DESIGN OF AN INSTRUMENT PANEL FOR AUTOMOBILES

Thesis by

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IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF INDUSTRIAL DESIGNER.

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ABSTRACT

Since 1937 the automobile instrument panel has gained appreciably in importance as part of the interior design. The panel has also been receiving attention as an additional safety measure to meet the increasing consumer demand for safety factors in cars. The value of the panel as an influential sales point has been stressed so much by dealers that definite efforts are being made to make the panel more attractive and distinctive.

The problem of designing an instrument panel for automobiles has been treated from the functional point of view. Careful analysis of market and consumer research has been used to develop a logical solution. Consideration has been given to efficient instrument lay-out and convenient location of controls and panel accessories. A method for the suspension installation of the panel has been devised for shock absorption using the principle of friction braking. A new application of crash padding has also been added to avert serious head and knee injuries to passengers in accidents.

Improved instrument lay-out and lighting are claimed as additional safety measures in this design, and all superficial stylizing eliminated.

INTRODUCTION

The automobile, by virtue of its great utility, has become one of man's proud possessions, and has provided an almost unlimited field for the play of the whims of all designers. To the consumer the automobile has become an unusually useful commodity and a good investment. To the designer it has accorded a wonderful opportunity for research and making new applications of his scientific theories. To the salesman the car has given a chance for ingenious displays and study of new angles in human psychology. Today mechanical developments have to be coupled with the ever-changing, ever-increasing human requirements, and an all round improved design must be sent at frequent intervals to meet the requirements of the salesmen in the highly competitive field.

A study of the history of automobile design will reveal the steady growth in importance of the interior design, and the increasingly effective role interior design is playing in the saleability of the car to a public that is growing to be extremely conscious of the possibility of buying comfort and safety along with the rest of the car. With the increase in the number of cars plying the roads and the accompanying increase in traffic accidents, the safety regulations of the land are being revised and strictly enforced to insure the safety of pedestrians and passengers. A new phase in design has therefore come into being, a phase wherein everything is calculated to meet the demands of the consumer and the law. The instrument panel is part of this changing phase in

design, and has become very important from both functional and sales points of view.

The design of the instrument panel for automobiles entails the fundamentals of instrument lay-out, with the dual purpose of placement of instruments in their logical sequence and location with an augmentation of the over-all appearance of the panel, and making it integral with the rest of the car design. With the introduction of safety features in modern designs, the instrument panel is giving additional functional value by offering itself as a safety device that can be effectively incorporated in future designs.

The purpose of the thesis problem is to make a detail study of the functional and esthetic requirements of the automobile instrument panel in order to arrive at a solution that will eliminate all the deficiencies of the existing panels, and incorporate features that will make driving very convenient and safe. In arriving at such a solution a study has also been made of the requirements of the consumer and the manufacturer.

HISTORY OF AUTOMOBILE DESIGN

Introduction:

In order that the design of the instrument panel be integral with the design of the automobile, a study was made of the development of the automobile and its relationship to the evolution of the instrument panel. A brief summary of such a study is given in this section.

History of Automobile Design:

The complete period of automobile design development can be divided into four stages:

1. The stage of fundamental development (ending 1911), during which period mechanized transportation was replacing the horse carriage. The design of the car body and the interior was more or less following the pattern of the costlier carriages, the main effort being in the development of efficient and powerful engines.
2. The second stage was that of fast mechanical development (1911 - 1926). Buyers in this period were demanding better designs. The manufacturer was striving to introduce more economical and popular cars.
3. The third stage (1926 - 1934) set the pace of development in fuel research. Metallurgy helped to build stronger and safer cars. Greater speeds and traffic density created a demand for higher safety factors and easier riding. Competition in selling cars was increasing. But most of the

development was confined to mechanical details and improvements. Soon after the depression of 1929 there was an innovation in automobile design. Manufacturers tried to stimulate the desire to buy cars, and new designs emphasized appearance and comfort. The stream-lined body, grille for radiators, fender head-lights, increased baggage space, better vision, easier controls attracted more attention of the designer and the consumer.

4. The fourth stage can be considered as the design development period (1935-to date). The increase in the standard of living has increased the urge to buy cars. American business has been exploiting this desire with all the available ingenuity, research and technical skill. Today a new standard of social status has been established based on the ownership of cars and the type of cars owned. Design has been striving for distinctiveness, luxurious compliments, passenger comfort, and much of the effort has also been to catch the eye of the woman who is becoming an increasingly important, but difficult, consumer. Consumer surveys are being made all the time, and salesmen are watching the changes in fashion and sentiments. Driving is being made easier for the woman, the aerodynamic qualities are being improved for speeds exceeding fifty miles per hour. The placing of the engine in the rear is no longer a remote possibility, and, though design changes were made piece-meal hitherto, radical changes in design are possible in the future.

Importance of Car Interior Design:

Until recent times the design of the automobile interior has been almost an after-thought, with no motif other than arranging some seats for passengers. With the advent of speedy travel for which the automobile became more and more suited, the interior drew more attention from the designer as a veritable means of providing comfort and attractive appearance. Requirements of human comforts in the case of long-distance travel is still a subject of intimate study.

Designers have been confronted with many limitations in their work on interior design, mainly because of the limitations imposed by the functional duties of the various items. The trend in the design of the interior has been a conformity to the general theme of car design in its lay-out and color.

The instrument panel received the same treatment given the interior of the car. Until very recently it merely served as a place for mounting the basic instruments and to hold the controls. Since 1937 the instrument panel has undergone radical changes in the details of instruments as well as the compliments. Today the manufacturer and the designer contend that the panel has become an item of distinction, and advertisements and salesmen are more loquatious of the qualities of the panel.

But in their anxiety to impress prospective buyers, many a designer has grossly ignored the functional duties of the instruments and have tried to score mainly by stylizing. In fact, some of the designs have become positively dangerous to the driver because of their complex shapes, shiny compliments and light-reflecting surface finishes. The instrument lay-out itself has

been detrimental to safe driving and the quick assessment of the performance of the engine and the conditions of driving.

Conclusion:

It is obvious from the previous discussion that the instrument panel has been gaining in importance both in its scientific application for the safety of driving as well as a sales point. But the design treatment given is far from satisfactory in many cases because of the over-emphasis given its styling. If future designs have to insure safety of pedestrians and passengers, the design has to be considered from the safety angle, and efforts have to be made to exclude items that do not contribute functionally to the panel. At the same time full consideration has to be given to the comforts of the driver and the front seat passengers.

CONSUMER PSYCHOLOGY AND DESIGN TREND

Introduction:

The extent of the influence of appearance and style on the sales of automobiles, and the psychological factors that directly and indirectly influence design, were made subjects of study to obviate defects in the design of the instrument panel.

Sales Analysis:

For the purpose of this study automobiles belonging to the low-price and medium-price classifications were chosen. The sales of these cars were compared with each other and with the total sales of all cars made by the manufacturers.

Figure I gives the sales of the low-priced cars--Ford, Plymouth, and Chevrolet; Figure II gives those of Chrysler, Buick and Studebaker; and Figure III represents the sales (total) of all models made by three of the manufacturers--General Motors, Chrysler, and Studebaker.

It can be said that the upward and downward trends in sales are closely followed by all the curves, all curves experiencing a similar percentage of increase or decrease. This similarity also extends to the total sales curves.

The similarity in the nature of the curves may be considered as due to the fact that design as such has only limited influence on sales, but that there are several factors connected with the business cycle that influence sales*. So far as

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* "Dynamics of Automobile Demand"- G. M. Pub. 1939

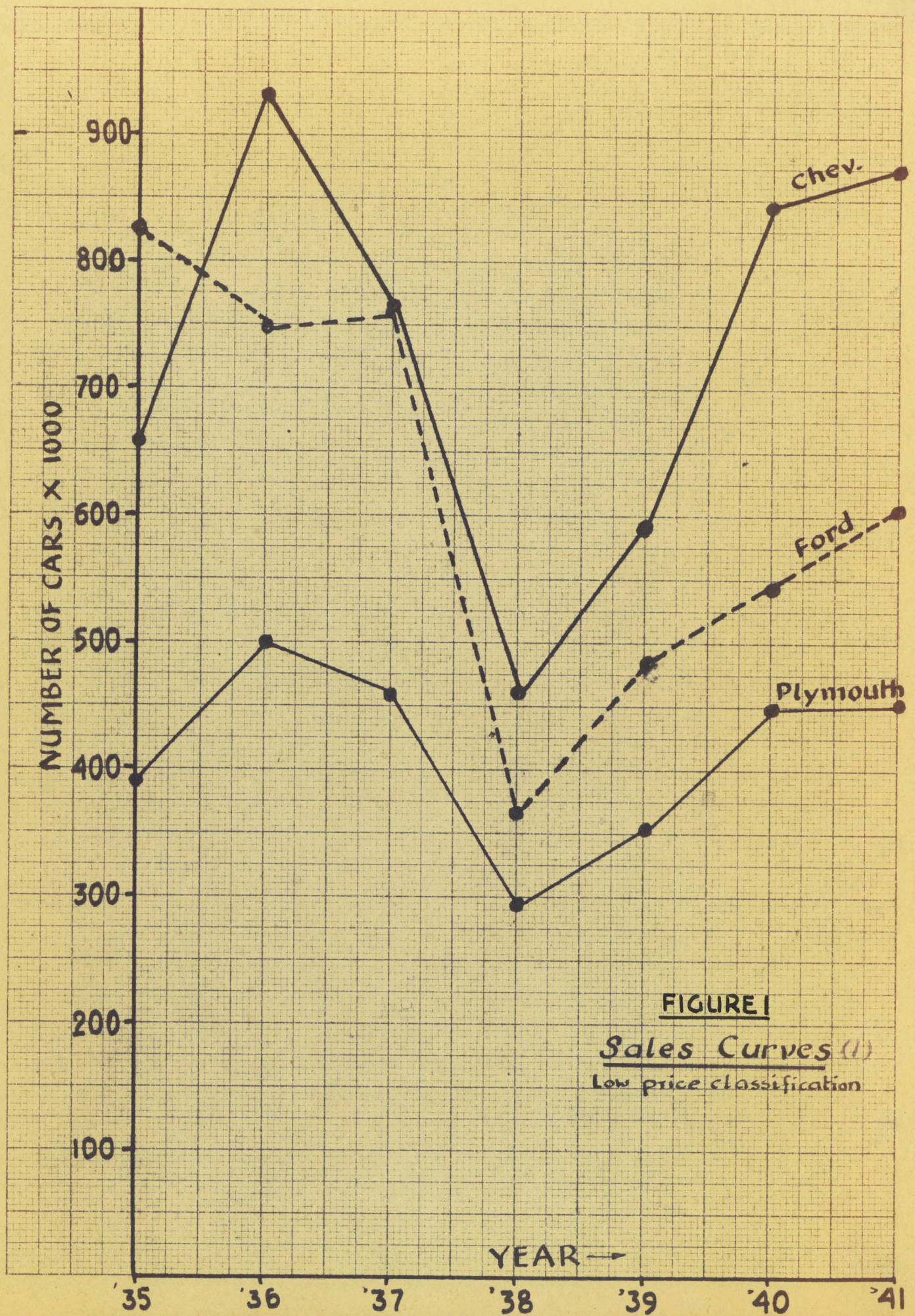

FIGURE I

Sales Curves (1)

Low price classification

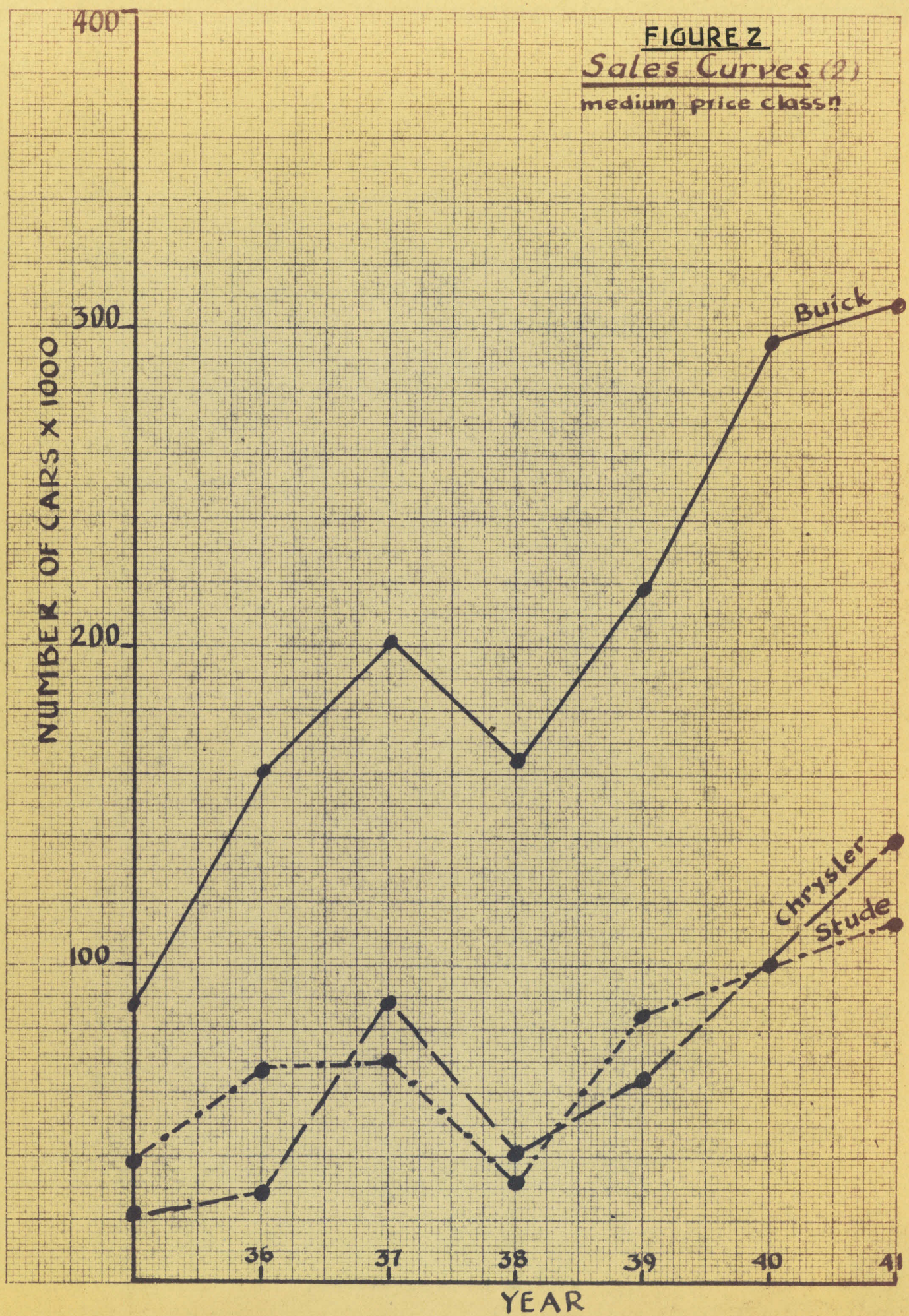
FIGURE 2
Sales Curves (2)
medium price class?
400
300
200
100
NUMBER OF CARS X 1000
Buick
Chrysler
Stude
36
37
38
39
40
41
YEAR

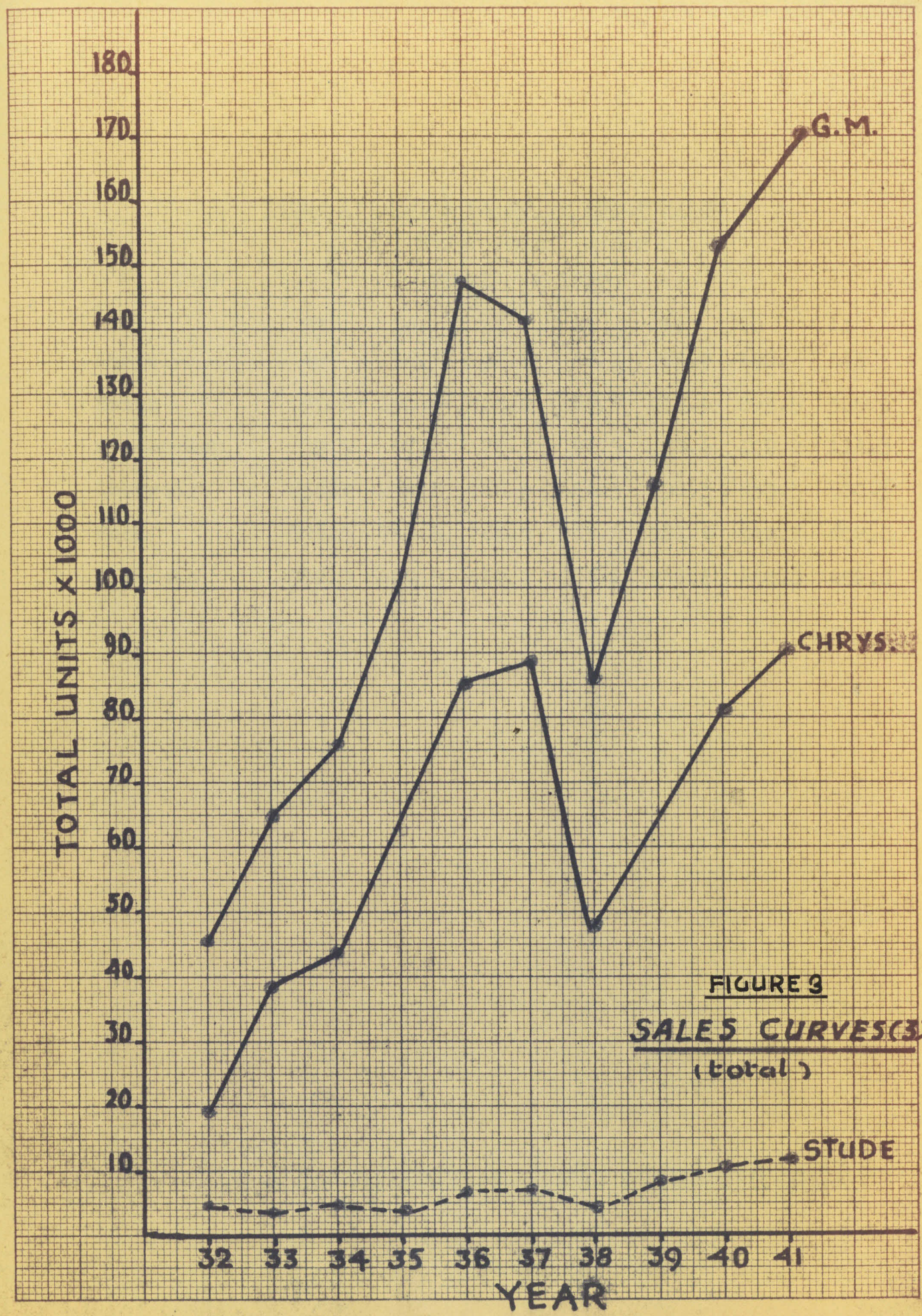

FIGURE 3

SALES CURVES(3)

(total)

TABLE I: TOTAL SALES OF AUTOMOBILES *

(Refer Figs.1 and 2)

TYPE	TOTAL X 1000						
	35	36	37	38	39	40	41
Chrysler	40	58.7	91.6	46.1	63.9	100.	143
Buick	87.6	160.6	205.2	166.3	218.9	295.5	308.6
Studebaker	39.5	67.8	70.0	41.5	84.6	102.2	114.3
Chevrolet	656.7	930.2	768.0	464.3	598.3	853.5	880.3
Ford	826.5	748.5	765.9	363.6	981.5	542.7	602.0
Plymouth	382.9	499.5	462.2	286.2	348.8	440.0	452.0

* " Automobile Facts and Figures "- A.M.A. Publication

TABLE II: TOTAL SALES OF ALL MODELS BY MANUFACTURERS *

(Refer Fig. 3)

MAKE	TOTAL X 1000									
	32	33	34	35	36	37	38	39	40	41
Chrysler	191.4	385	432	629	851	883	472	641	809	901
G. M. Corp.	455	647	752	1052	1467	1414	847	1159	1625	1765
Studebaker	42	36	42	39	67	70	42	84	102	114

* " Automobile Facts and Figures "- A.M.A. Pub.

appearance and other features are concerned, it may be said that there has been a close follow-up on the over-all design of the different types of cars, perfunctorily reflecting the requirements of the consumer. Moreover, buyers have been led into the purchase of certain types of cars belonging to the price classification they preferred to buy from. Once a purchase is made the consumer is likely to stay in that classification because of the transitive value of the car, and the benefit of "trade-in" purchases.

Consumer Psychology:

It took the automobile industry more than two decades to give any serious consideration to the case of the customer and his requirements. Today the consumer seems to hold the key to automobile development.

The buying motive can be said to be guided by the desire for quick transportation, social recognition, and the enhancement of prestige. The first factor has induced improvements in safety, comfort and economy with the incumbent improvements in vision, lower center of gravity, more effective controls, and instruments that more truly impart a message. The introduction of the chrome trims in 1938 and its increasing application is one of the indications of consumer demand for luxurious compliments and appearance. The housewife has typified the automobile as an obvious sign of social superiority. This has made the consumer less interested in the basic features of mechanical improvements and made him or her look for novel items, expensive looks and more equipment and details in the car.

Circumscribing these buying motives are factors like tradition that are pressing for recognition to a certain extent. Abrupt changes in appearance and design of details have increased sales resistance. The natural desire of the manufacturer for economy in production, and slow obsolescence have also reduced the tendency for radical changes in design every year.

An exception to this argument seems to be already in the field. The Studebaker 1947 models are bold departures from older designs and seem to have become popular. It is, however, too early to draw any final conclusions from available sales data.

Recent consumer survey conducted by the Popular Science Magazine indicated that an analysis based on apparent consumer demands may lead automobile designers into erroneous conclusions. The survey pointed out that (1) buyers, in general, are not well informed about, nor can they keep pace with, the technological changes made day by day; (2) buyers have not acquired full knowledge of what is available in the market to satisfy their demand, and are not aware of what manufacturers are capable of giving them; (3) buyers are increasingly demanding better appearance, sturdiness and safety.

Safety Feature:

Emphasis on safety features is very much on the increase on all cars. The front grille and bumper design have been putting an accent on the safety theme by appearing more solid and sturdy, thus typifying the structure of the car. Salesmen claim that this is giving them an edge on competitive selling against those not exhibiting the features to the same extent.

A detailed discussion on the safety feature will be made later in the Section on "Shock Absorption."

Conclusion:

From the foregoing discussion it may be asserted that the instrument panel as part of the design will play a more important role as a sales point, and will have to appear more functional, incorporating safety features.

CONSUMER CONSULTATION

It has been the practice in industry to evaluate consumer requirements concerning any product in order to design and produce a product that will go into the market with the least amount of sales resistance. The automobile industry has made constant efforts to predetermine the wants of prospective buyers belonging to different cross-sections of society. "Reports on special features and details of appointments are compiled from surveys made among motor enthusiasts--practical motorists who have more than a passing interest in motor cars."*

But, since 1945, the designers have been cautiously watching the outcome of consumer research, and the tendency now seems to be not to accept entirely the result of consumer questionnaires.

In the enterprise undertaken by the writer to question members of the buying public and auto-dealers on items typifying consumer trends, a similar experience was encountered. The questionnaire was restricted to the features of the instrument panel that the average consumer would desire to have. The questionnaire, with the more representative answers, have been reproduced below. The reaction of the persons to the questionnaire and their presentation of answers have not been too convincing to be accepted as final. The answers given by the average consumer tended towards favoring the conditions to which they have been accustomed, and the answers from the dealers have

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* "Automobile Research"--G. M. Report, 1939.

been mostly in the nature of sales talks on the type of cars they were selling at the time.

Therefore, it was decided that it will be safe to assume that the public can be guided into the acceptance of designs that have obvious advantages such as convenience, richness of appearance and additional safety factors. The result of the field survey was retained for guidance to decide cases of controversial issues.

Questionnaire:

The questionnaire was presented to individuals that were considered representative of different sections of society. This group comprised approximately twenty students, twenty-five women and twenty-five men motorists. Eight dealers in automobiles were also questioned. A report was received from the Sales Department of the Hudson Motor Company on the subject of the questionnaire. This report compared favorably with the majority answers given by the group questioned by the writer.

The questionnaire and the answers given by the majority are reproduced below:

(Please state your preferences on the following items concerning the instrument panel for your future car.)

Questions	Answers
1. Smaller or larger number of instruments?	1. Larger
2. Larger size instruments?	2. Yes
3. Speedometer in front the driver or on his side?	3. Right side
4. What kind of dial indicator, pointer or other type?	4. Pointer
5. Rectangular or circular type of dial?	5. Circular
6. Push-pull or rotary type controls?	6. Push-pull
7. Spherical or rectangular knobs?	7. Spherical
8. Larger or smaller radio grilles?	8. Same as existing

9. More or less chromium?	9. Same as now
10. Increased use of plastics?	10. No
11. What material for the panel?	11. Steel
12. Any change in size of glove compartment?	12. Larger
13. Grain finish or plain?	13. Both
14. Do you think the instrument panel has gained in importance?	14. As a sales point very important.
15. Any complaints?	15. Glare from chrome.

A STUDY OF THE INSTRUMENT PANEL

Introduction:

The automobile instrument panel is becoming more and more a case for satisfactory instrumentation on account of the increasing number of instruments and controls to be located on it. Space has limited the number of instruments used to somewhat less than what the buyer will probably like to have. This is a blessing in disguise since, otherwise, the danger of crowding off the more important instruments would be imminent, making it more detrimental to safe driving.

The advent of long-distance driving at higher speeds and the increasing night travel, have added to the requirements of the instrument panel. The increase in the size and accessories of the car have necessitated more control positions with an adequate over-all lay-out.

In addition, the panel design has to strike a medium between the utilization of the primary functions of the instruments of giving vital information on the performance of the car to aid the actual driving operation, and the styling combining the beauty of the instruments, their transparency, accuracy and motion, to form a balanced form, within the limits of the panel, to satisfy both the male and female buyers.

The problem of instrument panel design may be sub-divided into the following Sections:

1. A basic study of automobile instruments and accessories, their functions and relative importance in the over-all lay-out;

2. Survey of existing panel designs;
3. The manufacturers' requirements; and
4. The solution.

Automobile Instruments:

Automobile instruments are mostly contrivances to indicate the condition and performance of the engine which is the prime force operating the car. The series of essential instruments are:

1. Speedometer
2. Gasoline gage
3. Oil pressure gage
4. Battery charge and discharge ammeter, and
5. Water temperature gage.

Most of the modern instruments use the D'Arsonval moving coil milliammeter movements or similar principles. The D'Arsonval instrument movement has been highly developed and the instruments are sufficiently accurate. Very little service trouble is encountered.

Temperature indicators use thermocouple arrangement, with the Constantan-Copper leads placed under the spark-plug, the other ends fixed on the indicator at the panel.

Gasoline gages are mostly electric remote reading liquid quantity indicators, wherein a float operates a variable resistance changing the amount of current flowing through the indicator moving coil, according to the level of the fluid.

Speedometers that are tachometers having small d-c generators operated at definite ratio of the engine speed and connected to voltmeters calibrated in RPM, seem to be gaining popularity since 1945.

Oil pressure gages usually are instruments that pick up indications of pressure and movement close to the source and transmit these indications electrically to the gage.

All the instruments depend upon minute forces for their actuation and their operation may be impaired by shocks and vibrations. They have to be properly mounted and isolated from vibration sources. The usual practice is to use standard vibration-absorbing separators. This kind of mounting reduces the amplitude of vibrations picked up by the panel.

The style and size of instruments and their dials are not standardized for obvious reasons.

Accessories:

Of the important accessories that are usually found on the panel of modern cars, the following merit some discussion:

1. Radio unit
2. Light switches
3. Ignition lock and switch
4. Cigarette lighter
5. Heater control, and
6. Starter switch.

The automobile radio unit is very compact, specially designed for the car, and hence custom-made in various sizes, boxed to fit into the space available between the instrument panel and the fire-wall. The weights of these units vary from fifteen to twenty-five pounds. The speaker is usually an external separate unit, installed close to the inner surface of the panel. The speakers have been developed into circular or oval shapes, the former being more popular due to their alleged better fidelity. The average diameter is about seven inches.

Almost all the radios are provided with automatic press-button type selection as well as independent selection knobs. The press-button switch levers operate mechanically or electrically mechanisms that move the tuning condenser by the desired

amount of turn. Single switches that tune different stations at successive pressing, have also been developed as may be found on the Chevrolet 1941 models.

Light switches and heater controls have rotary or push-pull type controls with a relatively short action. Some of the light controls utilize both the push-pull and the rotary motion, the first to switch on different number of lights, and the second to increase or decrease the intensity of light. Most of these switches are sub-standard units that are usually installed together in a group.

Cigarette lighters which are now more or less standard equipment on all cars, use a heating coil that gets heated by short-circuit current when pressed into the socket. The unit pulls itself out of the socket by the action of the heat-expanding split sides.

Ignition lock and switch is a simple rotary type of sub-standard switch to which all the terminals of the electrically operated instruments and accessories are attached. Each car has its own standard type.

Starter switches are located on the panel on most of the modern cars, the tendency being to place them on the left hand side of the driver.

Manufacturer's Requirements:

Automobile production is based on the line system, the entire assembly being broken down into several sub-assemblies for fast production. In most cases the installation of the instrument panel is done in two stages--first, the installation of the

skeleton panel during the body assembly which is done in a more or less automatic assembly arrangement by body builders; and second, at the manufacturer's assembly plant as the first operation on the body after it is set on the assembly line. The assembly procedure that follows may be described as:

1. Install knobs
2. Assemble instruments
3. Tighten attachments
4. Fix connecting wires and rods to instrument lugs
5. Install radiator
6. Assemble hood and fenders
7. Install lights
8. Assemble body on engine
9. Fix floor and flooring material
10. Test operation of engine and response of instruments.

The chasis is placed on two side rails of the conveyer permitting entrance inside through the sides and from below before the floor is assembled.

Installation of instruments and wiring is facilitated by the availability of moving space behind the panel prior to the assembly of the floor.

So, it is imperative that the instrument panel be designed so that:

1. The panel board can be assembled during the body assembly;
2. Instruments can be assembled as a sub-assembly, preferably on the same mounting;
3. All connecting wire may be enclosed in the same casing or sheath to prevent loose wires from hindering driving screws or other assembly operations, or from scoring the sides;
4. Instrument sub-assembly shall be easy to handle and fix on to the panel;
5. All finishing operations can be accomplished prior to assembly;
6. Most of the joining operations, such as that of ribs and stiffners, may be done by easy operations like spot-welding.
7. Standard bolts, screws, etc., may be used in the assembly;
8. All materials used shall be easy to handle, process and assemble without getting scored or dented easily.

A Brief Survey of Existing Panels:

A study of existing panels will indicate that, except for a few cases, more attention has been given to the styling of instruments, placement of controls, and the design of the facia board, radio grilles and the clock. Although attempts have been made to take advantage of new materials and processes, few panels emphasize the unity of the functional theme. The efforts seem to have been directed mainly in creating a luxurious appearance by over-emphasizing design and beauty.

Summarizing the main defects in the various panel designs it may be stated that there has been:

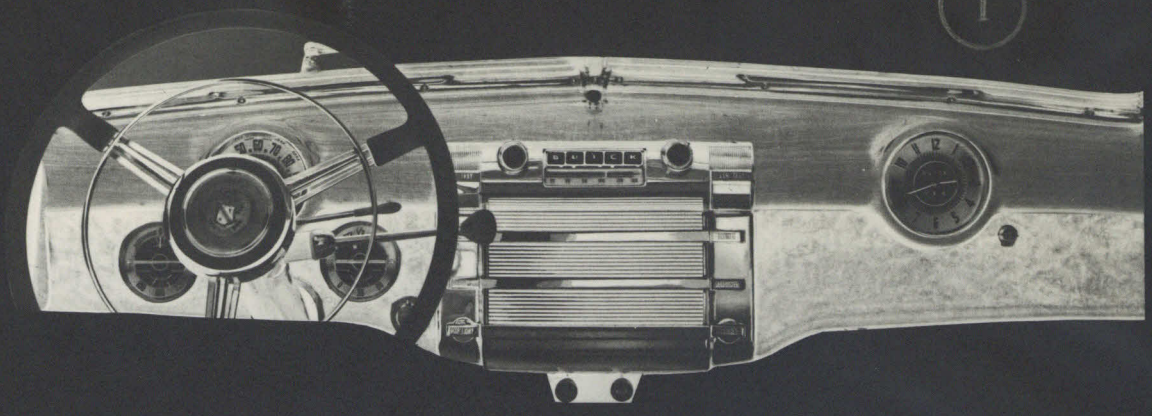
1. A liberal use of chromium on dials, grilles, etc., that has increased sun-light reflections, especially when the sun is in the zenith (Plate I and II top);
2. Unsatisfactory color combinations on dials which make it difficult to read the dials, color combinations that have been mainly guided by appearance (Plate I);
3. Improper locations for instruments; they are either too low or too far from the driver (Plates I and II top);
4. Cramping of dial readings (Plate III top);
5. Too many projections of control knobs which are still danger spots in case of accidents (Plates I and II)
6. Controls are scattered or located too low, necessitating slight stooping of the body or turning attention away from driving for their identification (Plates I, II & III);
7. Improper design of controls (Plate II bottom);
8. Over-emphasis of radio grille work, which serves no other purpose but supposedly enhancing the beauty of the panel (Plates I and II top);
9. Locations of clocks too far away from the driver, the size of the clock designed to balance the speedometer dial design (Plates I, II and III);
10. Insufficient room for the glove compartment which should be large enough to serve any useful purpose (Plate I);
11. No shock absorbing arrangements to assure some protection to the passengers along-side the driver.

Conclusion:

For an instrument panel to be functionally adequate and to be within the requirements of the manufacturer and the consumer,

the designer has to review the problem in terms of new materials, processes, and arrive at a solution which is simple, functional and efficient, and at the same time composed in such a manner as to be esthetically integral with the design of the rest of the automobile. An attempt to arrive at such a solution will be described in the following sections of this thesis.

1



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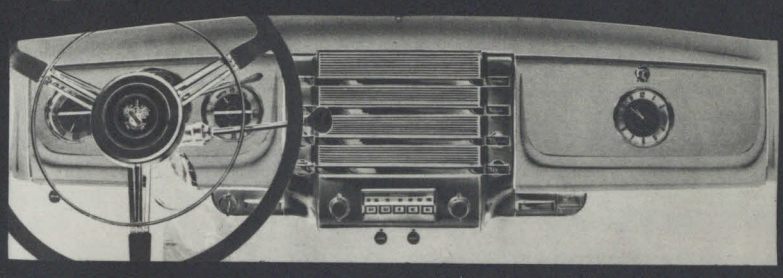

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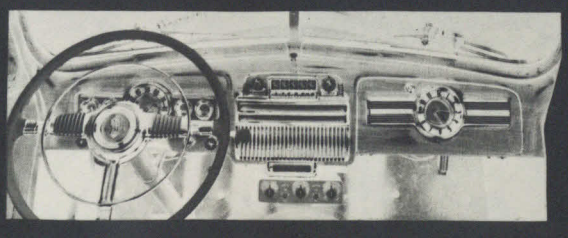

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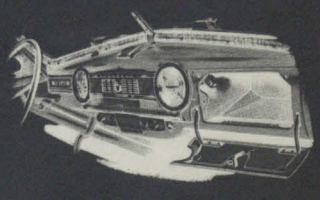
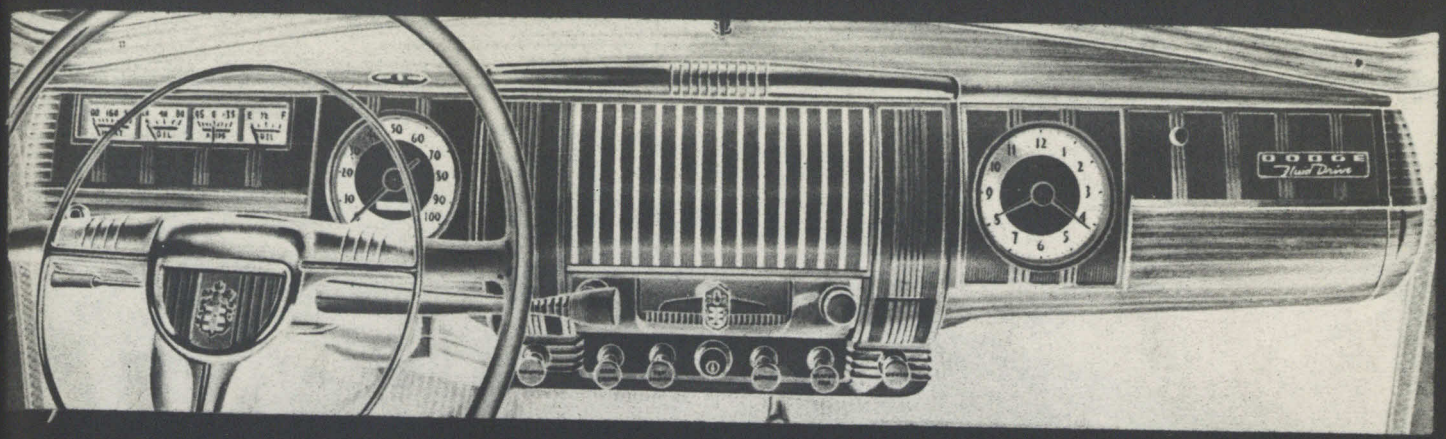


PLATE 1



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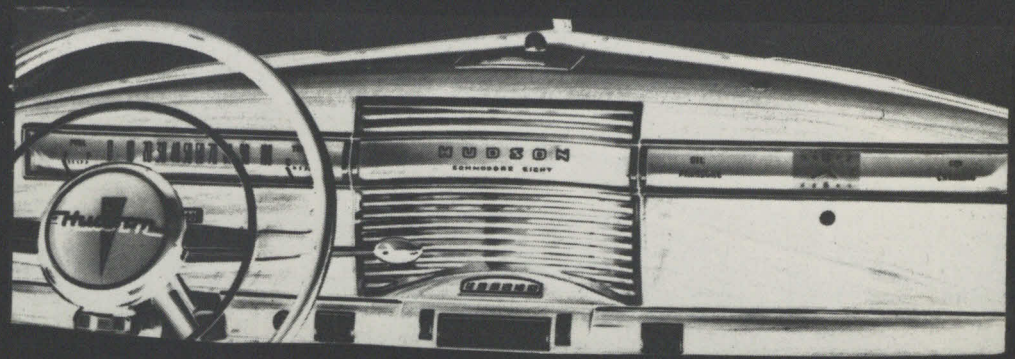

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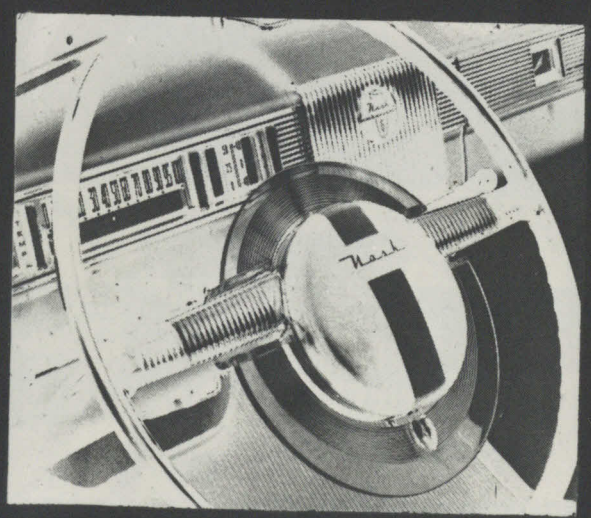

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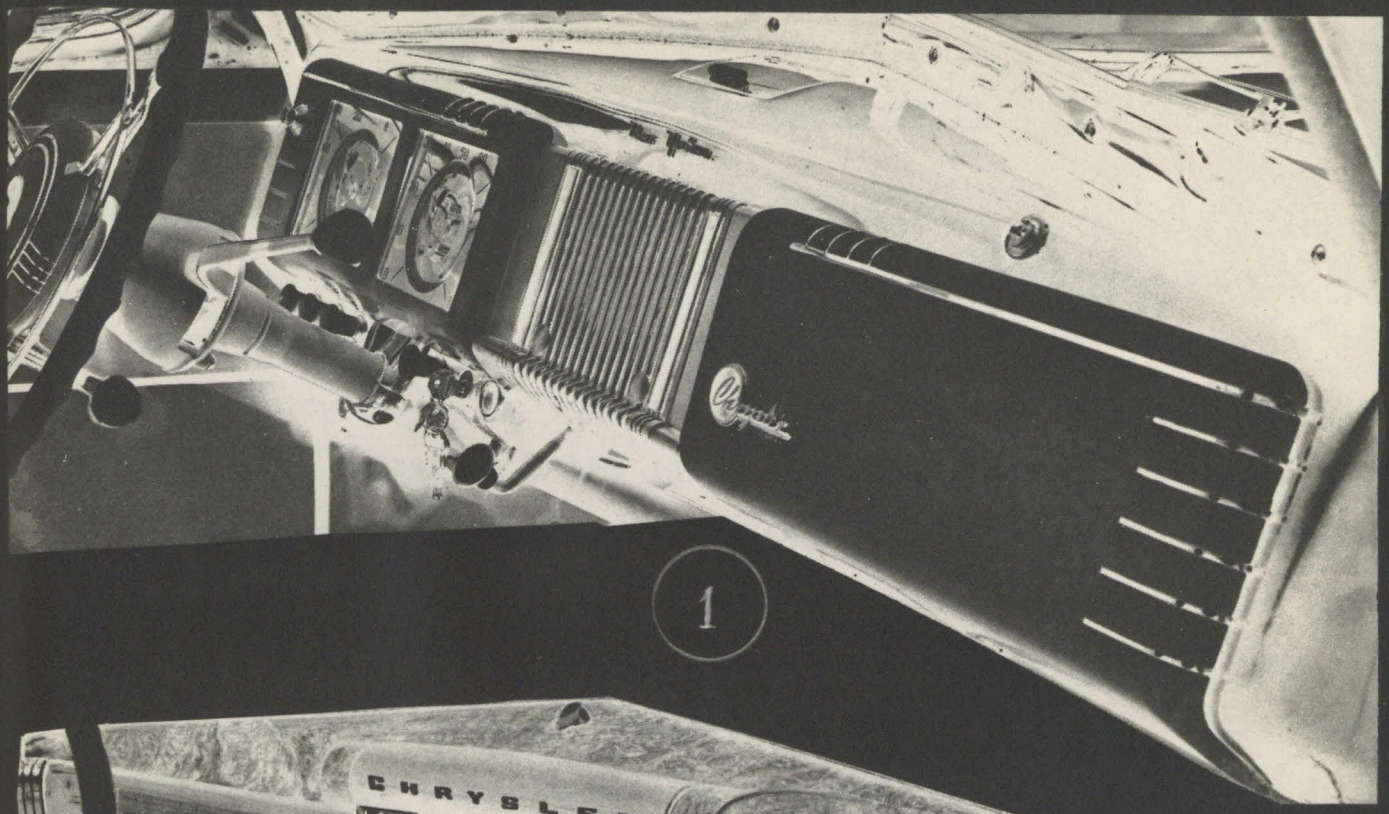
PLATE II



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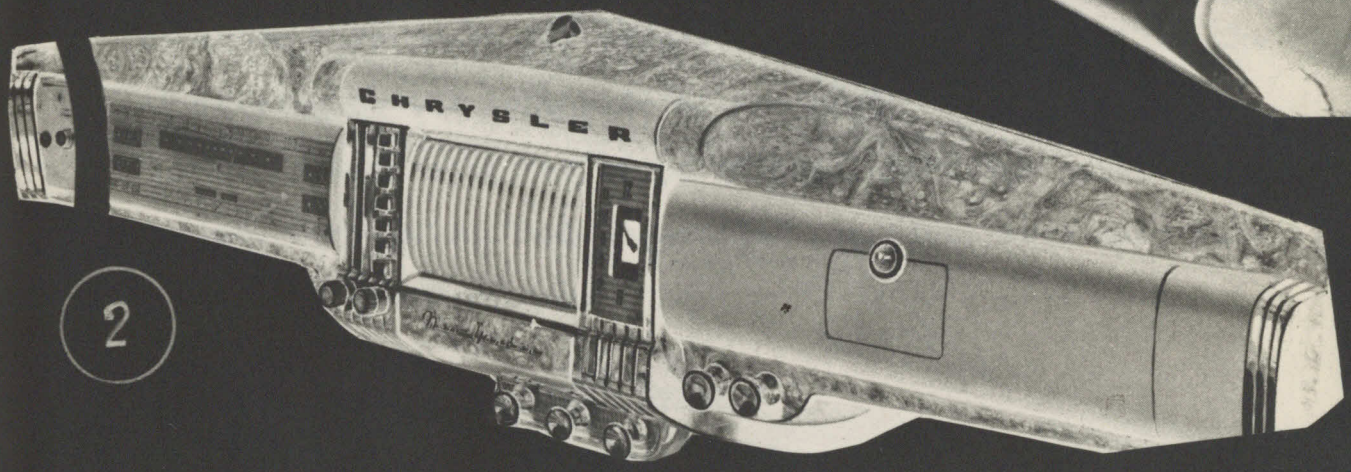

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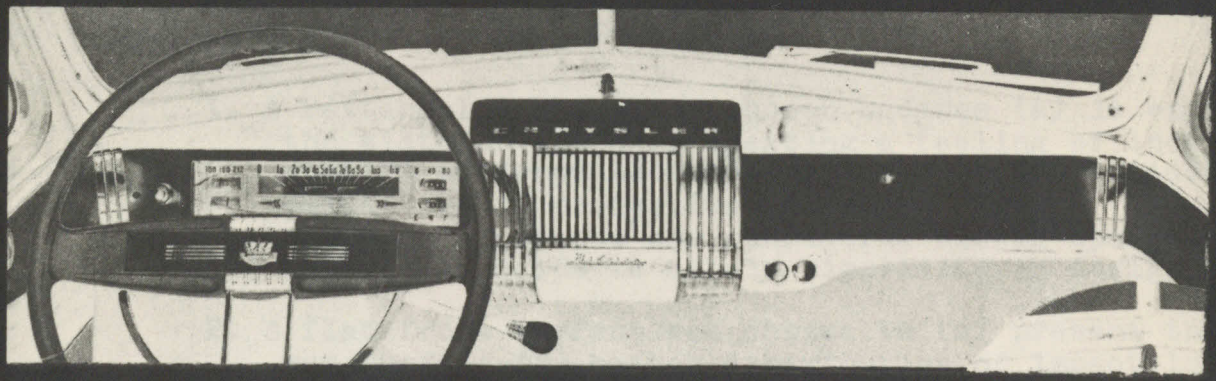

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PLATE III

SHAPE OF THE INSTRUMENT PANEL

Introduction:

The shape of the instrument panel in most of the modern cars may be seen to be basically rectangular, the variations made being mainly to conform with the stylized designs that have variously distributed the instruments and controls and appointments. It may also be observed that a certain amount of symmetry has been maintained in most of the panels about the central line for the sake of installing instruments on the right hand side, on those cars meant for export to countries that follow the rule of driving on the left side of the road.

In determining the shape of the instrument panel in subject design, conventions and commercial practices were made subsidiary to utility and function.

Shape of Panel in Subject Design:

(Please refer to Drawing Number 1-O.)

The following factors determined the shape in the subject design:

1. A rectangular shape was chosen because (a) it emphasizes the width of the car, creating a feeling of increase in seating accommodation and comfort; (b) it avoids complications in production, although rectangular shapes are considered slower operations; and (c) it helps to attain simplicity in design.

2. A flat front surface was chosen to (a) present the maximum surface for better distribution of impact loads in case a passenger hits against it in the event of a collision; (b) it prevents undue reflections from all directions especially from shiny surfaces; and (c) helps in spot-welding of stiffners and mounting of accessories.

3. The flat surface was inclined 15 deg. to the vertical to (a) bring the instruments and accessories as closely perpendicular to the line of sight when viewing the panel; (b) offer a greater surface to the striking body in case of collisions; and (c) provide more knee space for passengers.

4. The side of the panel facing the driver is brought forward three inches to bring the instruments and accessories as near to the driver as possible without in any way interfering with the operation of the gear shift lever under the steering wheel.

5. Liberal bend and corner radii were given to (a) improve esthetic qualities of the design and (b) to facilitate sheet metal drawing operation.

6. Independent suspension mounting designed for shock absorption as described under the section on "Shock Absorption."

(The idea of symmetrical design was not considered important in view of the fact that establishment of assembly plants in the countries to which cars are now exported is favored. This will make it imperative to manufacture items like the instrument panel on the spot.)

CHOICE OF MATERIALS

Brief Survey of Use of Materials:

The automobile industry has applications for many of the more important commercial materials such as steel zinc alloys, and plastics. These applications may be summarized as follows:

1. There has been an increased acceptance of steel for the construction of all primary structures, the chasis, and many of the secondary structures.

2. On account of shortage of steel plastics are finding additional applications. Mostly acetates, acetate butyrates and acrylics are being used for applications as instrument cluster panels, clock panels, dials, etc.

3. Laminated plastics are finding extended applications in the larger parts, and experiments are still being conducted to build complete chasis out of fiber-glass laminates. Paper laminated plastics have been used for interior panels, fenders and baggage compartment doors.

4. Die-castings show indications of decreasing in favor, especially because of the extreme popularity of stampings during the war emergency. Steel stampings well handled, have been found to compare favorably with die castings in crispness of detail.

Case Against Use of Plastic Molding for Instrument Panel:

Although much has been said about plastic automobile bodies, the matter is still in the experimental stage. As far as plastic instrument panels are concerned no American car has exhibited one yet. The panel itself is made of sheet steel, with large plastic parts such as the glove compartment door molded over steel, as may be found on Chrysler cars. (See Plate III). Other factors against the use of plastic molding for panel construction are:

1. Inferiority of plastics in strength as compared to steel. They are relatively brittle, and they have not reached the ductility and toughness of steel.

2. Plastics are impractical to use for deep molding. Time of setting for molding of laminates is too long (seven minutes to fifteen minutes), which would be uneconomical. Moreover, other manufacturing operations such as blanking, drilling and fastening of parts by rivetting are not possible without a laxity in quality control.

3. Faster colored plastic laminates are costly, and most of the forms of plastics which come in transparent and translucent colors range in prices between thirty-five cents and one dollar per pound. Even on a strength to weight basis they nearly all cost more than metals.*

Material Specifications for Subject Design:

Instrument Panel:

S.A.E. 1010 or 1020 steel is recommended. Thickness: .064 inch. This material is procurable as cold-rolled sheet steel and is the preferred stock in automobile industry. Deep draws as the one required by the subject design can be successfully made probably in a single operation if the hardness of the stock does not exceed Rockwell B 50.**

To be bonderized and finished as described in the section on "Colors and Finishes."

All Control Knobs:

Use cellulose acetate butyrate plasticized ester compound (Tenite II or Rexenite). This plastic has lower moisture absorption than most of the other thermoplastics, better weather resistance, high impact strength, improved finish and luster, resistance to distortion, and is available in a variety of colors by using acetate dyes.

It can be injection molded rapidly, and machined easily.

Holding Strip and Push Lever Knobs:

Same as above.

Instrument Dial Face-plate:

Anodized 24 S-T Aluminum alloy sheets 1/8 inch thick. Easy to print colors on surface. Material has high tensile strength (66,000 lbs/sq.in.)

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* "Plastics vs. Metals"- Metals & Alloys. June 1946

** "Production Processes--Their Influence on Design" - Bolz Pages 44-45

Dial Number Plate:

Use methyl methacrylate sheet, clear. It is hard, tough, thermoplastic that can channel the light. Thickness 1/8 in.

Fabrication technique using this material is comparable to present sheet metal methods in economy.

To be formed to shape by the "grease-forming" or equivalent method.

Cut-out Cover Plate:

Laminated glass 3/32 in. thick.

Crash Padding:

Semi-hard Koroseal No. 3 extrusion 3/32 to 1/4 in. thick. This material is available in various colors, and is highly resistant to water, heat, solvents and sunlight; it has stamina against aging.

To be bonded to the panel by using Goodrich Rubber Cement C-316-B or equivalent. This is a non-vulcanizing, air-drying cement, that can be applied to the metal surface, the padding placed on the surface and rolled over tight.

LAYOUT OF THE INSTRUMENT PANEL

Intruduction:

The layout of the instrument panel should be a proper arrangement of instruments and accessories mainly on the basis of their functional importance in order to have the most efficient arrangement for the convenience of driving. Such a layout may be evolved by a point-by-point consideration of the factors involved. Existing designs reflect some of the guiding factors, though there are deficiencies that have to be rectified and some additional features incorporated to satisfy the customer's demand.

Primary Factors Involved:

The location and general arrangement of the various instruments, accessories and controls can vary widely, but are mainly governed by:

1. The sizes of items and the space available;
2. The sequence of importance of instruments and others with which they are associated;
3. The type of automobile;
4. Restrictions imposed by the human element, and the convenience to the driver and passengers.

Secondary Factors:

In addition to the primary factors mentioned above the following secondary factors are also to be considered:

1. Vibrations and shocks;
2. Standard type of mountings;
3. Standard control systems and their required locations.

Instruments and Their Location - A Discussion:

Standards have not been established in automobile instrument design, and their sizes and forms have generally followed the

theme of the panel for that particular model. Instrument manufacturers consider it economical to retool for either modifications or complete changes in instrument design since production orders for instruments normally run into tens of thousands.

Although the lack of standardization of instrument design opens a broad field to the designer, it has increased the possibility of the hazard that styling may submerge the functional aspects. Cases where such unfortunate laxity is shown are not hard to find amongst the existing designs.

Inasmuch as the instrument panel is also a place wherein the driver seeks a sensation of restfulness and repose--it being always in front of him--perhaps more cognizance of the likes and dislikes of the driver has to be taken.

But, in spite of the fact that an average consumer--especially the female--desires to feel that the automobile is a very complicated gadget requiring careful and intelligent handling, the fact remains that from the point of view of easy and safe driving, it is better to have fewer instruments and controls. "Regarding essential instruments it seems reasonable to assume that the tendency will be towards a decrease in the number of separate units."*

Of the instruments, the speedometer is definitely of prime importance, and should be given a special consideration if prosecutions for over-speeding, and the incumbent traffic hazard, are to be minimized. Resolving the problem of the speedometer into its effective components it can be seen that:

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* "Instrument Location" - Automobile Engineer, March, 1941

1. The speedometer view should be unobstructed;
2. The dial should be such as to enable calibrations wide enough to make reading easy and not confusing;
3. The location should be such that at no instance the driver has to withdraw his eyes from the line of vision too long to get an accurate reading.

Indirectly affecting the panel lay-out is the design of the steering wheel. Almost all the modern cars have steering wheels which are, in effect, horizontal spokes joined to the wheel rim, the spokes remaining horizontal when the car is steered straight, thus giving the driver an open view of the section of the instrument panel in front of him. The most logical location for the speedometer would then be the space directly in front of the driver, in line with his direction of vision.

Another suggestion that has been made by a number of designers in the past, and still seems to be slightly favored by some, is to mount the speedometer on the central embossment of the steering wheel, directly under the driver's eye. This arrangement will have the following serious disadvantages:

1. A bigger diameter of the steering wheel boss will be necessary;
2. A deeper boss to accommodate the speedometer will entail new manufacturing problems;
3. Rigidity of the steering column necessitated by the embossment may be detrimental to the safety of the driver in case of accidents; and
4. Assembly and dismantling of the speedometer may not be easy.
5. The main instruments will not be in line of vision.

Most of the existing panel designs indicate a trend in the location of the speedometer in front of the driver, though some still prefer placing them to the right of the driver and increasing their size and the size of their numbering, as can be clearly seen from the Picture Plates I, II and III.

The location of the gages that are associated with the speedometer is naturally alongside the speedometer. The lay-out

can be made in such a manner that the more essential gages are kept next to the speedometer, thus enabling a quicker co-relation of the condition and performance of the engine and accessories. The instruments may be assembled in a group on a dial panel and then installed on the instrument panel as a single unit. This arrangement will also give the additional advantage of lending itself to quicker assembly on the bench and an easier assembly on the panel, saving many man-hours.

It is perhaps worthwhile at this stage to consider the case of the combination type of instrument wherein all the gages are integrated with the speedometer, or a group of them are placed on the same dial. This type of instrument was in vogue inmany cars in the late thirties, and is still favored by designers of Continental cars, especially for the smaller types.* It is stated that:

1. This makes a compact arrangement possible;
2. There is better visibility,on smaller cars;
3. By this arrangement there will be a saving of material, space, and man-hours in installation; and
4. Small cars are seldom capable of attaining speeds comparable with the bigger types, and therefore safety features will be less potent on them;

But the same cannot be said of American cars, and it will therefore be inadvisable to use such an arrangement which is bound to create confusion in reading. A minor, but nevertheless important, defect with this arrangement is that if one of the instruments has to be repaired, the entire unit has to be removed from the panel.

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* "Placement of Instruments" - Automobile Engineer, Sept. 1941

Taking the case wherein instruments are laid out as separate units as is found in Plate I, it can be seen that in such instances the advantages may be:

1. Effective isolation of important instruments from the less important ones;
2. Increase in dial surface area possible, and therefore more clearly legible lettering can be used;
3. And flexibility of arrangement of instruments to some extent.

But, in the opinion of the writer, the following disadvantages off-set the advantages:

1. Apparent lack of balance and unity in design;
2. Separate lighting for individual instruments necessary;
3. Too many cut-outs spaced close to each other;
4. Combination of gages necessary in order to reduce the total number of instruments; and
5. The final arrangement will necessitate staggering or lowering of instruments, which is not conducive to safe driving.

From the aforesaid considerations of the instruments, their locations and their general arrangement, the following conclusions have been drawn and incorporated in the design: (See Drawing No. 1-O.)

1. The speedometer being the guiding instrument, should be placed directly in front of the driver, and as near to his line of sight as possible;
2. The fuel gage being the next in importance and the one more frequently referred to while driving, should be placed next to the speedometer and on the right hand side of it, that side being the one mostly attended to by the driver;
3. The oil-pressure gage is to be considered next in importance, and is probably the one that should be referred to more frequently by the driver; it should be placed next to the fuel gage and on the right side;
4. Charging and discharging of the battery being the one that would worry the driver constantly, it should be placed next to the speedometer on the left hand side;
5. The temperature indicator comes next, on the left hand corner.

Instrument Mounting and Dial Design:

In order to facilitate group-mounting of the instruments in the sequence mentioned above, the rectangular dial was chosen.

The dials are single plates which are designed as indicated in Section AA of Drawing 1-O. The body of the instrument is mounted at the back of the dial plate permanently by the instrument manufacturer and the individual instrument installed in the box cut-out as shown in Drawing 1-O. Although face-mounting (or front-mounting) has the advantage of ease of replacement because the back of the panel need not be accessible, it has the disadvantage of placing the mounting flange on the front of the panel which will hinder indirect lighting. Also instruments are seldom removed for repair or replacement. So, back-mounting has been chosen, with the flange on the back side of the mounting panel, with an arrangement for bolting the assembly to the mounting panel as shown in cross-section AA. Instruments are removable individually without making the rest vulnerable.

Included in the instrument dial series is the radio dial, which will be discussed later in the section.

The next step taken was to devise a means for discrimination between the dials. The speedometer has to be the "eye-catcher" everytime the driver's eyes scan downwards, and at the same time an effective means of breaking the continuity of the line of dials has to be introduced.

The public attitude towards colors is changing, and colors have awakened a new interest in interiors. A proper use of colors cannot only accent letter legibility, but also can enable the eye to distinguish similar objects placed together. This

fact was utilized in the design of the dials as can be evidenced in the rendering presented. The speedometer is of a light color, a reddish-gold background, with deep maroon lettering and numbers. The gages and radio dials have lighted backgrounds with a lighter maroon lettering.

Howard Ketcham has reported interesting facts from research conducted on color contrasts for letter legibility.* He states, "When one color appears on a background of contrasting color, the lettering should be separated from the ground color by an edging of lighter color."

He has also given some rules of value that have proven to be of help in industry already, of which the following may be quoted:

"Lettering on a gold background should be separated from the ground color by an edging of a darker color."

Light fast maroon colors were chosen with an edging of black on reddish-gold background for the speedometer, and with no edging on lighter background for other instruments.

Speed-range Indication:

Several methods have been suggested and tried on the panel to render the driver conscious of the speed range at which he is driving, thus indirectly inducing him to stay within the safe range. Of these methods the red-spot indicator placed in the speedometer or at a conspicuous place, and the spot that travels over a lighted arc below the speed-indicator disc giving it a green or yellow or red color depending upon the range wherein the indicator is, are common.

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* "Color" - Howard Ketcham, Automobile Engineer, Jan. 1940

Of the two methods the former one wherein the red spot appears at ranges above fifty miles per hour is the better, since a tiny spot moving along with the speed indicator is likely to impress less after some familiarity with it, and may be taken only to be the position indicator for the needle pointer. But the first method necessitates additonal electric equipment.

The method used in the solution of the problem consists of a band one-eighth of an inch wide, located above the speedometer numbers and using light-fast, light-reflecting material that is colored green up to the thirty miles per hour mark, yellowish-white up to the fifty miles per hour mark, and red for the rest of the speed range. The writer claims that this method will be very efficient, since the identification of color is in this case always tied up with the speed range, and cannot escape observation while checking the speedometer reading.

The Radio Unit and The Dial:

The radio is becoming more and more an essential home furnishing and is almost a "must" item on all the medium-priced and high-priced cars of today. There are but a few cars that are without a radio unit in any city of the United States, not excluding the rural towns. Although the writer could not furnish statistics to give the exact percentage of total cars sold that are equipped with radio units, it can at least be argued that automobile designers of today have definitely to fulfil the requirement of making provision for the optional inclusion of a radio unit on the panel of any car. It is also obvious from the existing panel designs that much effort is being expended to

impart a distinctive appearance to the panel by virtue of the appearance of the radio grille.

A look at the instrument panel designs (See Plates) will definitely indicate that emphasis on the grille design is becoming the central point around which the rest of the design is evolved. Much of the panel space is being utilized for the grille spread, many times at the risk of placing control knobs too far apart and outside the easy reach of the driver.

A survey of the existing radio units will indicate that, once again, no positive effort has been made by manufacturers to standardize the equipment. Units weighing between fifteen and twenty-five pounds are found, the outside dimensions of their enclosures also vary considerably from car to car.

Statistics have shown* that more than sixty percent of the total mileage made by an average passenger car is used for business purposes and therefore used by one person--the driver.

The following conclusions were drawn from the foregoing observations:

1. The radio unit, though classified as an optional item, is universally accepted by consumers as a necessity;
2. The radio grille, while it has accorded an opportunity to bring novelty and style in design, has been over-emphasized on most of the existing panels, and should be given less prominence;
3. In the interest of the driver, the radio dial should be kept in close proximity to his line of sight, and the controls should be within easy reach of the driver;
4. Automatic tuning system should be incorporated to minimize the necessity of looking at the dial for tuning some of the main stations; independent tuning system should also be provided, for accurate tuning as well as for tuning other stations;
5. Ease of operation should be given full consideration.

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* "Automobile Facts and Figures" - A.M.A. Publication - 1939

As in the case of instrument dials, the most logical place for the radio dial will be in front and slightly to the right of the driver. The system designed by the writer is as shown in Drawing No. 1-0 where:

1. The switch, marked S, is placed on the right hand side of the driver;
2. The automatic tuning knob AT--is placed at the center;
3. Tone control knob T is on the left hand side of AT;
4. Independent tuning knob IT is placed on the extreme right hand side so that there is no interference in the reading of the dial while tuning; and
5. The tone-loudness control L is placed on the extreme left hand side.

As may be seen from the Drawings No.1-2 and1-3 the central knobs are rectangular and have been separated by red vertical bands for quick perception of their location. They are operated by pressing them down. The round knobs use rotational movement for their operation for obvious reasons. They have also been banded for quick identification.

Loud Speaker and Its Location:

Three locations have been tried for the loud speaker:

1. In the header above the wind-shield;
2. On the fire-wall or the dash; and
3. The instrument panel.

The header position has the advantage of better distribution of high-frequency responce in the back seat than the other two positions, but on account of the small volume behind the speaker the low-frequency responce is usually attenuated.

The location on the fire-wall has the serious defect of poor distribution of high-frequency response at the back seat.

The most convenient position will be on the instrument panel, because here the loud-speaker, the radio receiver and the

controls can be combined into a single unit, and the sound distribution is excellent in the front as well as back seats.*

The subject design uses a location central to the panel which will not keep the speaker too far from the driver, but on the other hand will minimize the possibility of distracting his attention since it is beyond the off-set.

A loud speaker (of seven inch diameter) is used.

A feature of the radio grille is the complete omission of all superficial chrome work, with only four rows of rectangular perforations which emphasize the general theme of creating the feeling of length, and creates an impression that sound emanation will be without obstructions.

Radio Unit and Loud Speaker Mounting:

The standard mounting method wherein two tubular supports threaded at both ends are fixed to the radio at one end and attached to the instrument panel at the other end by hexagonal nuts is used in the subject design (See Section B-B, Drawing No. 1-O). The tuning and volume control lever rods carrying the knobs at the other end are located within these tubes. This method was favored after it was found that radio service men considered it as preferable for easier dismantling of the radio unit, since internal bolts and nuts need not be reached for detachment.

The loud-speaker is installed in a simple manner by bolting it as shown in Section C-C of Drawing No. 1-O.

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* "Elements of Acoustical Engineering" - Olsen, Page 299

Both the radio unit and the speaker are isolated from instrument panel vibrations by rubber strips as shown.

Instrument Lighting (A Discussion):

The problem of lighting and color backgrounds has been resolved into its basic components, and studied more from the point of view of the adaptability of the human eye to quick-changing conditions as in the case of persons driving at night. This problem has probably been better attacked in the aircraft field than in the automotive field, and it is therefore worth-while reviewing research findings of lighting engineers in that field.

Analyzing these reports it may be said:

1. The human eye does not possess the ability to see the brightness and colors of objects in the same manner. Vision can be described as foveal and para-foveal, the former being the capability to see colors in bright light, and the latter, the inability of the nerve rods to distinguish color as in the case of approaching twilight when colors seem to fade into grays increasing in blackness;
2. The best approach to the problem will be to increase the driver's ability to see the instrument panel with extreme clarity when looking straight at it and yet have none of the instruments or objects stand out which is not in line of vision. The eye should not be confused by reflections from the panel when looking outside;
3. Photo-chromatic interval should be kept minimum;
4. The ability to see objects at the side as well as the objects being inspected, termed the ratio of para-foveal to foveal vision, should be low. This is found to be for

blue light	500
green	200
yellow-orange	10
red	8

which means that blue and green colors are poor for night vision since the dark adapted eye may see these markings something like a blur at a reading distance, and that red color offers the best quality regarding side vision.

From the above discussion it will be evident that for best results in instrument lighting three main items are to be considered: (a) few markings, (b) large letters, (c) and proper color.

Systems of Lighting:

Three main systems are followed for instrument lighting both in the automotive and aircraft industries:

1. Masked lighting;
2. Ring lighting; and
3. Ultra-violet lighting.

Masked lighting is indirect lighting by diffused multiple reflections between a mask and the panel. The mask covers a light-conducting rod behind the contoured mask. The color of the light may be controlled by using filters on the light source, or by using colored plastic. Defects in this system are that close tolerances are to be held for the contours of the mask, the instrument cut-outs in the mask must be such as to obviate the effect of paralax, and the shape of the mask must be further controlled to prevent harmful reflections from the dial surface.

Ring lighting is commonly used with instruments that have circular dial faces, by placing a light-conducting plastic ring round the periphery. This method can no doubt be used for any type of dial faces. The defect that is mostly encountered in this system is a lack of uniformity in lighting of the dial surfaces.

Ultra-violet lighting is perhaps the most popular system today. This utilizes the well-known luminescent property of phosphorescent and fluorescent paint materials that glow when ultra-violet light or incandescent light is thrown on them. Of the two, fluorescent paint is preferable for many applications on account of the availability of such paints in many colors.

Instrument Lighting On Subject Panel:

Following the conclusions deduced from the discussion on

lighting systems and requirements, a new system was evolved incorporating all the good points from the various systems. This system consists of:

1. Two sanded ¼ in. acrylic rods running across the length of the dial panel are end-lighted by a 6-volt, 15 candle power lamp on each end as shown in Figures 4 and 5. The rods light the surfaces of instrument dials. (Lamp specification: 2 pin-bayonet Candelabra Base, No. 88, Fed. St.);
2. A plexiglass dial number plate with embossed letters and numbers on it that are filled with deep maroon paint as shown in the rendering is fixed to the panel by the side flanges, the horizontal flanges rubbing against the acrylic rods. The light transmitted by the rods is picked up by the etched sides of the number plate and conducted across, illuminating the pigment in the embossment.
3. The color system chosen (See Page 38) for the background color on the instrument faces and the numbers give clarity and vividness to the reading of the instruments.

The effect of edge-lighting of plexiglass has been clearly shown in the mural edge-lighting exhibition conducted by Rohm & Haas Company in 1946.*

The Case of the Clock:

The clock has found a place on the instrument panel since the late thirties and has been, for no adequate reasons, considered an accepted accessory on every panel. In the opinion of the writer the inclusion of the clock in the panel design is no longer warranted, and its elimination should be considered seriously for the following reasons:

1. Almost every person carries a watch and it is definitely reasonable to assume that every car owner owns a watch.
2. It is everybody's experience that a wrist or pocket watch is a more reliable and convenient source for finding time than a clock located some place on the panel.
3. It is also common experience that most of the clocks do not function properly, whether they are mechanically or electrically driven.

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* "Edgelighting Murals" - Plastics, Nov. 1946, pg 30

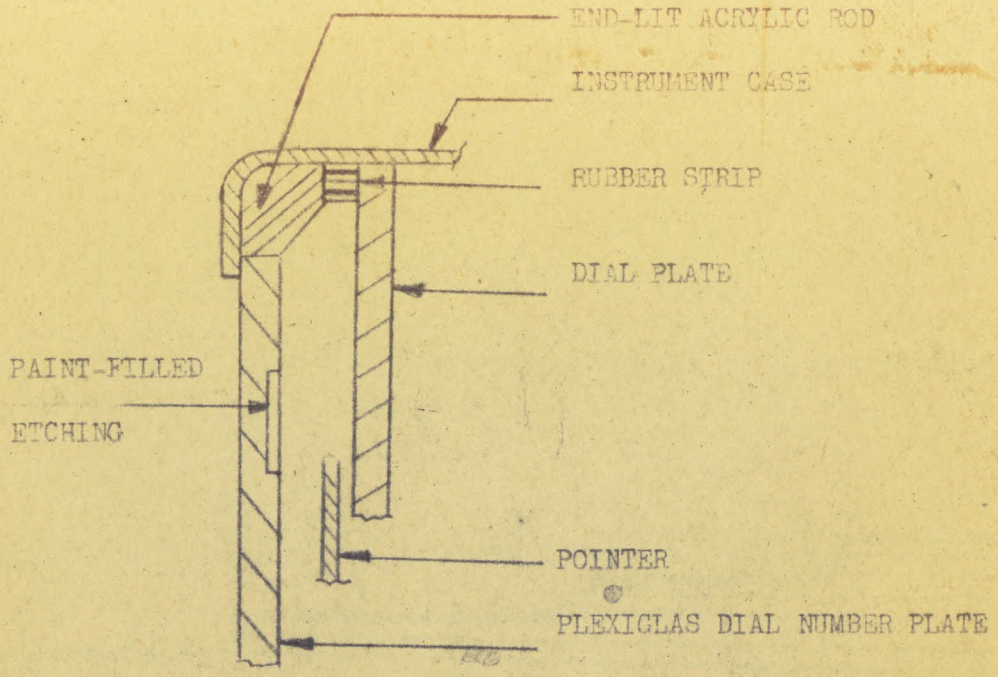

Figure 4

ILLUSTRATING LIGHTING PRINCIPLE USED ON PANEL

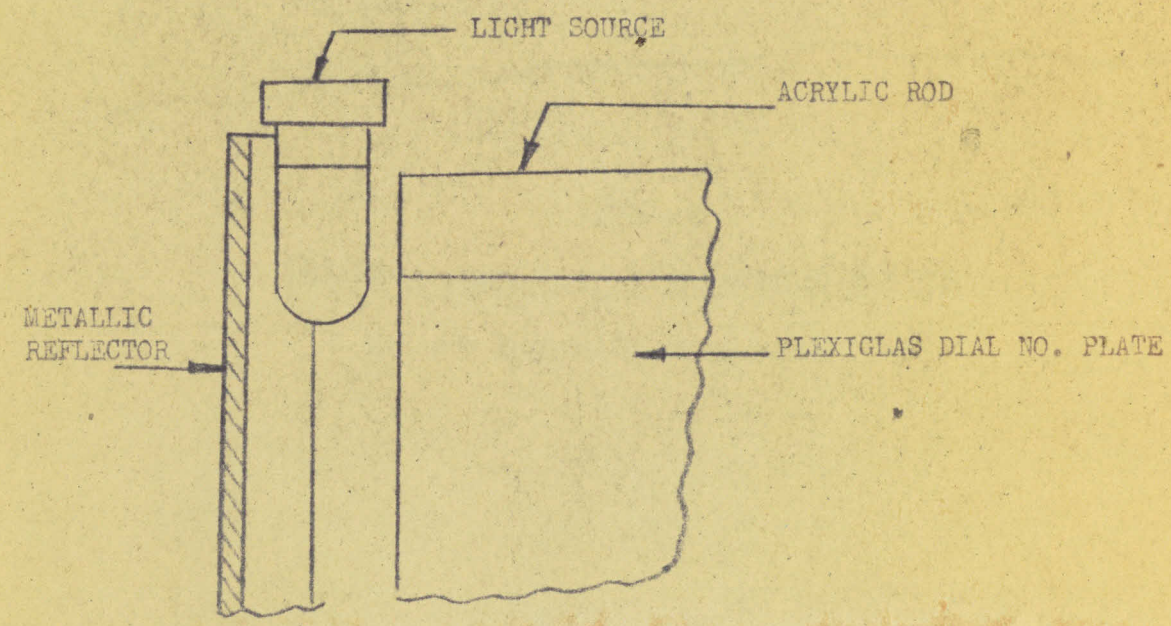

Figure 5

ILLUSTRATING END-LIGHTING SYSTEM USED

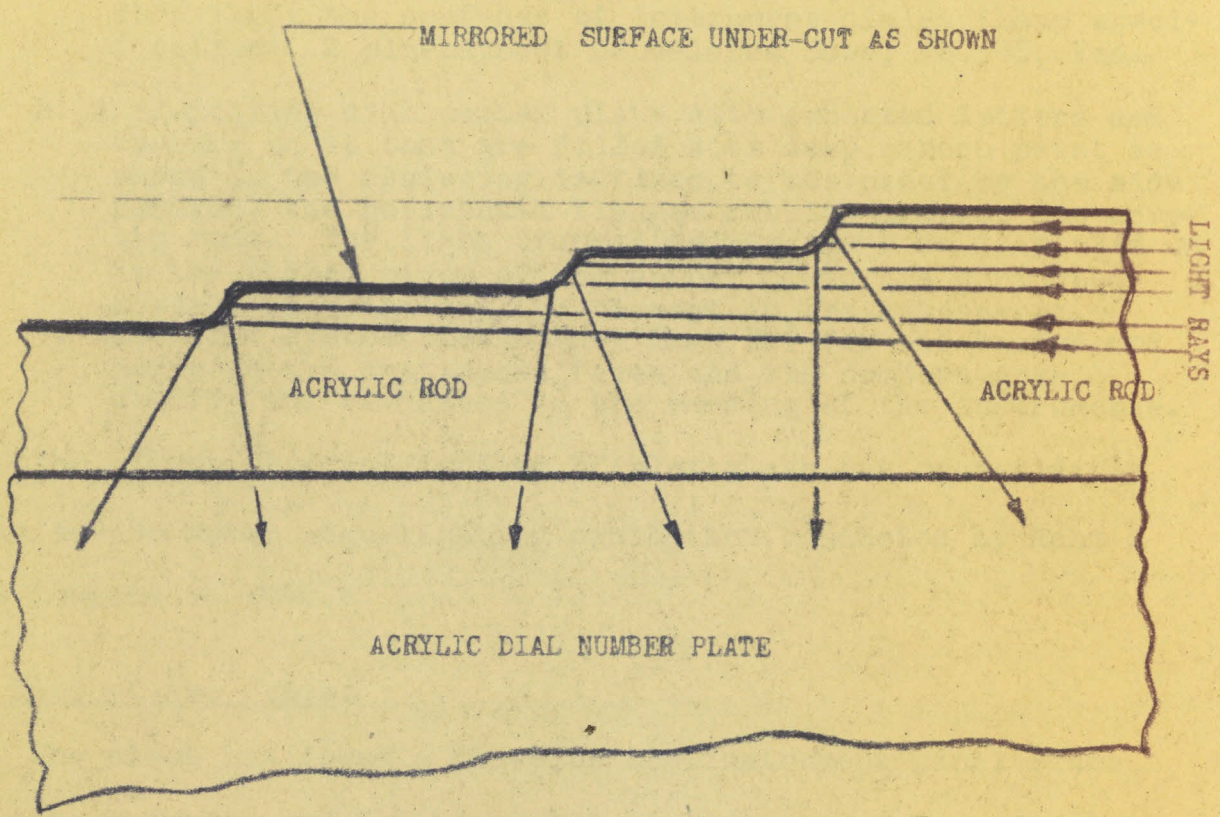

Figure 6

SUGGESTED UNDER-CUTTING OF ACRYLIC ROD FOR

MAXIMUM TRANSMISSION OF LIGHT

4. An average owner does not wind the clock or set it to time, mostly because of the awareness of a watch on the person; and
5. A clock that ceases to work, ceases to be an ornament, if it is meant to be one.

In the subject design, therefore, the clock has been omitted altogether. It is suggested that it may be used as a substitute on cars that are purchased without a radio.

The Glove Compartment:

The glove compartment in the subject design has a width of 13½ inches and a possible average depth of 10 inches and height of 7 inches.

Push-button locker usedhas a hollow strip on either side which permit a second-and-third-finger hold on the door to pull it open while the thumb pushes the lever down. This will definitely obviate the necessity to hammer on the lever button head that has injured many a delicate palm.

The interior of the glove compartment will be lighted automatically when the door is opened by means of a lever as indicated in Section D-D of Drawing 1-O.

COLOR AND FINISH

Color:

The trend in automobile finishes is having a further swing towards lighter colors as may be evidenced by the number of light grays used in 1946 - 47 cars. In the years 1940 and 1941 manufacturers reported sales percentages based on color as:

Color	Percentage
Black	26.0
Light and deep gray	10.2
Maroon	7.7
Two-toned olive green	7.7
Deep gray	5.9
Pearl gray and black	4.7
Deep green	4.5
Light and dark blue-green	4.4
Others	28.9

The demand for black has been reported to be dropping since 1941 and shades of green increasing in popularity.

The colors used in the interior generally match and are ranged according to the upholstery and trim. The color scheme for the panel will, therefore, be guided by the color scheme chosen for the car. In general it may be said that it will be more gray in shade than the outside, making it possible to use the same color of the panel for allied colors of the exterior.

The color of the crash padding should be a darker tint to give a beautiful two-tone color scheme with the panel. In case the panel itself has to be given a lighter shade, then a combination of exterior color for the panel and a two-tone matching color for the padding will give the desired effect.

It is suggested that reddish-brown color be chosen for the plastic knobs with a deep red or maroon for the strip lining.

The color scheme for the instrument dials has been discussed on page 38.

Finishing:

Automobile finishes are considered in respect of their stamina to resist sun-light, moisture, extremes of weather, chemicals and abrasion.

From the manufacturer's point of view, for quicker production schedules the finish should be able to give a sufficiently mar-proof surface on short baking schedules.

The answer has been found in the alkyd-type lacquers with higher solid content and high-grade pigments, which are almost universally used for automobile finishes today.

As far as the subject panel is concerned, the common practice of using decalcomania facing on the sheet prior to fabrication may not be feasible in this case, since the draws are rather deep. So it is suggested that alkyd enamels be used on the outside of the panel after the whole draw has been bonderized. One or two coats of the enamel can be given to be followed by baking for one hour at 250 to 260 degrees F. to give a smooth and glossy finish without rubbing or polishing.*

The finishing operation must be done before assembly.

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* "Modern Organic Finishes" - Chemical Pub. Company

INSTRUMENT PANEL AS SAFETY AID

Introduction:

The appalling number of increasing fatalities due to automobile accidents has brought the matter of safety to the fore. The establishment of the National Safety Council, that has since been organizing many safety councils, with full-time staff to carry on its activities, is a further indication of the serious attention given the problem.

Definite contributions are being made to curtail the number of accidents by new applications of traffic signals, extension of speed regulations, etc. The best way of prevention of accidents probably lies with the reasonableness of the driver.

The automobile designer is attacking this problem more from the angle of saving lives in case of accidents. The first positive step taken was the provision of front and rear bumpers that take the impact collision load and transfer it directly to the strong frame at a favorable deceleration speed.

Studies of air-crash fatalities have shown that more lives can be saved if more attention is given to the safety design of the interior immediately surrounding the pilot and the passengers. The case of the automobile is substantially the same, and a proper design and mounting of the instrument panel and the rear of the front seat can surely save people at least from severe injuries.

This section will deal with the solution suggested by the writer for the shock-mounting of the instrument panel.

Factors Ignored in Many Designs:

Hugh DeHaven* who has made very detailed reports on his findings concerning air-crash fatalities, states:

"Force of many accidents now fatal is within physiological limits of survival," and that, "needless injuries--both serious and fatal--are caused by the unfortunate placements and design of certain objects and structures."

The attitude of certain designers seems to be one of acceptance of injury and fatality as a reasonable expectation in all crashes. There are few records maintained of the number of accidents that are truly survivable.

Medical research has proved that the human body can stand tremendous forces for brief periods if given reasonable protection. Decelerations of 100g at speeds stopping motion at fifty miles per hour within six inches, have been withstood without injury. At the same time it is very significant that, according to the report of the National Safety Council, forty percent of the fatalities in the urban districts occur at speeds less than twenty miles per hour, and seventy percent of accidents involve speeds not more than thirty miles per hour. The momentum of the body and head if not checked during an abrupt deceleration of surrounding structures, will impart forces that can be extremely dangerous, especially if localized by hard spots, even though the speed from which such a deceleration occurred may be as low as ten miles per hour.

DeHaven has also given in his report many instances taken from aircraft crashes wherein broad structural surfaces that

---

* "Mechanics Of Injuries Under Force Conditions" - Mech. Eng. April 1940

could dent and yield, have distributed pressure and given amazing safety results. It has been proven that the head striking unchecked into the windshield is most likely to receive fatal lesions of the head with mechanical certainty, leaving small room to wonder "that head injuries in survivable accidents exceed all others in frequency and importance."

Dean A. Fales* places the responsibility of automobile accidents on the causes of poor visibility:

1. Long engine bonnet;
2. Low seating position;
3. Wide and rounded corner posts;
4. Ventilating wings in front door windows; and
5. Steeply sloped windshields.

Deduction of Factors:

Several factors suggest themselves to crash-proof the car interior, of which the following will be considered:

1. Shoulder harness or safety belts as used in aircraft;
2. Placement of windshield beyond the range of the head;
3. Crash-padding of seat backs and solid structures; and
4. Shock-mounting of the instrument panel.

Shoulder straps perhaps offer the best solution, since they check the forward momentum right from the instance of deceleration. But it is feared that it will be difficult to sell to the public the safety of the car, and at the same time convince them of the utility of safety belts.

The placement of the windshield will require a modification. Steeply sloped windshields seemingly give aero-dynamic quality and esthetic form to the car, but the factual advantage derived from such slopes cannot be appreciable from the functional point of view. On the other hand many disadvantages may be cited that will definitely favor an orientation in the windshield design. Steep

---

* "Driving Vision" - Paper read at the 1940 S.A.E. Convention

slopes gather more dirt, rain-drops collect on them in single formation causing double vision from approaching bright lights; they permit the sun to shine on the steering wheel and the instrument panel resulting in light reflections that can dazzle the driver, and they are too close to the head of the front seat passenger and form a tough baffle plate in case of accidents. (See Fig. 7)

The advantages offered by crash-padding of hard objects, though a make-shift arrangement for protection against built-in hazards, are still appreciable.

The instrument panel can be an effective bumper to modify impact injuries. This aspect of the thesis problem will be discussed in the next Section.

INSTRUMENT PANEL AS A SHOCK-ABSORBER

Shock-absorption by Other Parts:

The chasis frame and body shell (minus its doors) not only are responsible for thestrength of the car, but also act as "protector" shields. The larger amount of sheet steel and even the frame itself, can buckle and crush in during a collision, thus reducing the force of impact upon passengers. The front and rear end bumpers also act in a similar manner.

The windshields which form an easy target for the head of a passenger to hit, can offer very little protection the way they are found on most of the modern cars, in spite of the non-shatterable quality of the laminated glass used, unless the installation is made less rigid, the glass less inclined and more curved to distribute impact force more unfformly on the skull of the striking head. It is to be hoped that future designs will follow the trend already set in by the latest Studebaker models in this direction. (See Figs. 7 and 8)

Prerequisites For Shock-proofing Instrument Panel:

The form of the windshield is a first prerequisite if the instrument panel can be an effective bumper. The passenger should hit the panel first before any part of him hits the windshield so that the momentum of his forward motion is partly lost before he hits the hard surface of the windshield, if he hits it at all.

So it has been assumed in this design that the windshield in future models will approximately take the shape indicated in Fig. 8 as part of the body design.

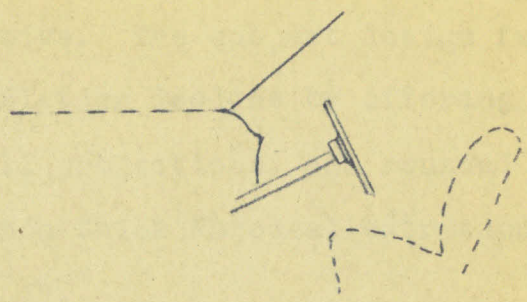


Figure 7

WINDSHIELD LOCATION ON EXISTING PANELS

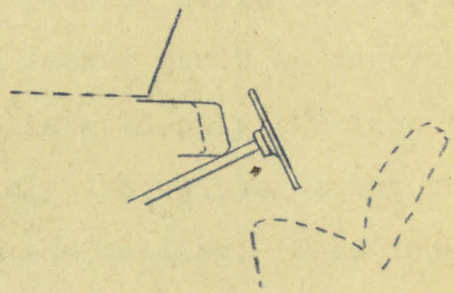


Figure 8

SUGGESTED LOCATION AND PLACEMENT OF WIND-
SHIELD AND INSTRUMENT PANEL

Shock-Distribution by Instrument Panel:

Removal of projections, rounding off and padding of edges was the first step taken by Chrysler in 1937, to aid in reducing injuries to passengers. This has been more or less followed by other models, though most of the designs still deserve further treatment to be effective. The subject design further elaborates and improves on the existing designs by offering a flat surface devoid in effect of all projections, and rounded corners that are padded with 3/8 inch thick Koroseal extrusion as shown in Drawing 1-O and Plate IV.

The radio controls protrude only 1/2 inch from the surface of the panel and mostly are of the press-button type that will readily yield and plunge in when pressed. The other controls do not reach outside the padding strip and are therefore protected. The glove compartment locker strip is carrying a flat surface with rounded edges, and is located only 1/2 inch from the edge of the padding making it nearly impossible to hit the strip without hitting at the same time the padding. Knee injury possibility has been greatly minimized by extending the padding sufficiently under the rounded corners.

Shock-mounting - Assumptions Made:

The problem of shock-mounting of the panel involves factors directly connected with the mechanical design of the chasis frame, body, bumpers and so on. In presenting the calculations and the ultimate design, it is desired to make it clear that several assumptions have been made because of lack of data on the other factors, but the final design will easily lend itself to modifications required by the other factors.

The assumptions are that:

1. The shock-mounting is for minimizing injuries as far as possible, and not for the complete prevention of injuries;
2. The calculations are to be made for the hypothetical case of a head-on collision into a stationary object at a speed at which seventy percent of the accidents are reported to occur by the National Safety Council reports. It is considered logical to assume further that for collisions at higher speeds the shock-mounting is bound to act favorably in preventing very serious injuries;
3. The passengers will be bodily lifted from their seats and they will act as a mass moving forward with the velocity, and in the direction of the car just before collision;
4. The driver will be protected by the steering wheel and the extent to which he receives such protection will depend on the design of the steering wheel;
5. Front seat passengers will hit the instrument panel prior to hitting any other part of the car;
6. On account of the front bumpers the car will decelerate and travel 12 inches after the bumper has crashed into the stationary object;
7. The designs of the hood and windshield will lend themselves for a properly coordinated assembly as shown in the Drawing 1-O-O, Section E-E, View X-X.

Type of Shock-mounting Chosen:

Of the several types of shock-mounting possible, the type which utilizes hydraulic or air-cushion absorbers was ruled out because of the increase in complexity of installation, higher costs of maintenance and servicing, and the necessity of periodic inspection of the equipment to insure operation of the absorber. It was decided to utilize the simple frictional type of mounting, (See Fig. 2) wherein a small block of steel attached to the side of the panel slides into a fixed channel with a certain amount of frictional pre-loading in such a manner that the entire instrument panel is held in suspension rigidly enough. When an impact force exceeding a certain value acts upon the panel, the block slides instantaneously into the fixed channel and is ultimately brought to rest by inter-facial frictional resistance and

self-energization. The total distance of retraction of the panel will depend upon the impact force, the maximum travel being predetermined. If after the retraction there is no warpage to prevent forward motion of the panel, it can be pulled out into its former position. Replacement of damaged channels will be relatively easy and cheap.

Theory And Calculations:

Taking the case of a block loaded by a weight W, sliding on a fixed surface by a moving force P as shown in the accompanying figure, and assuming the coeft. of friction between the two surfaces to be μ , and the velocity at which P strikes as V,

Writing the equation of forces,

$$P - \mu W = \frac{W}{g} \times \frac{d^2x}{dt^2}$$

Integrating both sides,

$$(P-\mu W)\, t = \frac{W}{g} \frac{dx}{dt} = C \quad \ldots\ldots (1)$$

At an instance when $t = 0$ and $\frac{dx}{dt} = V$ this equation will give

$$0 = \frac{W}{g} V - C$$

from which $$C = -\frac{W}{g} V$$

Using this value, in equation (1)

$$(P - \mu W)\, t = \frac{W}{g} \left(\frac{dx}{dt} - V \right) \ldots (2)$$

Integrating this equation,

$$(P - \mu W) \frac{t^2}{2} = \frac{W}{g} x - Vt - K \ldots (3)$$

Once again when $t = 0$, $K = 0$, equation (3) becomes,

$$(P - \mu W) \frac{t^2}{2} = \frac{W}{g} x - Vt \quad \ldots \quad (4)$$

Since $X = \frac{V}{2} \cdot t$, we get from equation (4)

$$t = \left(\frac{W}{g} \cdot \frac{V}{2} - V \right)^2 / P - W$$

$$= V \left(\frac{W}{g} \cdot \frac{2}{} \right) / P - W \quad \ldots\ldots (5)$$

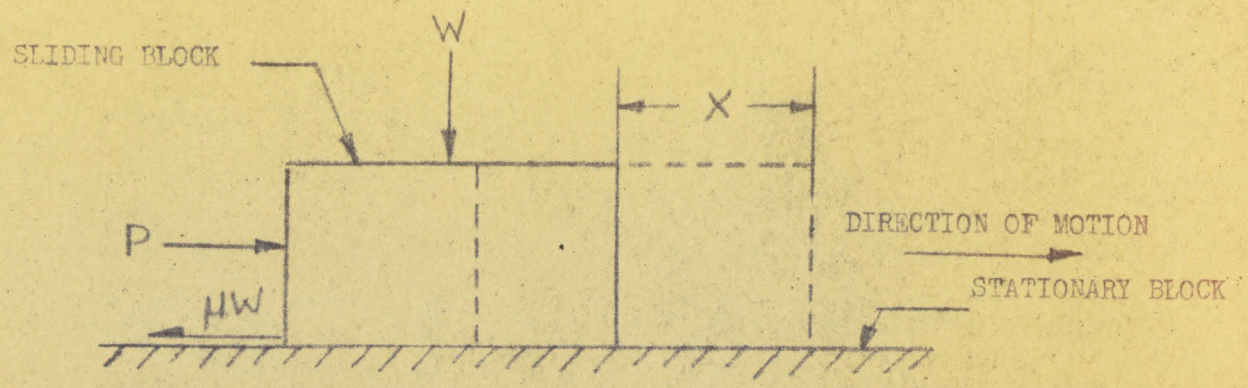


FIGURE 9

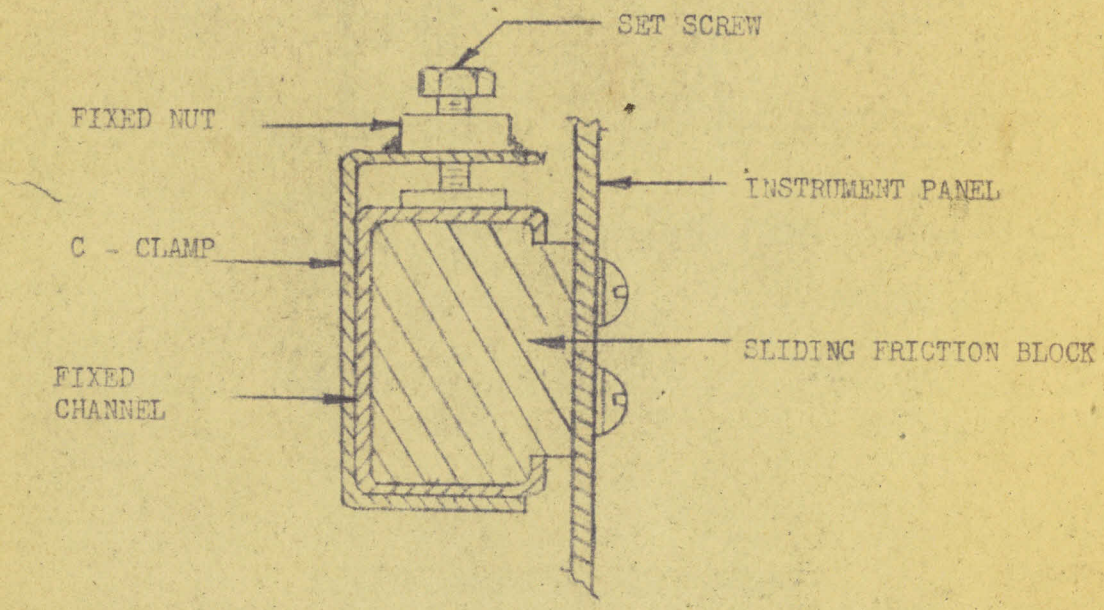


FIGURE 10

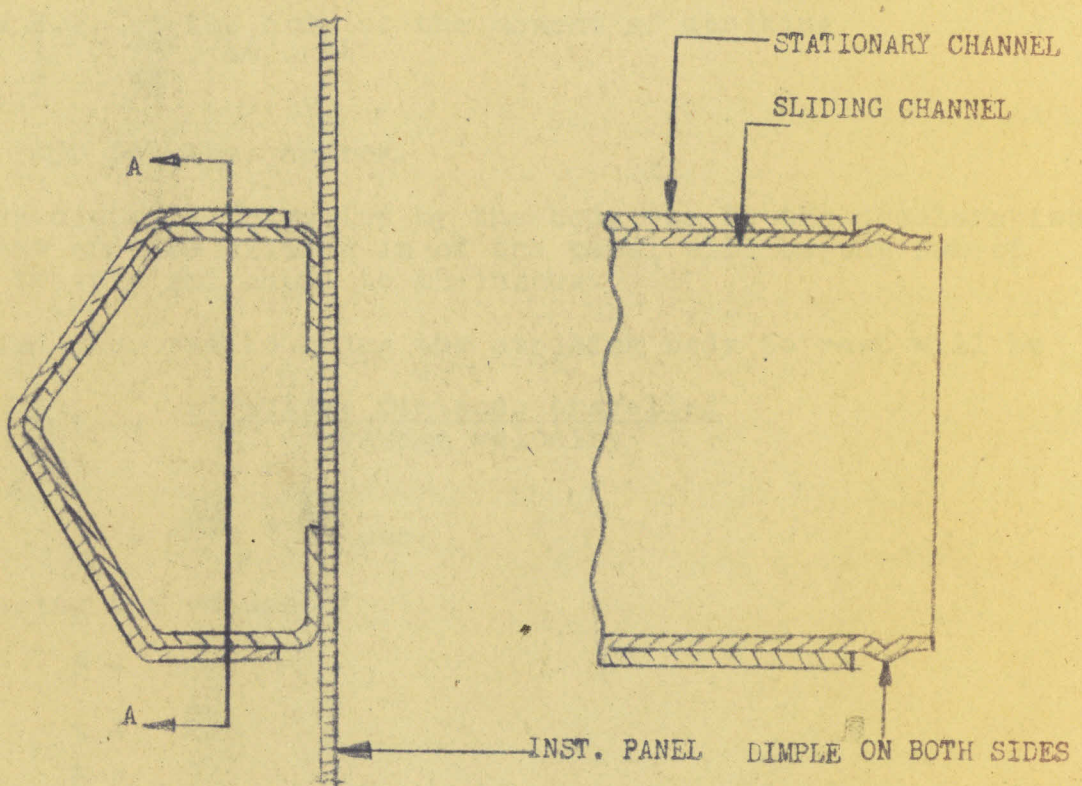


Figure 11

ALTERNATIVE METHOD FOR MOUNTING

INSTRUMENT PANEL

In the present case assuming that:

(a) the car is brought to rest after a decelerated travel of 12 inches after the crash,

(b) the panel is pushed in 3 inches max. absorbing the impact force P due to the weight of an average body of 75 lb. falling on the panel at 30 miles per hour,

(c) the coefficient of sliding friction between the steel block and the steel channel as .3,

we find that

$$P = \text{K.E. of the body at the moment of striking} = \frac{1}{2} \cdot \frac{75}{32} \cdot 44 \cdot 44$$

$$= 450 \text{ ft. lbs. approx.}$$

Effective distance travelled by the body due to the deceleration of the car and the sliding in of the panel will be the sum of the two travels and equal to 15 inches.

Then, time required to bring the striking body to rest will be

$$t = \frac{\text{effective distance travelled}}{\text{average velocity}}$$

$$= \frac{15}{44/2} = \frac{15}{22} \text{ sec.}$$

Substituting the values of

$$P = 450$$

$$t = \frac{15}{22}$$

$$g = 32$$

and $\mu = .3$ in equation (4) we get,

$$W = 350 \text{ lb. approx.}$$

The sliding block has to be pre-loaded to 350 lb.

This can be accomplished either by finding the fit for the channel and block that will be equivalent to a pre-loading of 350 lb. by using friction testing equipment, or by using a c-clamp of the type shown in Fig. 10 with a set-screw that can be pre-loaded by a torquo-meter and locked in position.

An alternative arrangement to give the same result will be as suggested in Fig. 11 where a dent made in the sliding channel

can be made to scourge against the side of fhe fixed channel during its slide building up frictional resistance by self-energization. The best type of dent and its dimensions required to get the desired result will have to be found experimentally by using friction testing equipment of the type used in Ferodo Physical Testing Laboratory.*

Advantages of The System:

This system will give a predictable result with a surity even if the steel surfaces get rust-coated after a time.

The block can be fixed to the instrument panel as a sub-assembly, and the panel slides on the more open free end of the fixed channel and fixed into position.

There is no danger of the panel sliding in at any moving force other than the one exceeding the impact force of 450 lb.

The instrument panel will be isolated from body vibrations by the use of rubber reinforcements and strips as shown in Drawing 1-O.

The panel is easy to be restored to its original position after it has been displaced, easy to be checked and repaired.

---

* "Testing of Friction Materials" - Auto. Eng. Feb. 1941, pg 43

CONCLUSION

In the subject design of the automobile instrument panel, practical applications of industrial and scientific facts have been made that will not only have consumer appeal but will also meet the requirements of the manufacturer as to materials, processes and costs.

Of the main features of the subject design the following are the out-standing:

The rectangular shape of the panel and the inclination at which it will be set, places emphasis on the simplicity and the functional congruity of the design, eliminating purely decorative elements that have been increasingly used on the panel of the modern car.

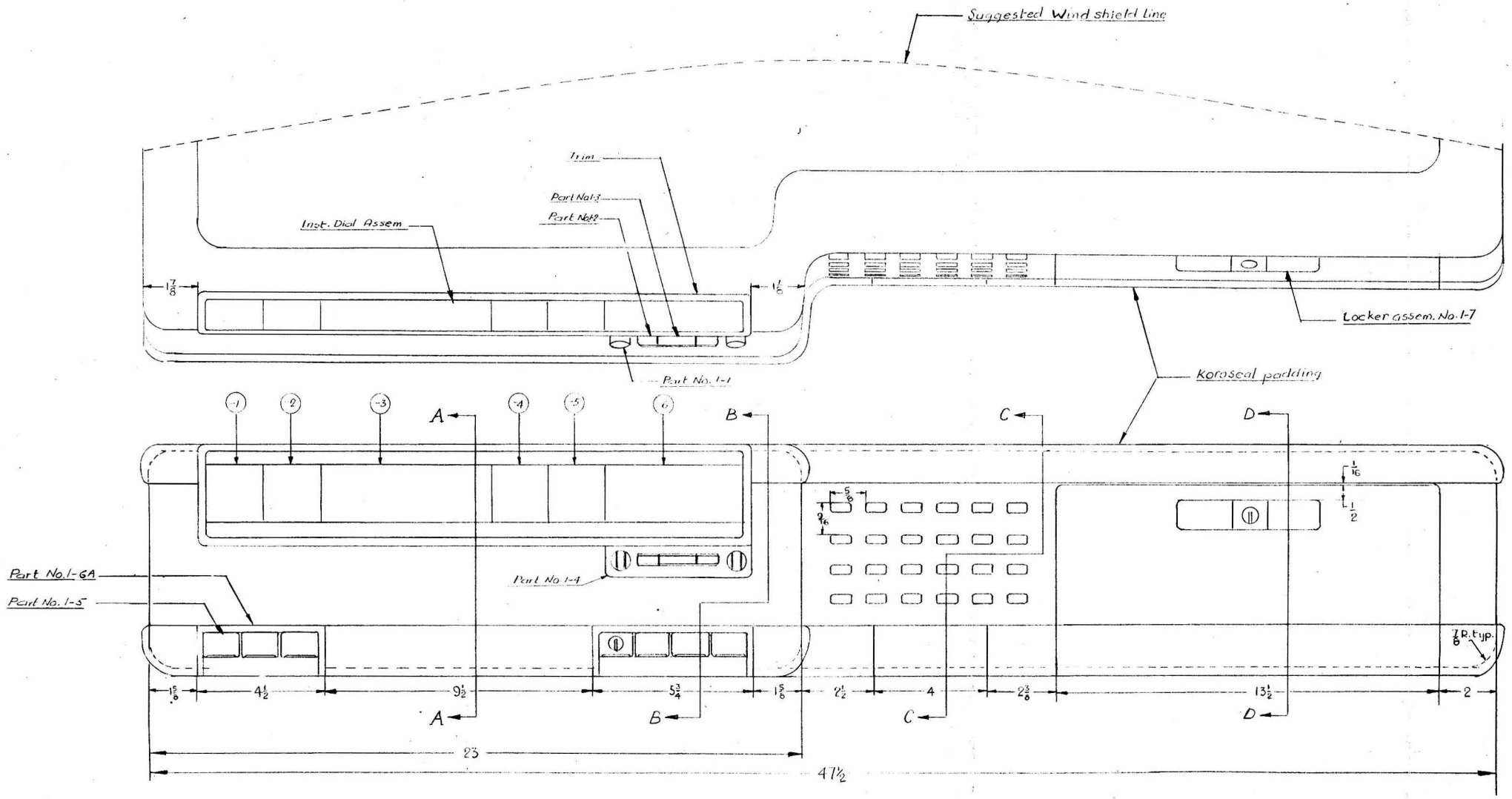
The shape, the bend radii, and the crash padding will pri--marily afford a less formidable baffle to a striking body in case of accidents.

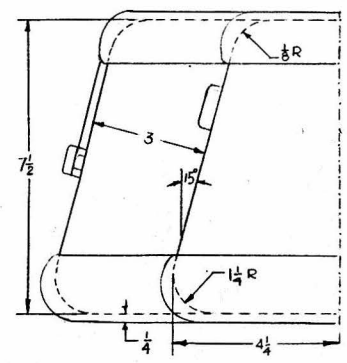
The general lay-out and the effective indirect lighting of the instruments that have been placed in front of the driver, and the placement of the control knobs nearer to the driver, will eliminate the possibility of distractions from driving.

The system of push-pull knobs and press-buttons used for the operation of the radio and controls, lend uniformity to the general theme of the design.

Additional space is now available for the glove compartment, and the holding strip provided will make it easy to open or close the glove compartment.

Finally, the indepemdent suspension of the panel and the sliding block attachment will help in absorbing shocks and reducing impact injuries to passengers in case of accidents.





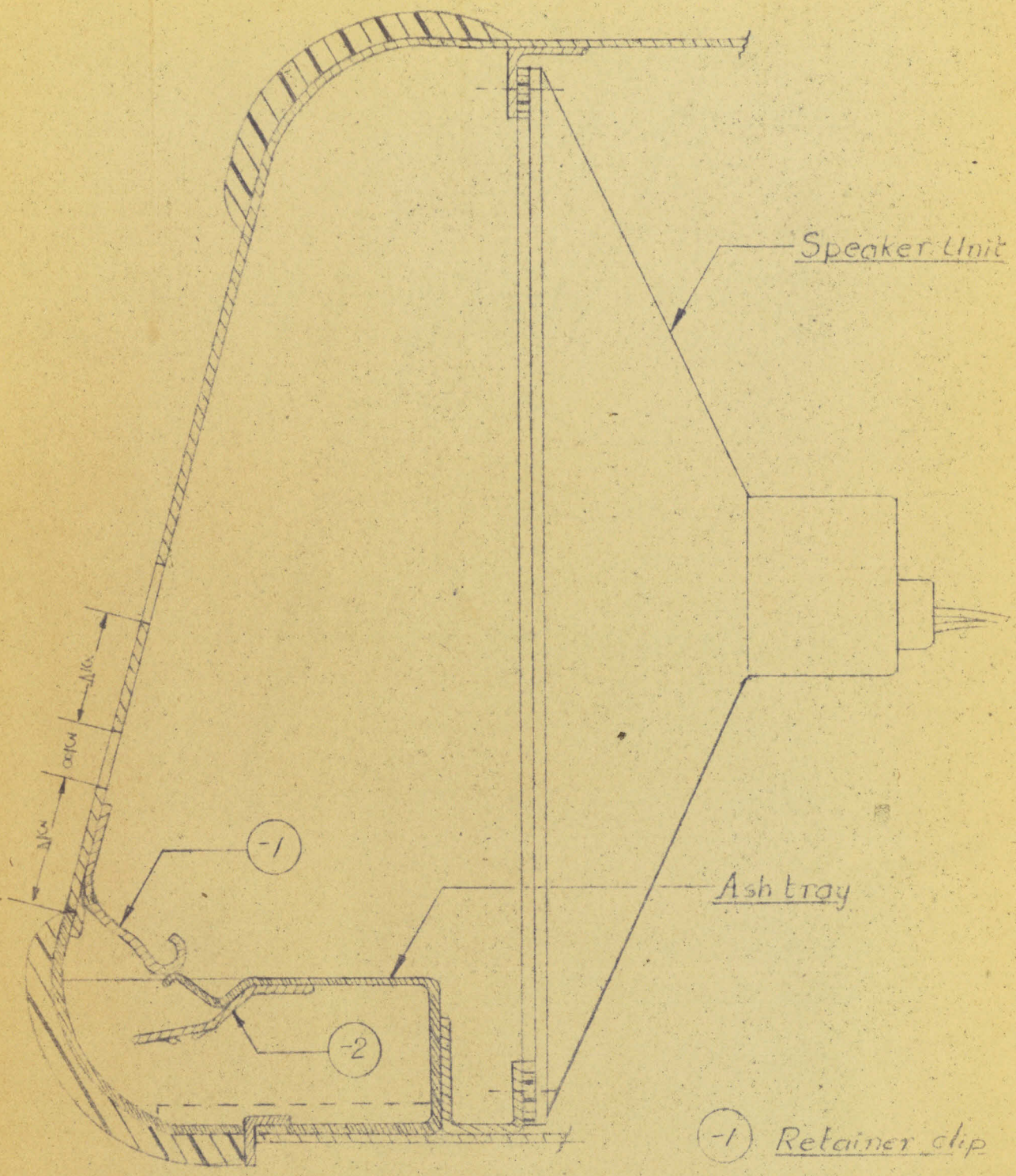
(-1) Head Gage
(-2) Battery ammeter
(-3) Speedometer
(-4) Fuel gage
(-5) Oil Press.
(-6) Radio Dial

1-0	INST. PANEL	1	S.A.E 1020	0.074 Thick	
Part No.	NAME	No. Req'd	Mat. Spec.	Mat. Des.	WE.

CALIFORNIA INSTITUTE OF TECHNOLOGY

Drawn by: M.V.K
Traced
Checked by: M.V.K
Approved:
Date: 8-1-47 · Scale: ½
Course: I.D.
Section: I.D.
Dwg. No. 1-0

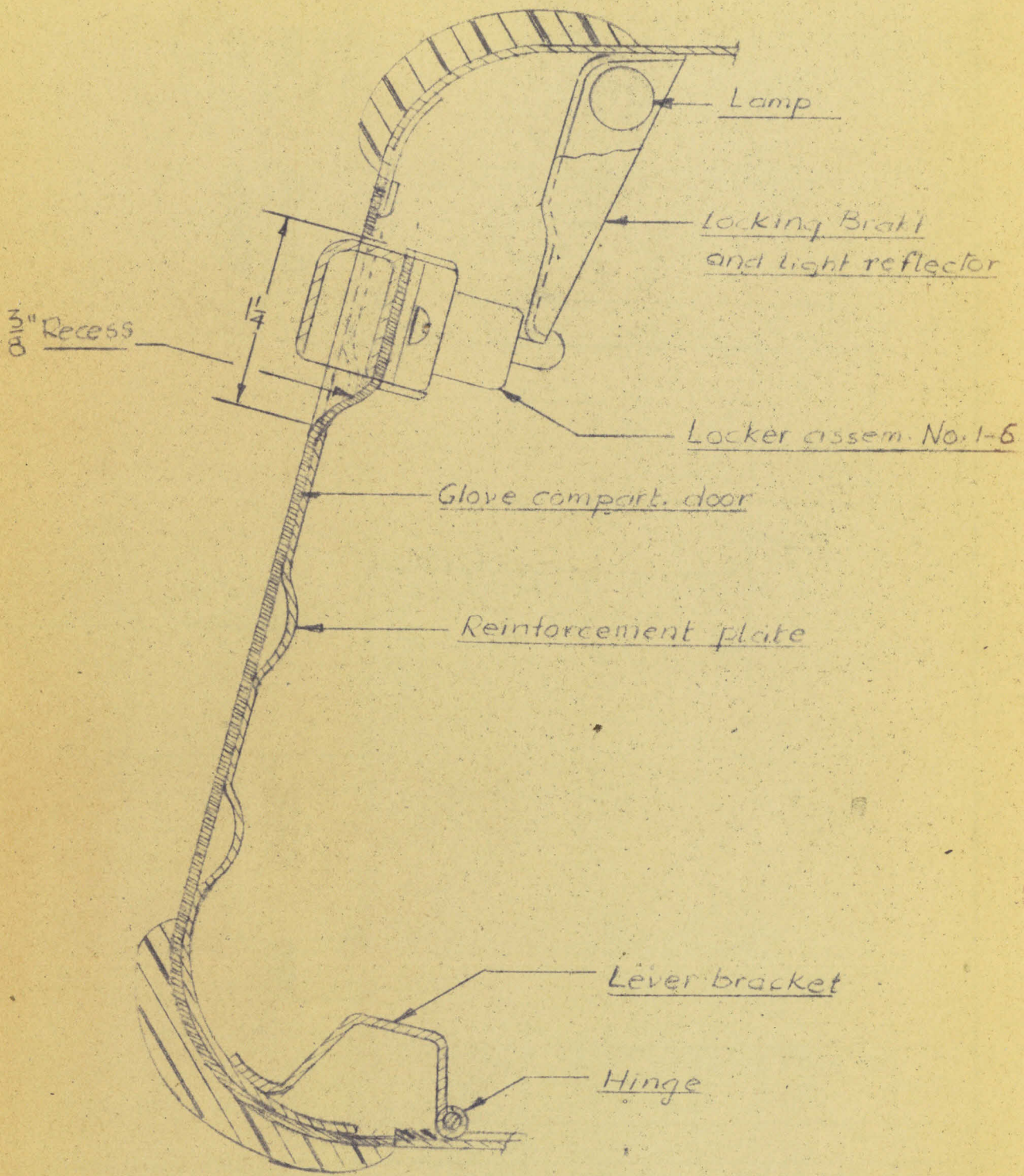
ASSEMBLY - INSTR. PANEL



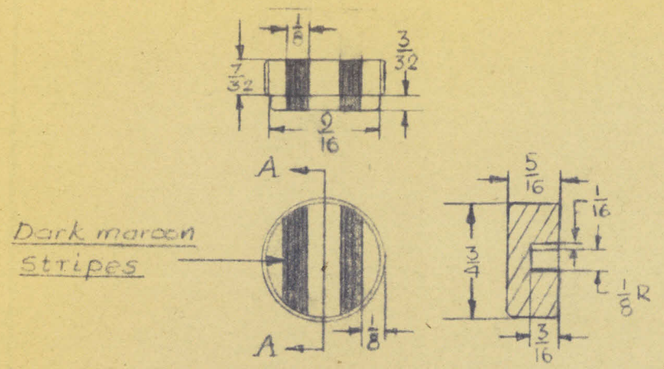
(-1) Retainer clip

(-2) Cig. extinguisher lip

SECTION C-C

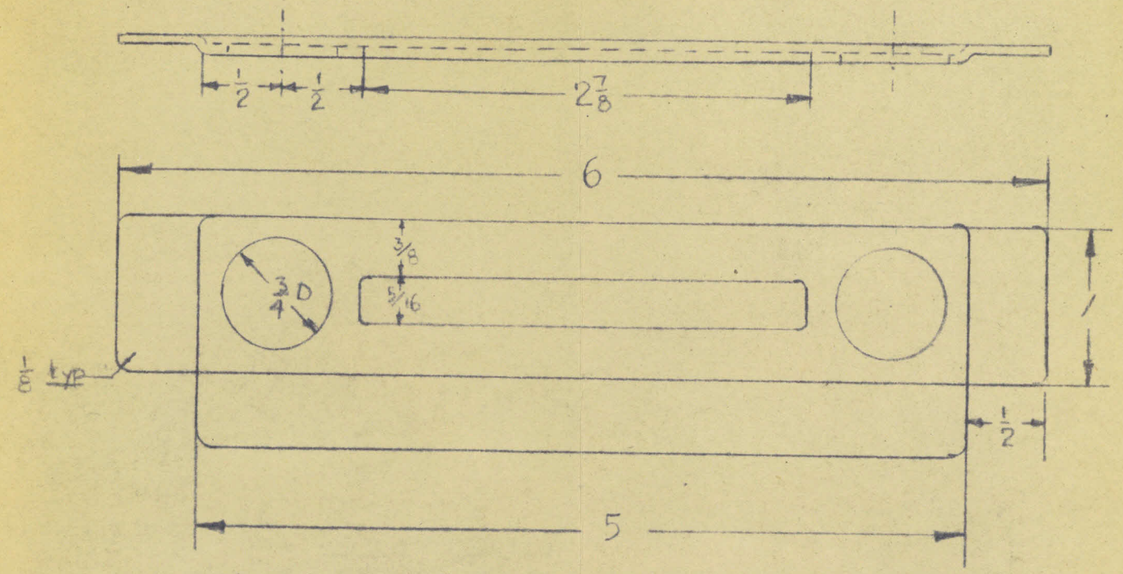

Lamp
Locking Brakt and light reflector
3/8" Recess
1 1/4
Locker assem. No. 1-6
Glove compart. door
Reintorcement plate
Lever bracket
Hinge

SECTION D-D

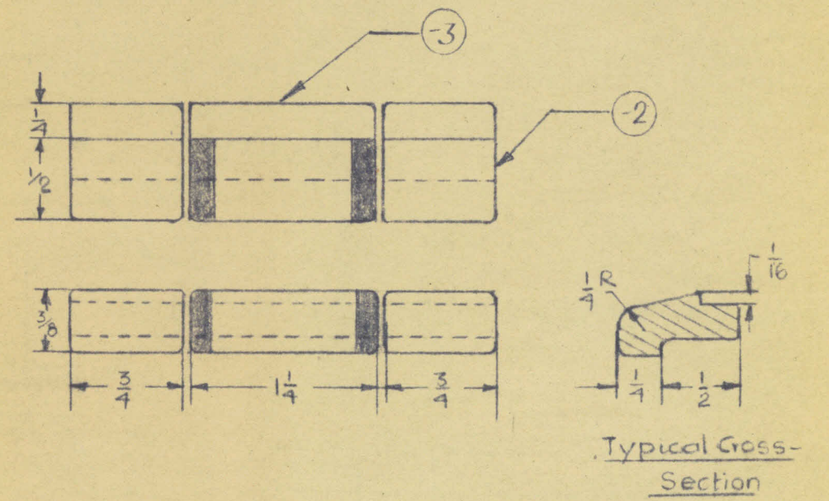


ALL CORNER RADII 1/16 IN.

PART NO. 1-1



PART NO. 1-3



ALL CORNER RADII 1/16 IN.

PART NOS. 1-2 & 1-3

PART NO.	NAME	NO. REQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
1-4	Mount Bkt	1 ea	Steel	SAE 1020, CR	
1-2 & 1-3	Press buttons	2 ea - 2 1 ea - 1	Cel. acetate butyrate		
1-1	Round Knob	2 ea	Cel. acetate butyrate		

ALL DIMENSIONS IN INCHES
LIMIT ON DIMENSIONS — UNLESS OTHERWISE NOTED
ANGULAR ± ½°
FRACTIONAL ± 1/32
DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES
R ROUGH MACHINE FINISH
250 SMOOTH MACHINE FINISH
40 ROUGH GRIND
16 FINISH GRIND
2 FINE GRIND, LAP
¼ POLISH

FINISH: Chrome plate - 5

HEAT TREAT:

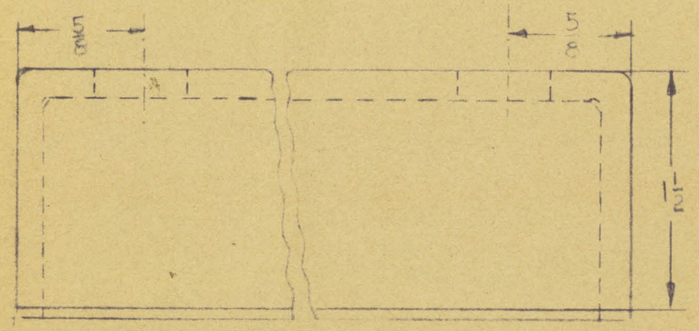
CALIFORNIA INSTITUTE OF TECHNOLOGY

RADIO KNOBS & MOUNT B'KT

DRAWN BY M.V.K
TRACED BY M.V.K
CHECKED BY
APPROVED BY
DATE 5-3-47 SCALE Full
COURSE NO. 1.D
SECTION NO. 1.D
DWG. NO. 1-1, 1-2, 1-3

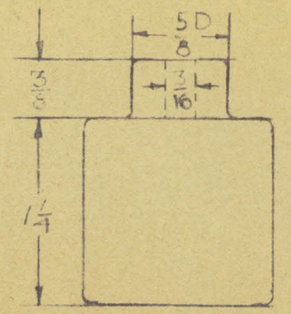
FORM 302

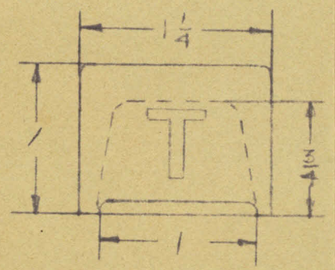
Part No.	Dim. 'L'
1-4A	4½
1-4B	5¾

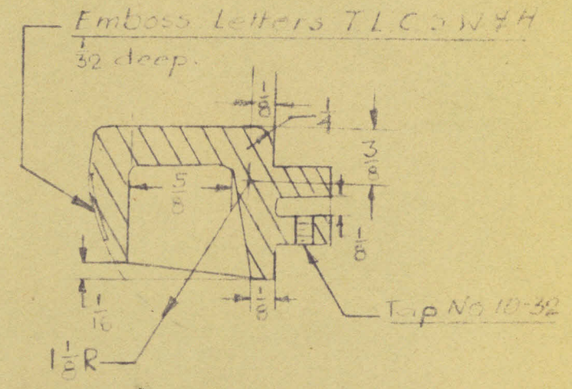


PART NO. 1-6A & 6B

ALL CORNER RADII 1/4" TYP.
BREAK SHARP EDGES







PART NO 1-5

PART NO.	NAME	NO. RQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
1-5	Control Knob	1 ea	Cold rolled steel	Autprate	
1-4	Support BKT	1 ea	Zn alloy	Die-casting SAE 921	

ALL DIMENSIONS IN INCHES — ANGULAR ± ½°
LIMIT ON DIMENSIONS — FRACTIONAL ± 1/32
UNLESS OTHERWISE NOTED — DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES

R — ROUGH MACHINE FINISH
250 — SMOOTH MACHINE FINISH
40 — ROUGH GRIND
16 — FINISH GRIND
2 — FINE GRIND, LAP
¼ — POLISH

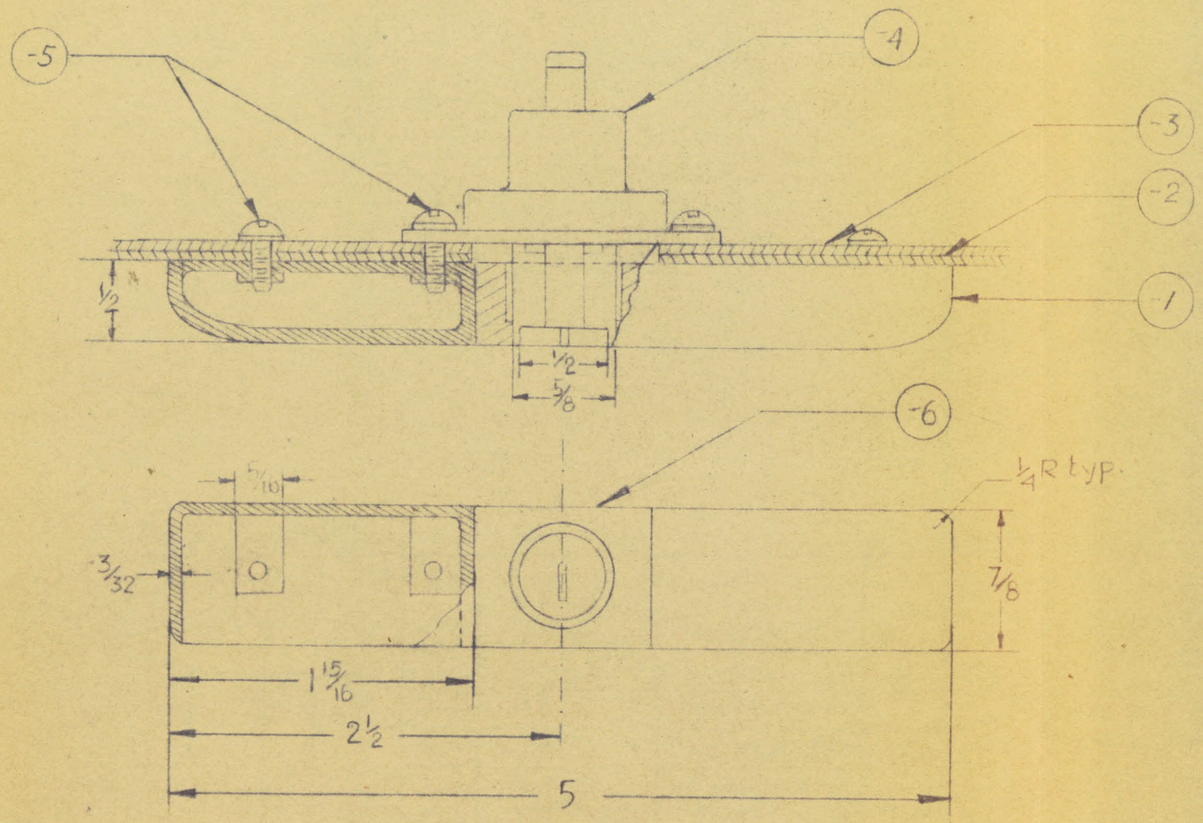
FINISH: Chrome plate Part No. 1-4A & B

HEAT TREAT:

CALIFORNIA INSTITUTE OF TECHNOLOGY

CONTROL KNOB & SUPPORT BKT

DRAWN BY M Y K
TRACED BY M Y K
CHECKED BY
APPROVED BY
DATE 5-3-47 SCALE Full
COURSE NO. 1 D
SECTION NO. 1 D.
DWG. NO. 1-5 / 1-6



PART NO.	NAME	NO. RQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
-6	Lock plunger Head	1	Deep mirror color	Cel. acetate butyrate	
-5	Shake proof screw	4	Cad-plated	Shake proof No. 12-24	
-4	Door Lock	1		Sub-standard	
-3	Door Panel Reinf.	1			
-2	Door Panel	1			
-1 Lft R	Holding Strip	1 ea	Deep mirror color	Cel. acetate butyrate	

ALL DIMENSIONS IN INCHES
LIMIT ON DIMENSIONS
UNLESS OTHERWISE NOTED
ANGULAR ± ½°
FRACTIONAL ± 1/32
DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES
R ROUGH MACHINE FINISH
250 SMOOTH MACHINE FINISH
40 ROUGH GRIND
16 FINISH GRIND
2 FINE GRIND, LAP
¼ POLISH

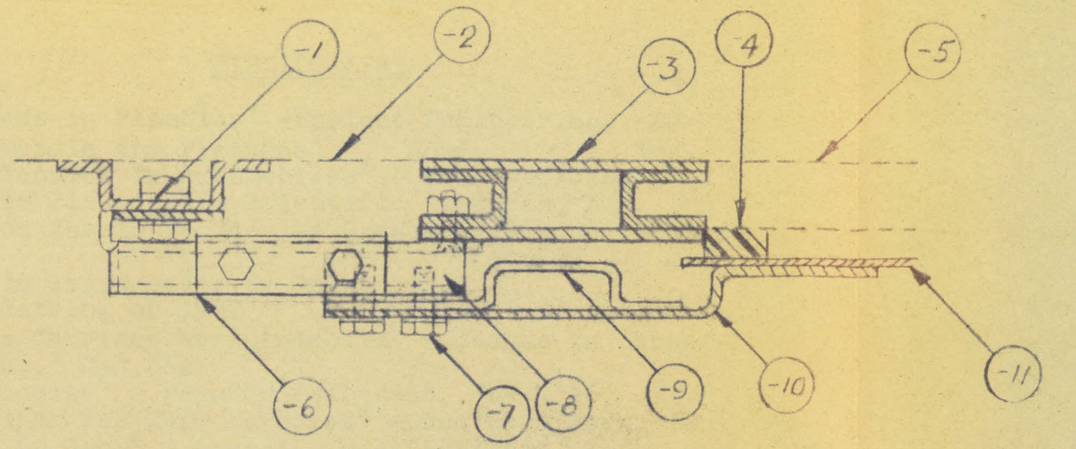
FINISH

HEAT TREAT

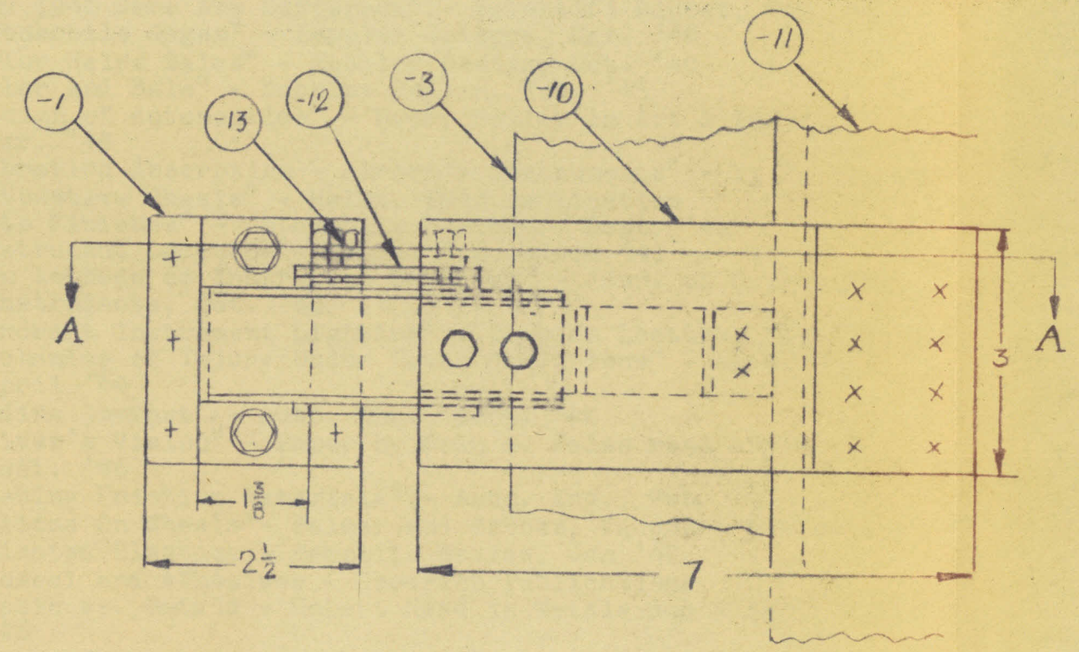
CALIFORNIA INSTITUTE OF TECHNOLOGY

LOCKER ASSEM-GLOVE COMPT.

DRAWN BY M. V. Kamath
TRACED BY
CHECKED BY
APPROVED BY
DATE 4-26-47 SCALE Full
COURSE NO.
SECTION NO.
DWG. NO. 1-7



SECTION A-A



Assumed References:

(-2) Side dash panel

(-3) Front post (box)

(-5) Side door Line

Spot-weld at places marked X

PART NO.	NAME	NO. RQD.	MATERIAL DESC.	MATERIAL SPEC.	WEIGHT
-13	Preload Bolt	4 ea	C.M.St.	1/4-28 NF3	
-12	Preload'g chan.	1 ea	M.S.	SAE1020 (.064)	-
-11	INST. PANEL	-	-	Dwg No. 1-0	-
-10	Attach. Plate	2 ea	M.S.	SAE1020 (.064)	
-9	Stiffner channel	1L & 1R	M.S.	SAE 1020 (.064)	
-8	Sliding Block	2	St. St.	18-8 (5/8 x 1 1/4 x 1 3/4)	
-7	Hex. Head Bolt	4 ea	1/4-28 NF3	1/4-28 NF3	
-6	Fixed channel	1L & 1R	St. St.	18-8, (0.125)	
-5	Door Line	-	-	-	-
-4	Felt packing	2	1" x 1/2",	Comm'l	-
-3	Front Post	-	-	-	-
-2	Hood side	-	-	-	-
-1	St.ch mount'g Bkt	2	M.S. 3/32" th.	SAE 1020	

ALL DIMENSIONS IN INCHES — ANGULAR ± ½°
LIMIT ON DIMENSIONS — FRACTIONAL ± 1/32
UNLESS OTHERWISE NOTED — DECIMAL ± .010

NUMBERS ARE SURFACE ROUGHNESS IN MICROINCHES

R — ROUGH MACHINE FINISH
250 — SMOOTH MACHINE FINISH
40 — ROUGH GRIND
16 — FINISH GRIND
2 — FINE GRIND, LAP
¼ — POLISH

FINISH

ALL M.S. INTERIOR PARTS TO BE COATED ACCORDING TO FACTORY PRACTICE

HEAT TREAT

CALIFORNIA INSTITUTE OF TECHNOLOGY

A METHOD OF SHOCK-MOUNTG

INSTR. PANEL

DRAWN BY M V K
TRACED BY M V K
CHECKED BY
APPROVED BY
DATE 5-7-47 SCALE HALF
COURSE NO. 1.D
SECTION NO. 1.D
DWG. NO. 1-8

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