ejected. It indicated that those ejected generally fared worse than those who were restrained inside of the auto. Examination of their data revealed that one or both front doors opened in 72% of the fatal accident sample and 44% of the injury-producing sample. Also pointed out was the consequences of door openings - 25% of those in cars where a front door opened were ejected in the injury-producing sample and 41% in the fatal sample. Ejectees fared considerably worse than non-ejectees: in the injury-producing group, 60% of the ejectees and only 25% of the non-ejectees suffered dangerous or fatal injuries, in the fatal sample, 91% of ejectees experienced dangerous or fatal injury as compared with 76% for the non-ejectees.

There were still many questions unanswered concerning ejection so a follow-up study by the ACIR was installed in 1957. This study by Tourin[35] considered in contrast to the earlier study which was concerned mainly with fatal accidents, a broad range of injury-producing accidents varying in 5 categories illustrated in Table 15.

DEGREE OF INJURY	TYPE OF INJURY
Minor	Contusions, abrasions, superficial lacerations.
Moderate	Deep lacerations, simple fractures, joint or muscle strain.
Severe	Extensive lacerations, compound fractures with displacement.
Serious	Lacerations with dangerous hemorrhage, crushing and compression fractures.
Critical	Dangerous chest or abdominal injury, spinal cord damage.

TABLE 15. INJURY CLASSIFICATION

Thus a better representation of the spectrum in all ranges of severity was achieved. The sample used consisted of 3,261 pre-1956 model cars and 7,337 occupants.

It was found that 13.6% of the occupants were completely ejected and of these 12% were fatalities. This is a fatality rate which is 5 times greater than that for occupants who were not ejected. Only 2.5% of the passengers who remained inside of the car were fatlities.

Since ejection occurred more frequently in severe accidents and since risk of ejection varied according to occupant seated position, comparision of ejectees and non-ejectees was conditioned under comparable conditions of accident severity and seated position. In order to estimate the expected frequency of fatality if no ejection occurred, the risk of fatality for non-ejected occupants was applied to occupants ejected under comparable conditions. It was assumed that had the ejectees remained in the car, they would not have been exposed to these risks. Totaling the observed and expected fatalities for each seated position and accident severity, it was calculated that the difference between the two -- 68 fatalities -- represented the lives saved in 3,261 accidents examined if ejection were completely prevented. This reduction was about 25% of the fatalities. This allowed an estimate to be made which indicated approximately 5,500 lives could be saved annually in the US through the prevention of occupant ejection in passenger car accidents. This estimate establishes a theoretical goal for application of anti-ejection control measures. The estimate was based on 25% of that portion of applicable fatalities (22,000) of the total national fatlities (40,000) which were applicable to ACIR's type accident sample.

$$\text{Theoretical lives saveable annually} = 22{,}000 \times 0.25 = 5{,}500$$

Since the sample involved includes only injury-producing passenger car accidents, certain accidents such as those involving trucks, pedestrians, cyclists and so forth were subtracted from the 40,000, leaving 22,000 fatalities as being applicable.[40]

A possible cure for ejection which has been in use for many years in the aviation field is the lap-type safety belt. This device began to amke its appearance in a few cars in the mid-fifties.

The safety belt as applied to cars appears to function in 2 principal ways: (1)it reduces ejection and (2)it modifies buffeting of passengers inside the car. By the term buffeting is meant the violent flailing action imparted to the passenger by the overwhelming forces of collision. A lap-type belt restrains or controls this buffeting to a certain degree, just as other devices such as a shoulder harness or diagonal belt of the European type would control buffeting, each to a different degree. Any of these devices would function with varying effectiveness to make the passenger become part of the car and decelerate with it rather than fly violently and uncontrollably against its interior structure.

In a study by Lindgren and Warg[38] originating in Sweden, the data from 2,109 auto accidents in 1958-61 revealed 88% of the collisions happened at a speed below 30 mph while 66% of the injuried persons received their injuries at this low speed including 8 of 15 fatal cases. This flatly contradicts the popular belief that a speed below 30 mph is safe. It also suggests that seat belts are as necessary at this speed as in high-speed driving.

Seat belts were worn in 382 of the accidents included in this survey. From this study, it was shown that 54% of the occupants sustained no injuries partly because they were using seat belts. It also noted that 51 cars of this group of 204 were involved in a head-on collision or turn-over accident in which the speed exceeded 30 mph. This latter finding confirms the view that it is 4-5 times safer to be fastened inside the car than to be thrown around inside or out of it.

At least partial protection was gained by 15% of the occupants with safety belts. Thirty percent received doubtful or no protection from their seat belts.

The authors of this study concluded that their investigation demonstrated the undoubted value of seat belts.

The latest and most reliable ACIR study of safety belts was published in 1960 by Garrett and Tourin[36]. This work compared injuries to 933 persons who wore lap-type safety belts with those 8,784 persons who did not wear belts during an accident. Based on the observed cases, the expectancy of major-fatal injury reduction was computed for different speed ranges, seated positions, types of accidents and so forth. The study showed that the use of belts could be expected to reduce the incidence of major-to-fatal grades of injury by about 35%. The major-to-fatal group of injuries in this study were those in a subjective scale of 4 categories comprised of (1) complaint of pain (2) minor (3) major and (4) fatal; thus, the 35% reduction may be applied only to the upper part of the whole injury spectrum. It is quite probable that reduction of injury in the lower grades of severity is less than 35%.

In this study, the seat belt did not prove to be a panacea. The rate of injury was about the same in both groups. But for each seated position examined, it reduced the proportion of major-to-fatal grade injuries. Directional analysis of these accidents (breakdown in terms of front-front, front-rear, rollover, angulated or lateral impacts) showed that the expected and observed number of major-to-fatal injuries in front-front and front-rear accidents were almost identical in the belt and non-belt groups, whereas in rollover and angulated impacts, the observed total major-to-fatal injuries in belt users was less than half that in the control or non-belt group. This suggests that safety belts may function most effectively in preventing ejection since it is known that rollover and angulated impacts result in ejection more frequently than front-front and front-rear collisions.[12] It also supports the evidence from simulated accidents using anthropomorphic dummies restrained in lap-type seat belts during barrier crashes that such restraint provides negligible protection against injury under severe accident conditions owing to insufficient clearance of head and chest and the interior structures in front of an occupant in the frontseat.[25,31] However, only about 33% of accidents are front-front or front-rear. Twenty percent are rollover and the remainder are angulated or lateral impacts. In the latter types, a safety belt provides the best known protection from ejection during impact and from violent dislocation within the automobile.

An earlier ACIR study[1] that is often quoted because of the highly favorable figures on the effect of the seat belts was obtained from data from two groups of car accidents that were matched for several factors, the only variable being the presence or absence of safety belts. The experimental group comprised 81 cars with 97 occupants using seat belts. The control group included 81 cars and 139 occupants without safety belts. No member of either goup were ejected from the car.

The frequency of any injury was reduced from 75.5% in the control group to 29.9% in the belt wearing group. Injuries ranging from moderate to fatal in severity were reduced from 26.6% in the non-belt group to 10.2% in the group wearing belts. In both categories this is a reduction of about 60% which in the moderate to fatal group was significant at the 98% level. A comparison study in which the control group suffered ejection showed that moderate to fatal injuries were reduced 80% among safety belt users.

An analysis of the reasons for the difference between 35% improvement in major-to-fatal grade injuries in the first study discussed and the 60-80% improvement in the small study of matched accidents is because the two groups of cases for the small study of matched accidents were not collected under the same conditions so that 81 cars whose occupants wore seat belts came from a group of less severe accidents than the cars in the control group. The 60% improvement in injuries was therefore labeled maximum improvement on the assumption that the bias weighted the figures in favor of seat belts.[12]

Lap-type safety belts reduce the incidence of major-to-fatal injuries about 35%. The effectiveness measured comes mainly through control of ejection. This finding applied to the 22,000 applicable national fatalities indicates that 7,700 lives may be theorectically saved each year by means of the seat belt. About two thirds of this action is attributable to ejection control while the remaining one third is due to buffeting control.

If a reasonable approximation of the number of safety belts being used by American motorists can be made, it is possible to estimate the annual saving of lives actually being achieved by means of seat belts. Some rough estimates of belt usage are available although known not to be entirely accurate. One way of estimating a use factor is to examine national belt sales. There is no central source which collects this information but a brief survey of opinions on the probable number of safety belts installed in American autos at the present time resulted in estimates ranging from about 2 million to 4 million. If 3 million is used as a representative figure and if it is assumed that one third of these belts are being worn regularly[37] a computation may be made which indicates that about 64 lives are being saved annually by seat belts at the present time.

Lives being saved annually by belts $\doteq$ 7,700 x 0.333 x 0.025 = 64[40]

The use factor is 0.025 (2½% of cars or occupants), derived from the assumption that 2 belts are installed per car in the applicable portion of the national registry of 60 million cars:[40]

$$\frac{3,000,000}{2 \times 60,000,000} = 0.025$$

Since the ejection study and the safety belt were conducted independently and from the seat belt study it was determined that about two thirds of the belt effect was due to control of ejection, the ACIR exponds that the correlation -- 5,500:5,134 (5,134 is two thirds of 7,700) -- may indicate an independent verification of the results of the ejection study in estimating that keeping passengers from being ejected through open doors would save 5,500 lives per year.

SEAT BELT USE

In 1958, the National Safety Council announced a National Education Program aimed a stimulating the use of seat belts. Sponsors of this joint program, in addition to the Council, were the US Public Health Service and the American Medical Association.

During the initial phase of the program, a major effort was directed at stimulating the use of safety belts by staff and membership personnel of the three sponsoring organizations. It was estimated that the 9,257 members of the Council could reach 13-18 million people.

As a part of this program, a survey was taken to assay the extent of seat belt usage among Council members operating fleets of motor vehicles.[11] The principal results gained from this survey were that of the 184,018 vehicles involved, 25.8% were equipped with belts -- 43.2% passenger cars and 10.9% commercial vehicles. The principle reasons why some fleets were not equipped were:

(1) Low speed, multi-stop urban type operation - 30%

(2) General indifference, lack of interest and apathy - 12%

(3) Not convinced of the value of seat belts - 15%

From fleets equiped with belts, the following are the main reasons they attributed to drivers accepting and using belts:

(1) Drivers themselves already realize the value of belts - 16.8%

(2) General educational program-
40.4%

(3) Accidents involving drivers, personal contact - 10.4%

In sharp ontrast to use of belts by Council members, a California study[37] of 54,348 accidents involving the general motoring public showed seat belts available for 1 or more occupants in 3.6% of the cars. The availability of this device varied according to the seating areas in the cars. About 3.5% of drivers and right front seat occupants had this safety device nad less than 2% of center front and rear seat occupants had seat belts available.

Among the cars equipped with belts, only one third had all of the installed belts worn by their occupants. Belt utilization differed among the occupants in the various seating areas, with the drivers using their belts about one third of the time, the right front occupants slightly less often and the occupants of all other seating areas using available belts less than one in six times.

In a nationwide poll conducted in May and June of 1961 in 47 states and the District of Columbia in connection with the National Vehicle Safety-Check program, it was learned by the Auto Industries Highway Safety Committee[28] that of the 757,164 vehicles participating in the program, 3.3% or 24,897 were equipped with seat belts. Seventy-three percent of the drivers of 24,897 vehicles so equipped responded to seat belt inquires as follows:

(1) Always use seat belts - 34.5%

(2) Use on long trips only - 37.3%

(3) Seldom use them - 29.4%

Comparing these figures with the California study in 1958, it can be seen that they are approximately the same. In view of the number of vehicles involved in this study and the concentrated efforts of the National Safety Council, A.M.A. and US Public Health Service in their national seat belt education program, it is rather sobering to observe that so few people have installed belts in the last three years and that there has not been an increase in use of belts installed. This is all to well shown in that none of the 442 motorists killed during the July 4th, 1960 holiday wore belts. Investigators stated definitely that in 42% of the crashes which did not involve a pedestrain, belts would have prevented death. In another 20%, they felt that belts probably would have saved the victim's life.[16]

On the other hand, the American Seat Belt Council reported more that 1,500,000 belts were sold the first five months of 1962 and that sales may reach 3,300,000 by year end.[26]

Also, US auto manufacturers are now demonstrating both there interest and their belief in increasing public interest in seat belts. As a result, seat belt anchorages are being installed in all 1962 US model cars for front seats. Factory installed belts are being offered as optionals on Chevrolet, Pontiac, Chrysler, Plymouth, Rambler, Dodge and Ford. Chevrolet is installing belts on about 12% of its 1962 models -- 67,000 seat belts out of a total 564,000 in the first three months. American Motors Corp. also reports a 12% factory installation rate.[29] As to the rear seats, one manufacturer is producing anchorages for three passengers in the rear seat. The other companies are producing depressions indicating the spots where seat belt anchorages for rear seat passengers should be installed.

The growing interest in seat belts is also shown in actions by various states and federal government agencies. In some states, legislation has been adopted. In others, governmental agencies or officials have taken action. Some of these developments are cited below:[28]

> California: After Jan. 1, 1962 all new passenger cars sold or used in California must be equipped with seat belt anchorage points for two front seats. All belts sold must be a type approved by the California Department of Motor Vehicles. The latest approved list of belts was published in January 1961.
>
> Connecticut: No new motor vehicle may be sold or registered after Jan. 1, 1962 without anchorage units for at least the two front seats. These units must be able to support a loop strenght load of 4,000 lbs. and be releasible with a pull of less than 45 lbs.
>
> District of Columbia: If a vehicle is to have seat belts, they must be installed according to the manufacturers instruction for that vehicle to pass inspection.
>
> Michigan: All private passenger vehicles manufactured after Jan. 1, 1962 must have brackets or bolts for the attachment of seat belts in order to be installed. The

state of Michigan has standards for seat belts sold or installed or webbing strenght of at least 2,250 lbs. and assembly strength of 3,000 lbs.

New York: As of Oct. 1, 1962 any new vehicle sold in New York must have knock outs or points of attachments for seat belts. In recent hearings by New York State Senator Edward J. Speno, legislation has been adopted to make seat belts mandatory for all 1965 model autos.[34]

North Carolina: Recommends but does not require the tensile strenght of belts to be at least 4,000 lbs. and that they be anchored to the frame of the car.

North Dakota: Seat belts must meet SAE standards and are listed by the state.

Ohio: Seat belt brackets are required on all new cars sold or operated in Ohio after Jan. 1, 1962.

Pennsylvania: There are state requirements for belts included in the state vehicle code, stating that they must meet SAE standards and be of the floor board mounting types.

Utah: Publishes regulations governing the installation and sale of seat belts.

Virginia: Has made mandatory, the presence of at least two seat belts for the front seats of any new car sold or traded in Virginia after Jan. 1, 1962.

Washington: Publishes a list of belts approved by the State Commission of Equipment of which the latest is June 1960.

Wisconsin: On Sept. 26, 1961, this state became the first state to require seat belts for the front seats of all new cars sold or traded beginning Jan. 1, 1962. The same requirements will apply to 1962 and later models when they are offered for sale as used cars.

Mississippi: Same as Virginia.

Rhode Island: Has made mandatory, the presence of at least two belts for the front seats of any new car sold or traded in the state after Jan. 1, 1964.

The Department of Motor Vehicles in each of the following states advises persons interested in seat belts to make sure they meet SAE or GSA specifications:

(1) Arizona	(3) Indiana
(2) Colorado	(4) Oregon

On June 23, 1960, the Federal Safety Council passed the following recommendations:

> "That seat belts meeting Federal specifications be installed in accordance with Federal Standards and be used in all federally owned motor vehicles except where the use of this safety devise is clearly impracticable or inadvisable for demonstrated reasons."

In 1962 the House approved by a voice vote and sent to the Senate a bill (H.R. 1341) which would give the Secretary of Commerce authority to establish "reasonable safety standards" for automobiles bought by the federal government.

This bill does not spell out the safety standards which the Secretary would be empowered to set, but Rep. Kenneth A. Roberts (D. Ala.), chairman of the House Safety subcommittee, said they would be worked out with the automotive industry and would undoubtedly affect safety features on autos sold to the public.[17]

In spite of the forward progress of many states and the relative apathy of others, the immediate goal is to breakdown public resistance to seat belts: the rest will follow.

PRESENT BELTS VERSUS AUTOMATIC BELTS

Upon collision people riding in cars continue forward in a straight line, without change in position, until they strike a surface which pushes back hard enough to stop them. These surfaces have not been designed with any thought of safely arresting the motion of a seated human being.

At the same speed of collision, heavier cars require more force to stop them, as more energy must be dissipated. Although energy increases with the square of the velocity, the front end deformation is about proportional to the speed. Thus, the farther the deformation, the greater the decelerating force.

If all the deaths produced in accidents by people striking the interior of the automotive structure, or being thrown out through open doors were circumvented by safe design, the number of fatalities would be reduced by about one-half.[25]

The detailed statistics are available and their permanency seems to be taken for granted. Since it is the forces offered by the resisting surfaces which injure and kill people, by reducing these forces to the minimum, the best possible opportunity for survival is presented. Let us assume that present cars constructed as they are now with attendant statistics, are rated as having forces which are transmitted to the human body on collision at 100%.

Since many parts of the human body are very vulnerable to small forces, even at low speeds, injuries and deaths may occur.

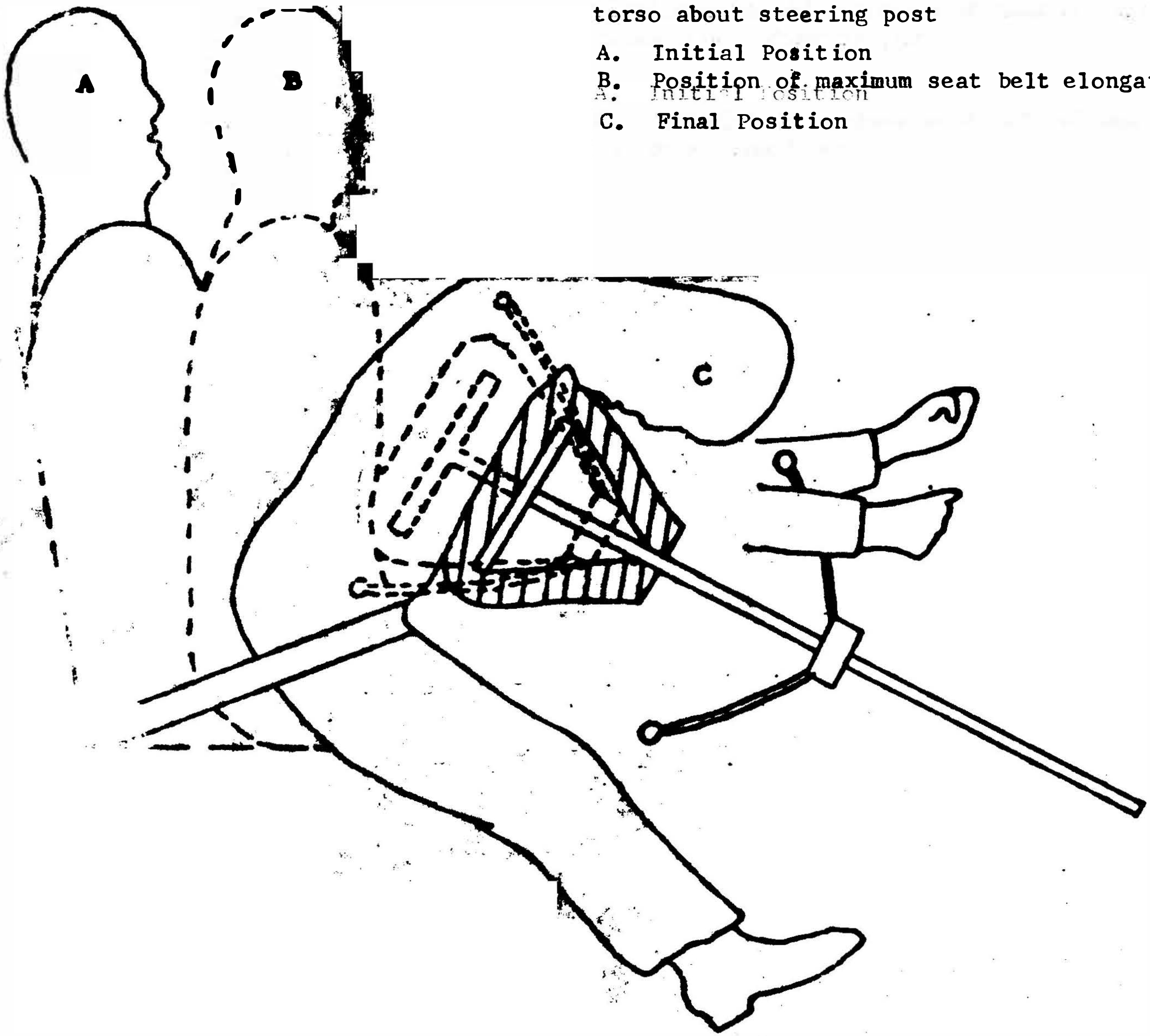
One of the most effective preventatives of the application of small forces is the use of seat belts. The pelvic bone structure, supported on a seat belt, is probably capable of resisting greater forces than any other portion of the human body.

The use of seat belts by the general public has been resisted for several reasons. Probably first, seat belts are going through the initial stages of development and require custom purchasing and fitting. The kind to buy and the strength to require are a matter of cost and both are influenced by the manner of attachment.

Secondly, the reaction of the wearer to the use of the seat belt is important. If they are restrictive to the wearer, they are a bothersome element. If they are caught in the door, are hard to fasten, get dirty and discolor easily, there is not much immediate incentive to keep people from sitting on them.

Thirdly, the forces of collision resisted by seat belts in present autos are twice as great as necessary with proper design. The motion of a body on a seat belt upon collision is like that of a suddenly-stopped weight on a spring (Fig. 15). The application of the decelerating force to the wearer of a seat belt in the present auto upon collision presents the worst possible condition. If, instead of the impact force increasing with penetration, it could be made about constant or decreasing for about the same distance, the seat belt forces on the human would be considerably reduced.

Other design and application factors affecting the installation



Six-foot dummy passenger (200 lbs.) impacted on cart at 25 mph with forward displacement and rotation of head and upper torso about steering post

A. Initial Position

B. Position of maximum seat belt elongation

C. Final Position

of seat belts refer to their elasticity, the slack of the belt at the floor fastening and around the waist of the wearer; the seat movement, both as a free flying object with an added load on the belt and as a support with a restricted displacement; the type, location and strength of the floor fastening; the previous use and freedom from weak spots of the seat belt system; the rotation of the human body striking the forward structure of the vehicle; the penetration of the driver's compartment by forward elements such as the engine, steering wheel and so forth; and the resulting elongation of the belt determining whether it adequately restricts the body to prevent injury.

Even with these recognized deficiences in seat belts, people should wear them at all times and by so doing reduce the hazard of injury and death in auto accidents in appreciable amount. As an average measure, it may be estimated that forces of impact for those wearing seat belts would be reduced to about 75% in present day cars.[25]

In the application of the decelerations forces from the vehicle to the man, it has been found by test that any slackness or looseness in the seat belt increases the forces in proportion. Thus, if the body continues to move three or four inches ahead of the seat before the belt is tight, the vehicle has slowed down a part of its decelerating distance and higher forces must be applied to the body to stop it.

Slackness or looseness of the belt is measured by the arbitrary adjustment of the belt about the rider's body, by the flexibility of the mounting connection on the floor and the straightening out of the belt to from the shortest line to support the body. The elastic elongation of the belt usually does not increase in proportion to the force, but greater forces do cause greater elongations. Thus, larger clearances are required to prevent the body from striking the interior surfaces (Fig. 16).

In present day cars, seats are pulled loose on their tracks on impact by their own inertia and by the motion of the passengers, since the seats are not adequately supported and locked. In the application of seat belts to automobiles, the lack of interest in their use may be found in the difficulty of initial attachment to the car floor, the complexity of the buckling, including adjustment and the restraint applied by the seat belt to the individual passenger. Thus, it is suggested that if automatic seat belts were installed in cars they could be utilized with less reluctance as an injury prevention device.

To meet this requirement automatic seat belts have been invented to be attached to the bar behind the seat as shown in Fig. 17.[25] They have a light clock-spring mechanism which continually keeps them retracted to the rear of the seat in proper position for immediate use. When the ends of the seat belt on each side of the passenger are grasped and slowly pulled forward, the belt may be easily fastened in front with metal-to-metal clasps. If the belt is pulled rapidly from a reel, it moves forward up a

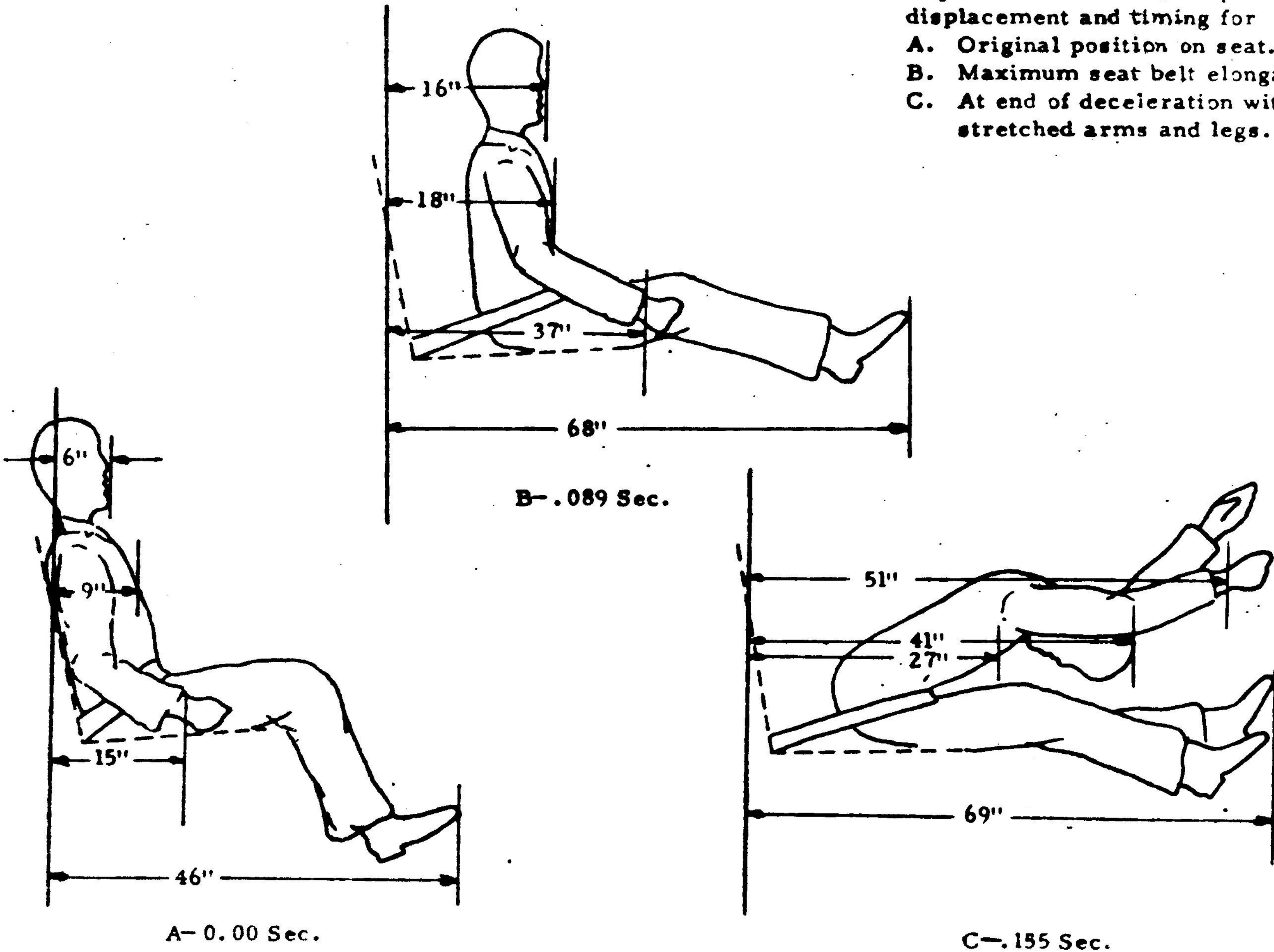
Fig.

Six foot dummy passenger (200 lbs.) impacted on cart at 25 mph with forward displacement and timing for

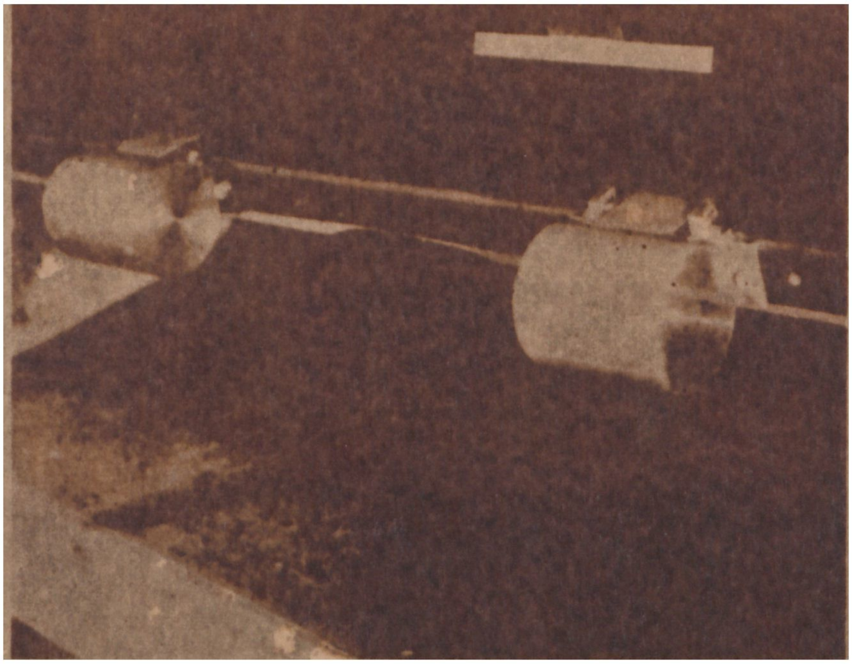
A. Original position on seat.

B. Maximum seat belt elongation, and

C. At end of deceleration with outstretched arms and legs.



Figure



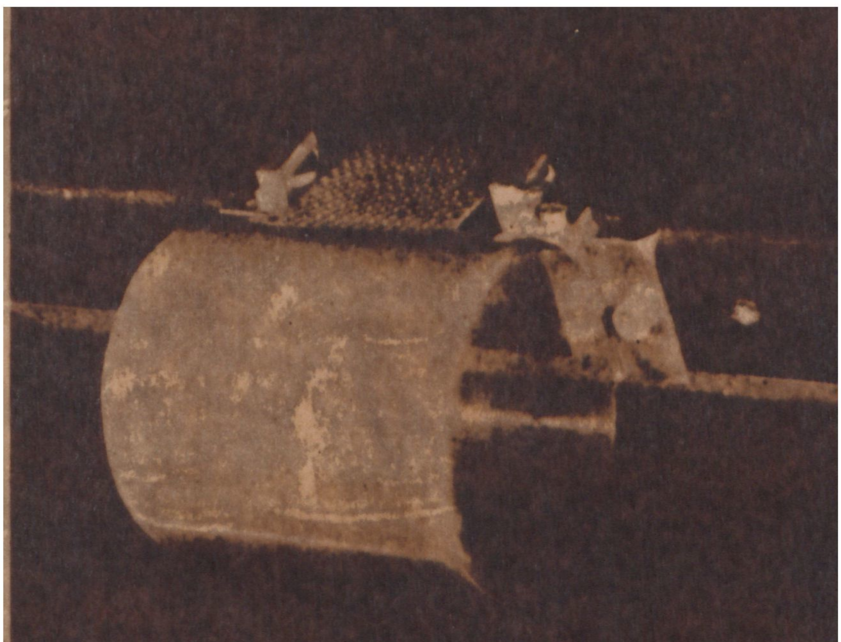


Figure 17 Automatic Seat Belts.

45 degree incline and locks in the housing. It also locks when the car is decelerated on impact. Cart tests in laboratories have shown instantaneous locking on crash. However, if the user rotates his body to back-up the car or observe something at the rear of the vehicle or if he wishes to reach forward and touch the dash, the seat belt freely and lightly follows the body motions. He is not restrained in forward, lateral or rotary motion. If a sudden movement is applied by the body on the seat belt, as in an accident, the belt is instantly locked and the passenger is restrained securely. When the buckle is released, the two ends of the seat belt retract to the back of the seat.

The use of automatic seat belts will maintain the belt in a snug position around the body of the passenger and will reduce the slack and looseness to a minimum. With these seat belts, means must be provided to anchor the seat securely in position. Since it is inadqquately supported at present, the seat must be connected to the floor with cables to limit its motion within the adjustments desired by the driver. The seat is attached to the floor with flexible steel cables of sufficient strength to decelerate the passengers and the seat. These factors provide an added measure of protection with the automatic seat belt and reduce the forces applied to the passenger on the seat belts from 75% to about 60%.[25]

THE SEAT BELT SYNDROME

While it is acknowledged that seat belts play an important role in protecting car occupants, some concern has been expressed over the possibility that the frequency or severity of certain injuries, particularily those in the abdominal region would increase. In a prophylactic or therapeutic regimen, the introduction of a new variable usually leads to modification of the clinical picture. In the use of seat belts, many physicians and investigators feared that the belt itself might contribute to many untoward situations and injuries. In other words, it was suspected that a seat belt syndrome might appear.

To help evaluate this possibility, Garrett and Braunstein[13] examined 2,778 automobiles in each of which at least one occupant was wearing a seat belt when an accident occurred. These cars contained 3,673 occupants of which 3,325 wore seat belts and of these 944 were injured.

A total of 150 occupants received some injury to the lower torso; 26 of these injuries were considered serious. No fatal lower torso injuries were found. The frequency of lower torso injuries among injuried seat belt users was essentially similar to that observed among occupants in injury-producing accidents without belts (about 15% in both).

In the majority of the 26 cases where serious lower torso injuries occurred, accident circumstances were severe. Only 7 of these patients showed evidence of severe seat belt application bruises, contusions and etc.

A summary of the principle injury findings are as follows:

(1) Intra-abdominal injuries were observed in 7 cases.

(2) Pelvic fractures were sustained by 7 occupants.

(3) Injuries to the lumbar spine were more frequent (12 cases). These injuries generally appeared either in high speed accidents with some vertical component of force, known to produce compression fractures, or in high speed accidents with sudden, violent changes of direction often combined with multiple impacts.

(4) Sprain or strains of muscles in the lumbar region was observed in 47 cases. In 41 of these the seat belt car was struck from behind and in no case was the snubbing action of the belt evidenced by bruises or contusions to the abdomen.

(5) Contusions or soreness in the abdominal region or over the bony protuberances of the hips were found in 77 cases without any accompanying injury to internal organs or skeletal structure.

Only 29 instances of belt failure, less than 1%, were found among 3,325 belt users. Examination of belt failures revealed that in only one case did an occupant sustain an intra-abdominal injury. Belt failure, like lower torso injury, was usually associated with high speed, severe accidents. The ability of the human to resist forces exerted on the lower torso without serious injury, exceeded the resistance of the belt to damage in 28 of the 29 cases observed.

In conclusion, the authors found that under conditions of low severity, where the vast majority of all accidents occur, the seat belt presents no hazard to accupants except possibly in unusual and isolated instances. Under more severe accident conditions, the localization of force in the pelvic area and the snubbing action of the seat belt may produce injury, but these injuries are as likely to be associated with such factors, as accident-type, speed or sudden and violent changes of direction as they are with the seat belt itself.

Certain accident situations, notably compartment impacts when an occupant is seated at the site of impact, are inherently dangerous and were not improved by the use of belts. These, however, are but a small proportion of all injury-producing accidents. When the impact was on the opposite side of the car or on front or rear fenders on the same side as the occupant, injuries were markedly reduced.

It was also found that the human body is capable of resisting the maximum forces exerted on the lower torso by the types of lap belts used by the occupants. Seat belts, by their snubbing or restraining action, appear to contribute to modification of injury patterns. Only in the most severe crash conditions are serious injury likely to be associated with seat belt application. Even under these conditions, automobile occupants are better off with a seat belt than without one.

In reference to human tolerance, the lap type seat belt has been evaluated by Stapp and Enfield[24] by exposing anthropometric dummies and human volunteers to experimental crash decelerations. They established that the normal hyman body can take up around

6,000 lbs. of impact loading without much danger of serious injury for the very small fraction of a second when such an impact is applied in an ordinary automobile crash. One of the human volunteers took an actual measured pull in a seat belt of 4,870 lbs. without any injury which in terms of deceleration units is 27G's.

The most common complaints following such exposure were of contusions over the anterior crests of the pelvis, beneath the belt and of abdominal pain at the lower rib margins corresponding to the attachments of the diaphragm. No fractures resulted from belt impingement.

These investigators did not claim that every human body could take 6,000 lbs. without injury. Only that trying for maximum safety, it is better to be somewhat injuried by the pressure of the belt against the hips and pelvic bones than to take the impact load with your head against the dash or through the windshield or be ejected through an open door.

In a report from Sweden,[38] a study of 382 seat belt wearing accidents, there was not a single case where the belt made the accident worse. In other studies in Sweden, the diagonal belt has been blamed for causing injuries — the most frequent being rib fractures and ruptured livers.

STANDARDS AND SPECIFICATIONS

Standards for safety products are generally desirable where the quality cannot be readily determined by inspection on the part of the purchaser. Seat belts for passenger cars are relatively new and many types have been put on the market. Essentially, a good seat belt should be wide enough to minimize injury to the individual; it should be strong enough; it should be securely anchored to the frame or floor of the car; the buckels should permit opening with a minimum of force after the crash load is applied. Specifications for seat belts thus far prepared attempt to cover all or most of these points.

G.S.A.-----S.A.E.-----A.S.A. These are a few of the initials so often heard and misunderstood or misused by manufacturers, salesmen and the consumer when dealing with automotive seat belts. These initials represent the names of various automotive societies, governmental agencies and individual testing laboratories which have been applied to seat belt specifications.

Another often misused and abused term in relation to the safety belt is "tensile strength". Many manufacturers put on their packaging and include in their advertising "6,000 lb. tensile strength", "5,000 lb. tensile strength", and etc. The truth is that the webbing manufacturers themselves guarantee the tensile strength of the webbing which they make available to the seat belt manufacturers. This guarantee does not have anything to do with the seat belt assembly as a whole. By this is meant that a

6,000 lb. tensile webbing is not very effective when the belt buckle or floor fittings may break at say 4,000 lbs. Therefore, the consumer should be aware that because a belt carries the standard of some organization or individual, it is not a guarantee of protection under all crash loads.

Listed below are several of the most widely used seat belt specifications:

A. Society of Automotive Engineers, Inc. (SAE)[28]

1. Webbing width------------------------- 1 7/8 inches plus
2. Webbing tensile strength--------------- 4,000 lbs.
3. Maximum elongation of webbing---------- 25% with 2500 lb. load
4. Loop strength of complete assembly----- 4,000 lbs.
5. Maximum force to release buckle-------- 45 lbs. with 250 lbs. loop load
6. Maximum slippage in buckle under load-- 1 inch

(Installation Specifications)

1. Anchor to fram or floor pan but not to seat.
2. Wen worn, the belt should pull downward and rearward at about 45 degrees and the two ends should be parallel.
3. Use reinforcing plates with "U" or "I" bolts.
4. Follow manufacturers instructions for threading belt through attachments.

B. Automotive Safety Associates (ASA)[2]

1. Webbing width------------------------- 2 inches + or - 1/16
2. Webbing tensile strength--------------- 3,600 lbs.
3. Loop strength of complete assembly----- 3,000 lbs.
4. Maximum force to release buckle-------- 45 lbs. with 250 lbs. loop load
5. Thickness of reinforcing plate--------- 1/8 inch

(Installation Specifications)

1. Same as SAE.

C. General Services Administration (GSA)[4]

1. Webbing width------------------------ 1 11/16 to 2 5/6 inches
2. Webbing tensile strength--------------- 4,000 lbs.
3. Maximum webbing elongation------------- 25% with 2,500 lb. load
4. Loop strength of complete assembly------ 5,000 lbs.
5. Maximum force to release buckle--------- 45 lbs. with 100 lb. loop load
6. Maximum slippage in buckle under load--- 1 inch
7. Type of buckle required---------------- metal to metal
8. Thickness of reinforcing plate---------- 1/16 inch
9. Area of reinforcing plate--------------- 4 sq. inches

(Installation Specifications)

1. The part of the belt with the release mechanism buckle should be installed on the side nearer the center of the car.
2. Holes in metal should be no more than 1/32 inches larger than bolts for which they are drilled.
3. With the seat in rear most position and the belt in use, the angle the belt makes with the floor should not be over 75 degrees.

D. Cornell Aeronautic Laboratory, Inc.[8]

1. Webbing width-------------------------- 2 inches
2. Webbing tensile strength---------------- 2,250 lbs.
3. Web stitching--------------------------- Zig-zag diagonally
4. Maximum webbing elongation-------------- 4 inches
5. Loop strength of complete assembly------ 3,000 lbs.
6. Maximum force to release buckle--------- 45 lbs.
7. Buckle type----------------------------- clamp

(Istallation Specifications)

1. The belt in use should make an angle of about 45 degrees with the horzontal plane approximately parallel to the longitudinal axis of the car.
2. Anchor to frame of vehicle.
3. One belt per passenger and anchorage.

E. Civil Aeronautics Administration (CAA)[28]

1. Webbing width-------------------------- 1 15/16 + or - 1/16 inch
2. Webbing tensile strength---------------- 2,250 lbs.
3. Loop strength of complete assembly------ 1,500 lbs.
4. Maximum force to release buckle--------- 45 lbs.
5. Maximum slippage in buckle under load--- 1 inch

F. Colonel John P. Stapp, US Air Force[33]

1. Webbing width------------------------- 3 inches
2. Maximum webbing elongation------------- 25% with 2500 lb. load
3. Loop load strength--------------------- 8,000 lbs.
4. Maximum force to release buckle-------- 45 lbs.
5. Buckle type---------------------------- metal to metal

SEAT BELT RATINGS

At the suggestion of the Division of Special Health Services of the US Public Health Service, Consumers Union of U.S., Inc.,[3] conducted a crash test study of 49 models of all widely distributed seat belts and some of limited distribution.

The tests were done by the National Institute for Materials Testing in Stockholm which is a Swedish Governmental Agency. The Swedish test vehicle looks like a toboggan on wheels. It has one seat mounted on a steel chassis with rubber-tired wheels. A cable and pully system uses a one ton weight to pull the buggy along a path leading straight into a concrete barrier. When the weight is dropped from a given height, the buggy is pulled into the barrier and the speed at the moment of impact can be closely controlled.

For CU's tests an unjointed, 150 lb., dummy resembing the torso and thighs in a seated postion was used in the buggy. A soft padding was placed around the lap where the belt touched the dummy.

The forces exerted on a belt in a crash are determined principally by two distinct factors: the speed of the vehicle and its stopping distance after impact. The same force can be exerted at a low speed during a short stop that would be encountered at high speed during a longer stop. The speeds used in these tests were 12, 15, 18 and 21 mph. The forces in the 21 mph crash are equivalent to those of a crash causing a full stop in one foot from 42 mph or in $2\frac{1}{4}$ feet from 63 mph. Three to nine samples of each belt model were tested.

No belt failed the 12 mph test but belts that broke at 15 mph were rated not acceptable. The rest were placed in one of three Acceptable Catagories according to whether they passed at 21, 18, or 15 mph. A belt that did not break at a particular speed but showed weakness, such as bunched webbing or broken stitching, was considered to have failed to qualify for ranking with those which passed at the same speed with no sign of incipient failure.

The belts broke most commonly in the webbing and the metal floor brackets. As for buckles, those with metal-to-metal clasps showed a lower rate of failure than the cam-type (clamp) in which a ridged cylinder presses against the webbing.

In this test, belts that survived the 21 mph crash without signs of weakness are listed first. Belts that passed the 21 mph test but showed incipient failure are listed next. Those that passed the 18 mph test without weakness are listed in the third group. Passing the 18 mph test but showing signs of weakness are fourth. The fifth group are those belts that passed 15 mph without weakness. The letter (M) stands for metal-to-metal buckles and the letter (C) signifies clamp-type buckles.

GROUP I

Manufacturers designation	Manufacturer	Buckle type	Retail price not installed
1. Buick 980237	General Motors-made by General tube Co. Sturgis, Mich.	M	$10.95
2. Hickok Traveler	Am. Safety Equip. Co. 216 Madison Ave. New York 16, N.Y.	M	10.95
3. Brown-Line WB 2025	General Tube Co. Sturgis, Mich.	M	12.50
4. Beam 100	Beam Mfg. Co. 1327 N. Robinson Olka. City, Okla.	M	12.95
5. Safe-Hi 850	Rose Mfg. Co. 2700 W. Barberry Place Denver 4, Colo.	M	12.95
6. Cadillac 1476955	Same as #1	M	13.00

(Number's 1, 3 and 6 are the same belt)

GROUP II

7. Star-Lite Super 500	Lite Industries 1026 S. Santa Fe Ave. Los Angeles 21, Calif.	M	6.95
8. Rupert Safety Belt	Rupert Parachute Co. Wheeling, Ill.	C	6.95

GROUP III

9. Star-Lite Delux 300	Same as #7	C	4.95
10. Tulareloft Lifeline	Tulareloft Inc. P.O. Box 248 Tulare, Calif.	C	5.95

11.	Sears Allstate 6431	Sears-made by Pontonier Inc. Chicago, Ill.	M	6.79
12.	Mopar 2162312	Chrysler Corp.-made by same as #2	M	15.00
13.	Safe-Hi 858G	Same as #5	M	9.95
14.	Alofs Lyfe-Belt 5100	Same as #4	M	10.95
15.	Beam 200	Same as #4	M	10.95
16.	Beam 262	Same as #4	M	10.95
17.	Impact Imperial	Ray Brown Automotive Co. 910 N. Orange Drive Los Angeles 28, Calif.	M	10.95
18.	Irvin Auto Seat Belt 66	Irving Air Chute Co. 1315 Versailles Road Lexington, Kentucky	M	10.95
19.	Am. Motors 8990951	Am. Motors-made by same as #2	M	11.95
20.	Pontonier E-Z Seat Belt	Pontonier Inc. Chicago, Ill.	M	11.95
21.	Beam 261	Same as #4	M	12.95
22.	Davis FDC2700F	Davis Aircraft Products Inc. Scudder & Woodbine Ave. Northport, L.I., N.Y.	M	12.95
23.	Chevrolet 985179	Same as #4	M	12.95
24.	Guardsman 100A	Narrow Fabric Co. Reading, Pa.	M	12.95
25.	Hickok Royal Traveler	Same as #2	M	12.95
26.	Pontiac 989728	General Motors-made by same as #18	M	12.95

27.	Tulareloft 300	Same as #10	M	12.95
28.	Tulareloft Acme 400	Same as #10	M	14.95
29.	Eversafe JA-50	Jeffrey-Allen Ind. 1139 S. Wabash Ave. Chicago 5, Ill.	M	10.95
30.	Impact Auto Saf-tee Belt	Same as #17	C	10.95
31.	Jeffrey-Allen Lifemate JA-55	Same as #29	M	10.95
32.	Rayco Safety Belt	Rayco-made by same as #29	M	10.95

(Number's 11 & 20 - 18, 22 & 26 - 19 & 25-27 & 28 - 29, 31 & 32 are the same belt)

GROUP IV

33.	FO-MO-CO AZ6461200A	Ford-made by Auto-Crat Mfg. 2425 San Fernando Road Los Angeles 65, Calif.	C	12.00
34.	Wards 12894	Montgomery Ward-made by Greenfield Co. 2100 Estes Ave. Elk Grove Village, Ill.	C	4.95
35.	Sears Allstate 6564	Same as #11	C	4.98
36.	Safeway 700 & 750	Greenfield Co. 2100 Estes Ave. Elk Grove Village, Ill.	C	9.95
37.	Safemaster 707	Same as #36	M	10.95
38.	Auto-Crat Bodr-Gard 200	Auto-Crat Mfg. Co. 2425 San Fernando Road Los Angeles 65, Calif.	M	12.95
39.	Buckles Livesaver	Henry Buckles Co. Sikeston, Mo.	C	9.95

(Number's 34 & 36 are the same belt)

GROUP V

40. Brown-Line WB 2030	Same as #3	M	12.95
41. Hickok Traveler Continental	Same as #2	C	12.95
42. Oldsmobile 989472	Same as #1	M	12.95
43. Protecto CC-200	R. J. McQuarrie Entp. Culver City, Calif.	C	9.95
44. Reece Safety Belt	Reece Mfg. Co. Cincinnati, Ohio	M	10.00
45. Rupert Safety Belt	Same as #8	M	10.95
46. Studebaker Seat Belt AC3109	Studebaker-made by same as #3	C	19.95
47. F80 Crash Belt JA40C	Same as #29	C	9.95
48. Rayco Safety Belt	Same as #32	C	10.95
49. Jeffrey-Allan Safe-T-Mate JA45C	Same as #29	C	9.95

(Number's 40 & 42 are the same belt)

The following list of seat belts have meet GSA specifications and is used by the Government in the procurement of belts for Federal motor vehicles.[10]

Manufacturers Designation	Manufacturer
1. A5100 Lyfe Belt	Alofts Mfg. Co. 345 32nd St. S.W. Grand Rapids 8, Mich.

2. AS-1960-1 SM-1960-H	Am. Safety Equip. Corp. 216 Madison Ave. New York 16, N. Y.
3. X-15	Atlas Safety Equip. Co. Inc. 175 N. 10th St. Brooklyn 11, N. Y.
4. CP-77991	Mine Safety Appl. Co. 201 N. Braddock Ave. Pittsburg 8, Pa.
5. 100	National Ind. for the Blind 15 W. 16th St. New York 11, N. Y.
6. B-750	Products Research Co. Cummings & Sander Div. 2900 Devby Ave. Los Angeles 29, Calif.
7. Rayco #3, R.M.C. Model 1-C	Rayco Mfg. Co. E. 221 State Highway 41 Paramus, N. J.
8. 500A	The Roberk Co. Norwalk, Conn.
9. 850, 858-G	Rose Mfg. Co. 2700 W. Barberry Place Dever 4, Colo.
10. MM-1	Shore-Calnevar, Inc. 7701 E. Compton Blvd. Paramount, Calif.
11. Federal Model 3095	Service Belt Co., Inc. 810 Broadway New York 3, N. Y.
12. 500K, 5200, 600K, 300K	Star-Lite Industries 1026 S. Santa Fe Ave. Los Angeles 21, Calif.
13. UTK5600	Sturges Mfg. Co., Inc. P.O. Drawer 59 Utica, N. Y.

14. 980	Superior Industries Inc. 14721 E. Compton Blvd. Paramount, Calif.
15. Guardian 150, Crash Guardian 200	Tulareloft, Inc. P.O. Box 248 Tulare, Calif.
16. Stock 100, Model B M3-1501, FOMOCO C2AZ 6261200A, Stock 250, Model B M3-7001	Auto-Crat Mfg. Co. 2425 San Fernando Road Los Angeles 65, Calif.
17. U500	Auto Safe Corp. 633 E. St. Clair St. Indianapolis 7, Ind.
18. HB-1	Barlow Mfg. Co. 10 Leonard St. Amsterdam, N. Y.
19. 100, 200, 500, 200SH	Beam's Mfg. Co. 1327 N. Robinson Oklahoma City, Okla.
20. Impact A, B, C, D, E	Ray Brown Automotive Co. 910 N. Orange Drive Los Angeles 38, Calif.
21. FDC-2700 F1 FDC-4200 F1	Davis Aircraft Products Inc. Scudder & Woodbine Aves. Northport, L. I., N. Y.
22. Safemaster 700, 707, 707-20	The Greenfield Co. 2100 Estes Ave. Elk Grove Village, Ill.
23. 579A	Hubsch Mfg. Co. 3856 Grant Road Jacksonville, Fla.
24. 1D-51-198-1	Irving Air Chute Co., Inc. 1315 Versailles Road Lexingtion, Kentucky
25. JA-45C Safe-T-Mate, JA-55, JA-55PN, JA-65 Lifemate, JA-75 Trav-L-Mate	Jeffrey-Allan Industries 1139 S. Wabash Ave. Chicago 5, Ill.
26. SB100-200	Market Forge Co. 35 Garvey St. Everett 49, Mass.

MISCONCEPTIONS AND QUESTIONS

The impact that would result would be hard to describe if medical research were to announce the development of a pill which would reduce mortality from the two leading causes of death -- heart disease and cancer -- to less than one-fifth. Yet for a third leading killer -- auto accidents -- there already exists a lifesaving device which relatively few people use.

Safety, like medicine and law, works for the majority and like these two fields, it has no claim to perfection. Because it involves a relatively new area of automobile safety, the seat belt has given rise to a number of conflicting statements and claims. The following are typical questions and beliefs of the average motorist. The answers are based on facts presented in this paper.

<u>A. Seat belts are useless unless there is an accident.</u>

1. Seat belts can help make the occupant a better driver because:[30]

   a. With all occupants belted in their seats, he will feel free to apply the brakes as hard as necessary to avoid a collision.

   b. He holds his seat at sudden stops, on quick turns and under unexpected road hazards.

   c. When children and friends wear belts, he can give undivided attention to driving.

   d. Belts help him control the car in a minor collision that might otherwise knock him away from the steering wheel and brake.

e. When he buckles on his belt he is admitting to himself that he can possibly be involved in an accident which is a daily safety reminder.

f. Belts keep him more alert by preventing fatigue caused by a slouching position and keeping him in an upright position for better viewing of the road.

B. <u>How do seat belts save lives in a collision?</u>

1. By preventing ejection -- you are five times more likely to be killed if you are thrown out of your car.

2. By spreading impact force.

3. By extending stopping distance -- which in effect lowers the impact force by increasing the time it takes.

4. By absorbing part of the force -- the resilient non-cutting surface of the belt will pass along 3,000-5,000 lbs of impact force to parts of the body that can take it.

C. <u>What if the car is submerged or catches fire?</u>[9]

1. Only about one-fifth of 1% of accidents involve fire and only three-tenths of 1% were under water. Since a belt greatly reduces the risk of serious injury, it follows that the occupant has a better chance of remaining conscious and being better able to get out.

D. <u>Isn't wearing a seat belt in a convertible useless?</u>

1. Only 2% of all accidents involve a convertible turn over which is dangerous with or without a belt. However, since 4 out of 5 injury-producing accidents do not involve rollovers, the odds favor the seat belt wearer.

E. <u>What about the criticism that belts target the head on the dashboard?</u>[39]

1. This theory holds that the belt acts as a hinge, permitting the upper torso to swing forward and down just about the right arc to strike the head against the instrument panel. The main thing wrong with this theory is that it assumes an alternative would be better -- that you might be less seriously hurt if you were permitted to hurtle into the windshield or the top frame or be catapulted out of the car. This is conjecture and overlooks the value of belts in preventing ejection, in minor collisions and sudden stops.

Even moderate restraint in changing the path of the body from a straight line to an arc will decrease the violence of an impact.

F. Seat belts cause injuries themselves.

1. A study by ACIR showed only a 0.4% dangerous to fatal injury to the lower torso as compared to 2.5% for non-users under almost identical conditions -- a ratio of about 6:1.

G. Most of my driving is local.

1. Forty-seven percent of all fatalities in 1958 occurred at speeds below 40 mph and 66% took place within 25 miles of the drivers home.

H. The time required to fasten and unfasten the belt makes them a nuisance.

1. It requires 5-10 seconds to fasten a belt and not over 1-2 seconds to get out of a belt using one hand.

I. Belts are expensive.

1. Belt prices have decreased in price about 50% since 1956.

J. How effective are seat belts?

1. ACIR has shown that seat belt wearers were injuried as often as non-belt wearers but the degree of injury was lower (35%) for belt wearers.

SUMMARY

This thesis primarily concerns automobile seat belts and their role in reducing the severity of injuries sustained in automobile accidents. Because of the evergrowing list of casulaties, those who work in the enforcement, educational, medical and engineering phases of the traffic problem have in the past few years been increasingly studying methods on how to reduce injury resulting from auto accidents. From this combined effort has arisen many changes in auto design in an effort to stem this tide. One of the products has been the seat belt.

In examining the effectiveness of seat belts, information is given in an effort to show the magnitude of the traffic problem and some of the considerations that are involved in the development and use of traffic safety devises.

It has been shown that more than half of the auto accidents involve only one vehicle traveling at a relatively slow rate of speed and closely related is the fact that ejection from the auto is present in a large percentage and the injury ratio resulting from ejection is high. But inspite of the efforts made to reduce the traffic toll, injuries continue to rise each year.

One of the greatest difficulties in understanding the basic cause of accidents has been the lack of an over-all conceptional framework within which the results of different approaches and different kinds of data might be integrated. Therefore, an attempt

has been made to relate the traffic accident problem to the host-agent-environment relationship that is so well known in the prevention of disease.

An effort has also been made to show that accident cause and injury cause are not synonymous. The point is made that there are three main factors involved in a collision injury, namely, the speed of the vehicle and occupant, the distance in which they must travel to stop and the human body area struck during deceleration.

In following the development of the seat belt, it appears that the concept of the seat belt is not very different than the concept of many other solutions developed in the history of medical and scientific research. Knowledge of improvement exists many years before there is widespread public acceptance.

From studies of auto accidents has come a major problem area - ejection and its relationship with the severity of the injury sustained. It was found that the fatality rate is 5 times greater with ejection than that for occupants who were not ejected. It was estimated from the results of these studies on ejection that 5,500 lives could be saved annually by control of ejection.

The latest and most reliable study of seat belt effectiveness revealed that the rate of injury among seat belt users and non-users was the same but that seat belts can reduce the incidence of major-to-fatal grades of injury by about 35%. This finding applied to applicable national fatalities indicates 7,700 lives could be theoretically saved each year by means of the seat belt.

Even though confronted with the overwhelming evidence of the value of seat belts, evidence indicates that only about 3.5% of U.S. autos are equipped with one or more seat belts and only 33% of those installed are being worn.

On the other hand, the American Seat Belt Council indicates that seat belt sales are increasing rapidly in 1962. Also U.S. car manufactureres are installing anchorage points on all 1962 model cars. The growing interest in belts is also shown in actions taken by the various states from recommending belt specifications to requiring all 1962 and newer cars have at least 2 front seat belts. In addition to the value of the seat belt now in use, it is advanced that by using an automatic belt, the forces applied to the passenger on the seat belt could be reduced 15%.

From investigations of the possibility of the seat belt causing injury itself, it is shown that under conditions of low severity, the seat belt presents no hazard to occupants except possibly in unusal and isolated instances. Under more severe accident conditions, the belt may produce injury but these injuries are as likely to be associated with such factors as accident-type, speed or sudden and violent change of direction as they are with the seat belt itself.

Seat belt standards currently being used to evaluate and advertise belts are presented with ratings of some models of all widely distributed U.S. seat belts and some of limited distribution from performance tests conducted in Sweden.

Some of the most frequent questions asked and misconceptions held by the motoring public concerning automobile seat belts are discussed.

It is anticipated that the public will not lose its interest in seat belts and that there will be public acceptance in much the same way that they accept and use turn siginal indicators and other safety devices developin in the past few years.

CONCLUSIONS

In 1960, traffic injuries rose 7% as compared to a 1% rise in traffic fatalities.

The average traveling speed at the time of impact was 45-50 mph. One car was involved in more than 50% of the traffic accidents.

The head and chest are the most frequently injuried body regions in auto accidents.

The most lethal parts of a car interior are the steering wheel and instrument panel.

The host-agent-environment relationship offers one method for effective study in the accident field.

When used properly, the car exterior can greatly augment the reduction of injury causes.

Ejection from the vehicle is a very prominent factor in injury severity.

The fatality rate is 5 times greater for those ejected than for those who are not ejected.

Control of ejection could theoretically save 5,500 lives each year.

Seat belts do not alter the frequency of injuries but do reduce the incidence of major-to-fatal injuries about 35%.

By controlling ejection and buffeting, seat belts could theoretically save 7,700 lives each year.

Only about 3.5% of present cars are equipped with at least one pair of seat belts and only 33% of those installed are worn.

The use of automatic seat belts could reduce the forces applied to the passenger on the seat belt 15%.

Seat belts cause little injury themselves.

The loop load strength of the complete belt assembly should be about 8,000 lbs. using a 2-3 inch wide nylon webbing and a metal-to-metal buckle.

There are numerous seat belts of excellent quality commercially available at the present time.

Even in the light of present informaticon, much of the public is unaware of the value of seat belts. But there is increasing public acceptance of seat belts as evidenced by the action of state and federal agencies, the automobile manufactureres and seat belt sales.

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