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A MANUAL FOR EVALUATING THE PERFORMANCE OF THE ELECTRICAL CIRCUITRY OF THE GENERAL MOTORS AIR CUSHION RESTRAINT SYSTEM

by

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16. Abstract

Design features of the GM ACRS include the ability to differentiate between crash deceleration thresholds, and monitoring of the ready condition of the system, in addition to crash sensing. Also, time elapsed since a system malfunction was indicated is recorded. Methods to determine levels of deployment, gas pressure failure, non-deployment in a crash, and crash severity beyond ACRS capability are described.

These are presented to permit crash investigators to more effectively evaluate ACRS performance once a crash has occurred. The discussion of ACRS electrical circuitry presented here was obtained from the investigation of many crashes involving ACRS equipped vehicles and available descriptive technical literature.

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INTRODUCTION

Since 1973 over 10,000 General Motors Corporation passenger cars have been manufactured with a passive* system for protection of front seated occupants in crashes. The system concept is based on the rapid inflation with air of neoprene coated nylon bags located in the hub of the steering wheel and in the lower right side instrument panel. These air bags, when inflated during a crash, both distribute and dissipate energy imparted to them by the occupants who continue to move forward in the crash. The air bag, or air cushion, restraint system satisfies the requirements of Motor Vehicle Safety Standard #208 in barrier impacts.

The purpose of this discussion is to describe the electrical functions of this air cushion restraint system (ACRS)** so as to more effectively evaluate the performance of the system after a crash. This electrical description of the sensing, activation and diagnostic features of the ACRS is based on knowledge obtained relating to the system from the investigation of many crashes involving ACRS equipped vehicles, and available literature*** descriptive of the ACRS. It should be emphasized that this electrical description is primarily the result of analyzing existing production circuits and interpreting these existing circuits within ACRS components involved in crashes. There may be some inaccuracies, but such inaccuracies if they do exist, are believed to be quite minor and not related to the salient features of this system.

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*Where no effort, on the part of a vehicle occupant, is required to achieve a predetermined level of protection from injury in vehicle crashes.

**Name given to the General Motors Corporation system.

***See bibliography.

FUNCTIONS

The primary functions of the ACRS are:

(1) Crash sensing,

(2) Determining crash deceleration thresholds, or degree of crash severity, so as to deploy the air bags and record the type of deployment,* and

(3) Monitor the reading condition of the system for the driver.

In addition are features which measure the time elapsed in which the system indicated a malfunction, as well as sensing when a deployment signal emanates from a sensor and the air bags do not deploy.

ELECTRICAL CIRCUITRY

An electrical schematic for the ACRS is shown in Figure A-1. The dotted lines encompass the various components which comprise the ACRS.

Bid Deployment. The Bumper Impulse Detector (BID) is located on the inside center are of the vehicle's front bumper. Two electrical switches close as results of a frontal barrier equivalent impact speed of approximately 11 mph or greater. One (S1) provides an electrical ground for the activation circuit, and the other (S2) provides the +12VDC activation signal.

Schematic A-2 better illustrates how this portion of the system operates.

*There are two distinct deployment rates for the passenger air bag, a "low level" deployment and a "high level" deployment. Each determines air bag deployment rate relative to the severity, or vehicle deceleration, in the crash.

- BID switches S1 and S2 close as a result of an impact.
- +12 volts D.C. from the "+12VDA A Bus" provided through Pin-D on the BID, through closed switch S2, returning out of the BID through Pin-E.
- This +12VDC activation signal (from above) is incident to Pin-N in the sensor unit, where it is applied through diode D4 to:
  - Passenger air bag (low level) through diode D7 and output Pin-K on Sensor Unit, and to
  - Driver air bag through diode D5 and output Pin-J on Sensor Unit.
- A ground return for the +12VDC through the air bag detonators (or activators) is provided through Pin-B on the BID, through closed switch S1, and out of the BID via Pin-A to ground.
- This ground output (Pin-B on BID) is provided directly to the ground side of the passenger air bag.
- And to the driver air bag through Pin-L on the Sensor Unit, which is common to Pin-H, hence to the ground side of the driver air bag detonator.
- Thus, both the +12VDC and a ground return is applied to both the driver air bag and low level deployment side of the passenger air bag.

To confirm that a low level deployment has occurred, the following test, or check-out, procedure may be followed:

(a) Disconnect the Sensor Unit from the ACRS through separating, or opening, the Sensor Unit electrical connector.

(b) With a low current resistance test meter*, measure as listed on the following page** under Table A-1.

Low Level Deployment. In this mode of deployment, the ACRS is activated through magnetically held, pendulum type, sensor switches in the Sensor Unit. These close as a result of an impact whose barrier equivalent speed is approximately equal to or greater than 11 mph, or 18 G in deceleration, but less than 30 G in deceleration.

This could be an underride type impact, or an impact where the front bumper is not contacted first, so that the BID is not activated. That is, BID switches S1 and S2 do not close in impact. This can be followed in Figure A-3.

- Sensor switch LL2 in the Sensor Unit closes, and
- +12VDC from the "A Bus" is applied to Pin-B of the Sensor Unit through diode D1.
- Closed sensor switch LL2 receives +12VDC through diode D5 of the Sensor Unit and is also incident to Pin-J.
- The +12VDC at Pin-J of the Sensor Unit is also common to the plus (+) side of the driver air bag detonator.
- Similarly, the +12VDC through diode D7 becomes incident to Pin-K of the passenger air bag, low level detonator.
- The path for ground return of the +12VDC is provided through sensor switch LL1 in the Sensor Unit, the low level arming switch. This switch offers a degree

*Where the test current is equal or less than 50 ma.
**These values are also given in a General Motors Corporation test procedure.

TABLE A-1

Connector Pin (Sensor) Numbers	Circuit	Normal Value Undeployed	Measure
K-L	Low level to common	1-1.4Ω	∞
M-L	High level to common	2-2.6Ω	~2 1/2Ω
E-D	Pressure device to ground	shorted	∞
M-K	Low level to high level	3-3.7Ω	∞
K-C	Low level to ground	∞	∞
M-C	High level to ground	∞	∞
L-C	Common return to ground	∞	∞

of redundancy to reduce the change of an inadvertent deployment.

To confirm that a low level deployment has occurred the test, or check-out, procedure described in Table A-1 may be followed.

High Level Deployment. This deployment mode results from crashes which are more severe than crashes which result in low level deployment. For high level deployment to occur, a similar functioning of the ACRS circuitry occurs.

- The +12VDC and ground needed for deployment of the driver air bag and low level deployment of the passenger air bag occurs as described above.
- The +12VDC needed to initiate high level deployment of the passenger air bag is provided through the "Hi Level" sensor switch to Pin-M of the Sensor Unit. This is shown diagramatically in schematic Figure A-4.

To confirm that a high level deployment has occurred, the following test, or check-out, procedure may be followed:

(a) Disconnect the Sensor Unit from the ACRS through separating, or opening, the Sensor Unit electrical connector.

(b) With a low current resistance test meter*, measure as shown on Table A-2.**

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*Where the test current is equal or less than 50 ma.
**These values are also given in a General Motors Corporation test procedure.

TABLE A-2

Sensor Side	Circuit	Nominal Value Undeployed	Measure
K-L	Low level to common	1-1.4Ω	∞
M-L	High level to common	2-2.6Ω	∞
E-C	Pressure device to ground	∞	∞
M-K	Low level to high level	3-3.7Ω	∞
K-C	Low level to ground	∞	∞
M-C	High level to ground	∞	∞
L-C	Common return to ground	∞	∞

PRESSURE FAILURE

The low pressure switch which is shown in the center left portion of the electrical diagram, and which is noted as being normally closed, is used to monitor proper pressure of stored gas in the inflator unit. When gas pressure is reduced to a level that could compromise performance (inflation rate and inflation level) of the passenger air bag this switch will open. When this occurs, circuit functions can be followed with the aid of Figure A-5 as follows:

- The electrical ground reference to input #4 of the comparator logic component in the Sensor Unit is opened.
- Output #5 of the comparator logic component is then raised in voltage, as a result of the loss of the ground reference on input #4.
- This increase in voltage on #5 forward biases the base-to-emitter junction of transistor QS-466 so as to permit conduction through the transistor.
- Transistor QS-466 in its conducting mode provides a ground return for warning lamp Pin-G of the Sensor Unit, as well as Pin-G and Pin-C of the Recorder Unit, to the warning lamp.
- Transistor QR-1834 in the Recorder Unit, normally biased "ON", or conducting, provides +12VDC to Pin-A and the positive (+) side of the warning lamp.
- Also, with Pin-G held low by QS-466, current flows through the time recorder to record time elapsed since the failure existed.

LOW SEVERITY CRASH - NO ACRS DEPLOYMENT

In this mode, a crash may occur but below the threshold of design severity for deployment of the ACRS air bags. A system feature in the Recorder Unit will record such an event by blowing a fuse. This can be followed on Figure A-6.

- The "Lo G" sensor switch in the Recorder Unit closes, or makes electrical contact.
- This provides a path from +12VDC to ground, through fuse F3 which causes the fuse to open.
- The path from +12VDC to ground through fuse F2 and diode D1, and through the normally closed low pressure switch causes fuse F2 to open.

To determine if such a low threshold crash has occurred, that is without deployment, fuses F2 and F3 must be checked. A recommended procedure for accomplishing this is as follows:

(a) Disconnect connector at Recorder Unit.

(b) With a low impedance resistance meter:

 (1) Place negative (-) probe on Pin-E.

 (2) Place positive (+) probe on Pin-B.

 (3) Reading should be infinite resistance for fuse F2 to be open.

 (4) If resistance reading is 11,500 ohms, then fuse F2 is intact and not open. (Note, reading may not be precisely 11,500 ohms because of the resistance drop through diode D1 and transistor EQ-1834. The actual reading will depend on the test meter used.)

(5) Move the negative (-) probe to Pin-D.

(6) If resistance reading is 4,300 ohms, fuse F3 is not open.

(7) If a resistance reading of 6,800 ohms, is shown, fuse F3 is open.

HIGH SEVERITY CRASH - BEYOND ACRS CAPABILITY

In this crash mode, a high speed crash, both driver and passenger air bags deploy. The passenger bag deploys at high level, yet the severity of the crash is beyond the capability of the ACRS, as an effective restraint system, to reduce injury. The manufacturer has incorporated features in the ACRS design to determine when such a crash takes place. What level of crash severity, or what constitutes a crash beyond the capability of the ACRS has not been specified.*

Figure A-7 is included as an aid to understanding circuit performance during such a crash.

- Driver and passenger air bags deploy in high level deployment as described under High Level Deployment above.
- The "Lo G" sensor switch in the Recorder Unit closes with a current surge from the +12VDC B-bus to ground through fuse F2, diode D1, and Pin-E to Pin-P in the Sensor Unit, to ground through Pin-E to the Sensor Unit and normally closed low pressure switch. This current surge opens fuse F2.
- Similarly, the "Hi-G" sensor switch in the Recorder Unit closes with a current surge from the +12VDC

*White not completely defined, it is conjectured that this limit may be an equivalent barrier speed equal or greater than 50 mph.

B-bus to ground through fuse F1 and Pin-D. This current surge opens fuse F1.

- The +12VDC incident to fuse F2, as a result of the "Lo-G" sensor switch closing is also incident to fuse F3. A path to ground is provided through Pin-D. The resultant current surge here opens fuse F3.
- Thus, all three fuses F1, F2, and F3 in the Recorder Unit will be open, or "blown" in a high speed, high severity crash deemed beyond the capability of the ACRS.

A recommended procedure for measuring whether these fuses (F1, F2, and F3) are open is as follows:

(a) Disconnect connector at Recorder Unit.

(b) With a low impedance resistance meter:

(1) Follow procedure for checking fuse F2 and F3 as described under "Low Severity Crash - No ACRS Deployment" above. Here resistance readings will be different for checking F3 because of F1 being open.

For fuse F1:

(2) Place negative (-) probe on Pin-D.

(3) Place positive (+) probe on Pin-B.

(4) Note the reading.

(5) Reverse the probe (- to B, + to D) and note the reading.

(6) If the ratio of the readings between steps (4) and (5) is greater than 100:1, fuse F1 is open.

SUMMARY

Design features of the GM ACRS include the ability to differentiate between crash deceleration thresholds, and monitoring of the ready condition of the system, in addition to crash sensing. Also, time elapsed since a system malfunction was indicated is recorded. Methods to determine levels of deployment, gas pressure failure, non-deployment in a crash, and crash severity beyond ACRS capability are described.

These are presented to permit crash investigators to more effectively evaluate ACRS performance once a crash has occurred. The discussion of ACRS electrical circuitry presented here was obtained from the investigation of many crashes involving ACRS equipped vehicles and available descriptive technical literature.

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G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

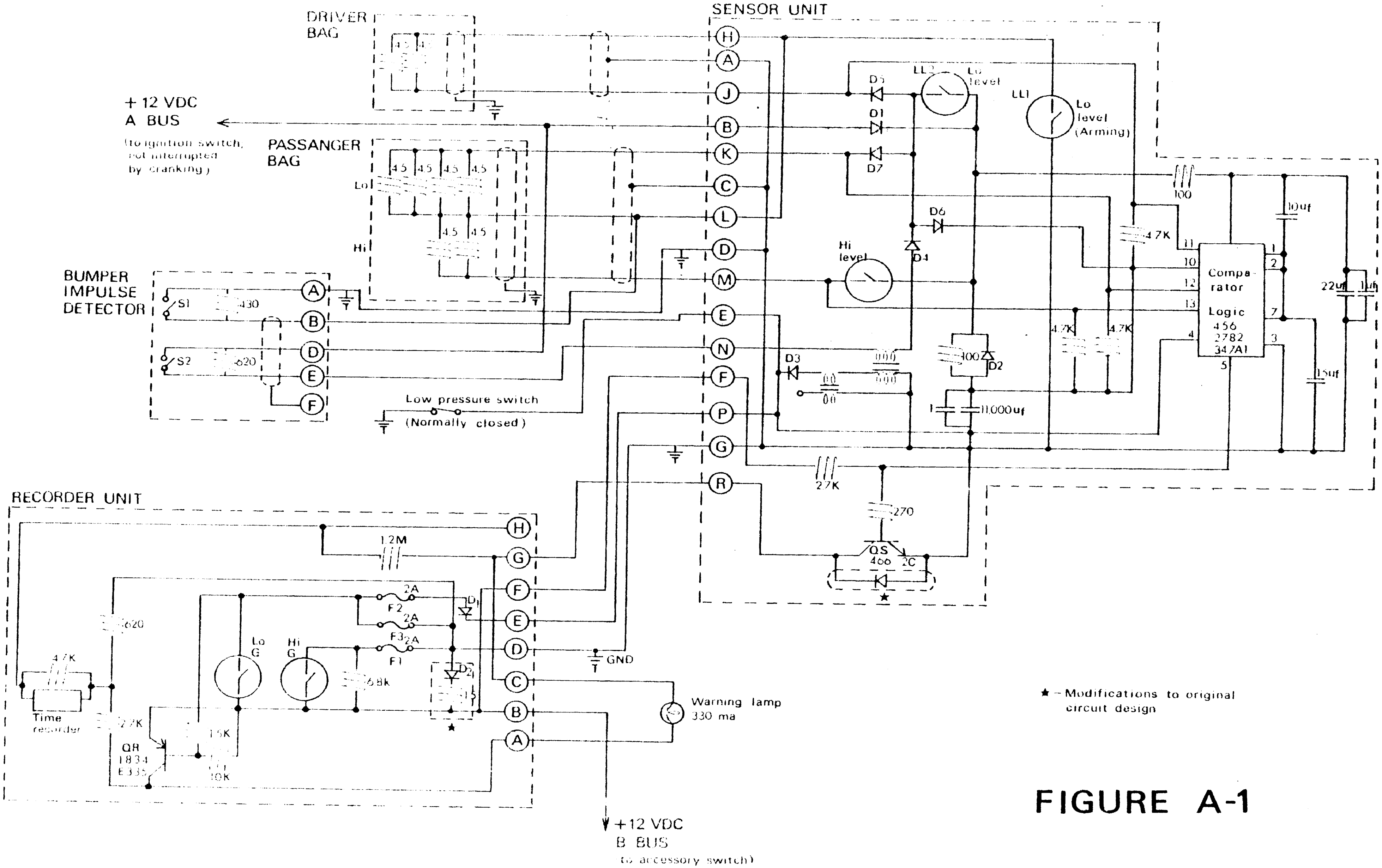

FIGURE A-1

G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

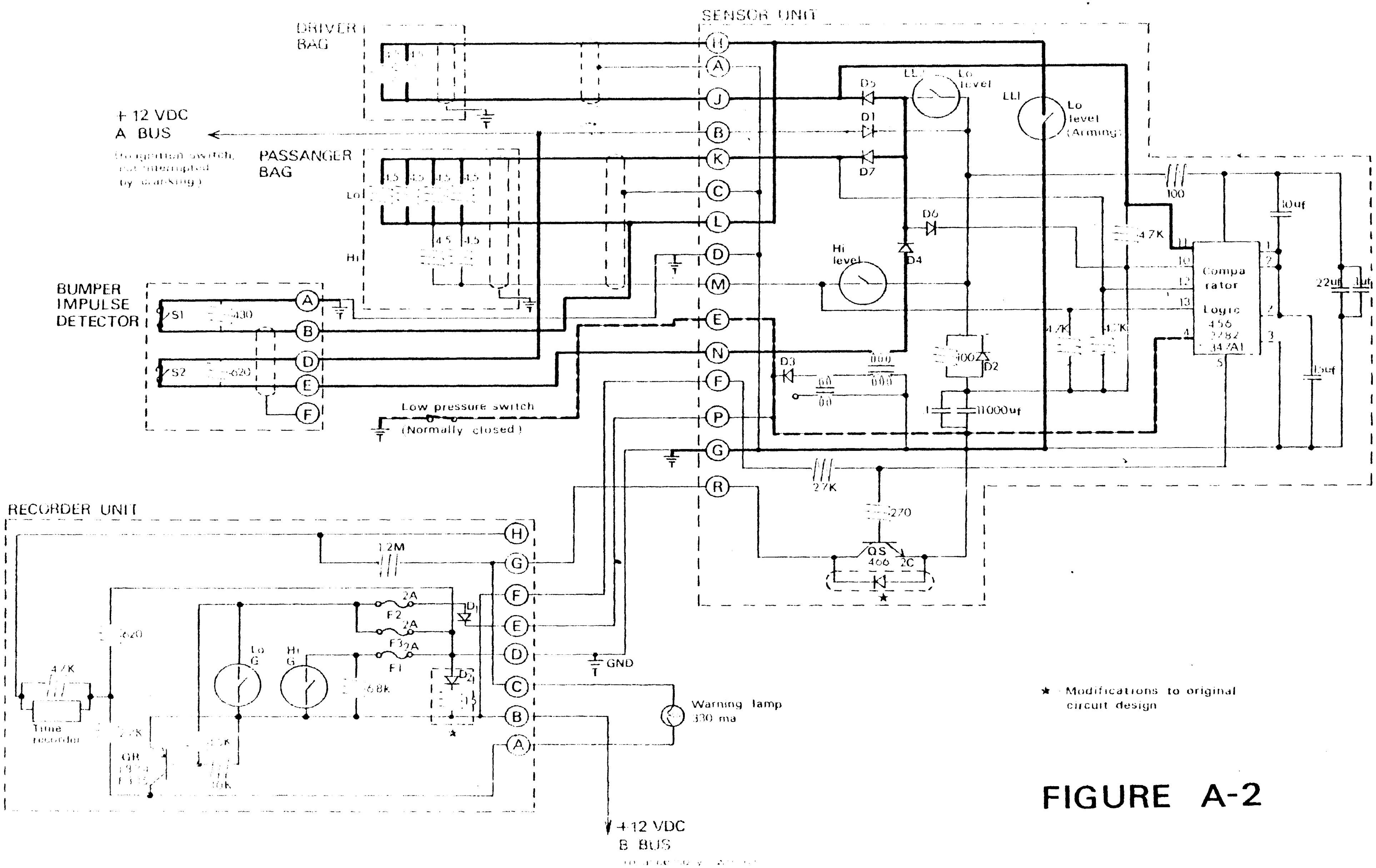

FIGURE A-2

G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

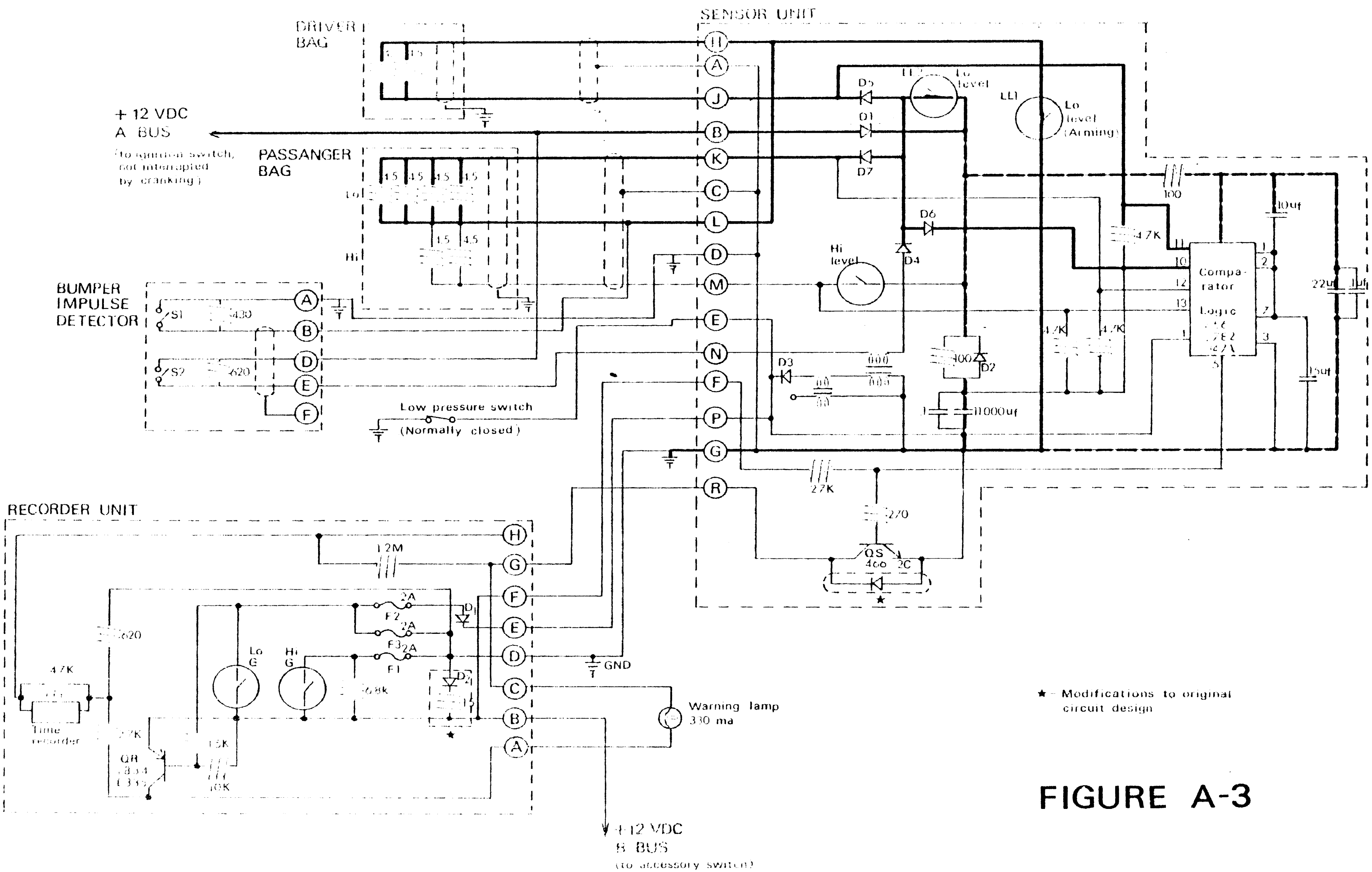

FIGURE A-3

G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

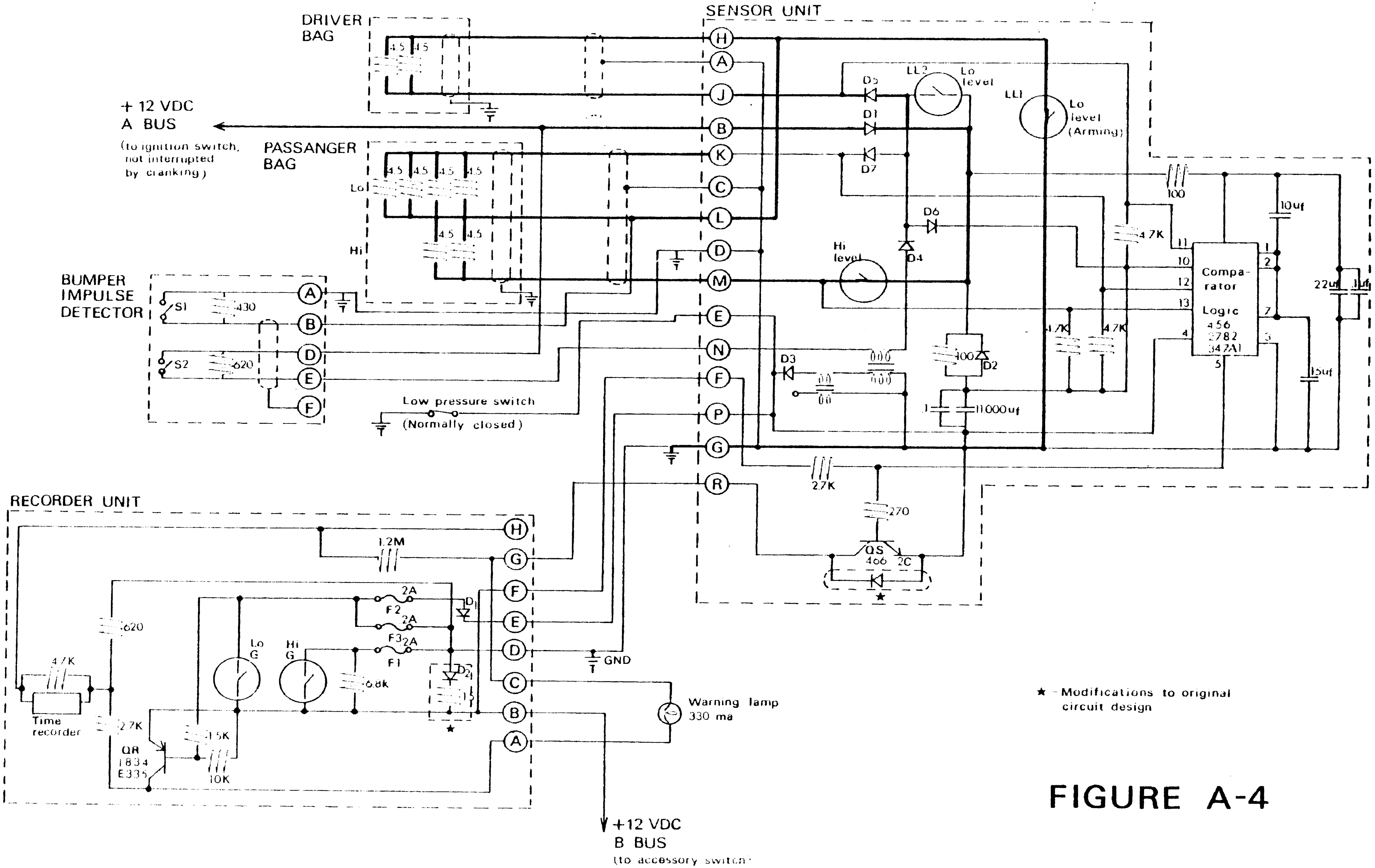

FIGURE A-4

G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

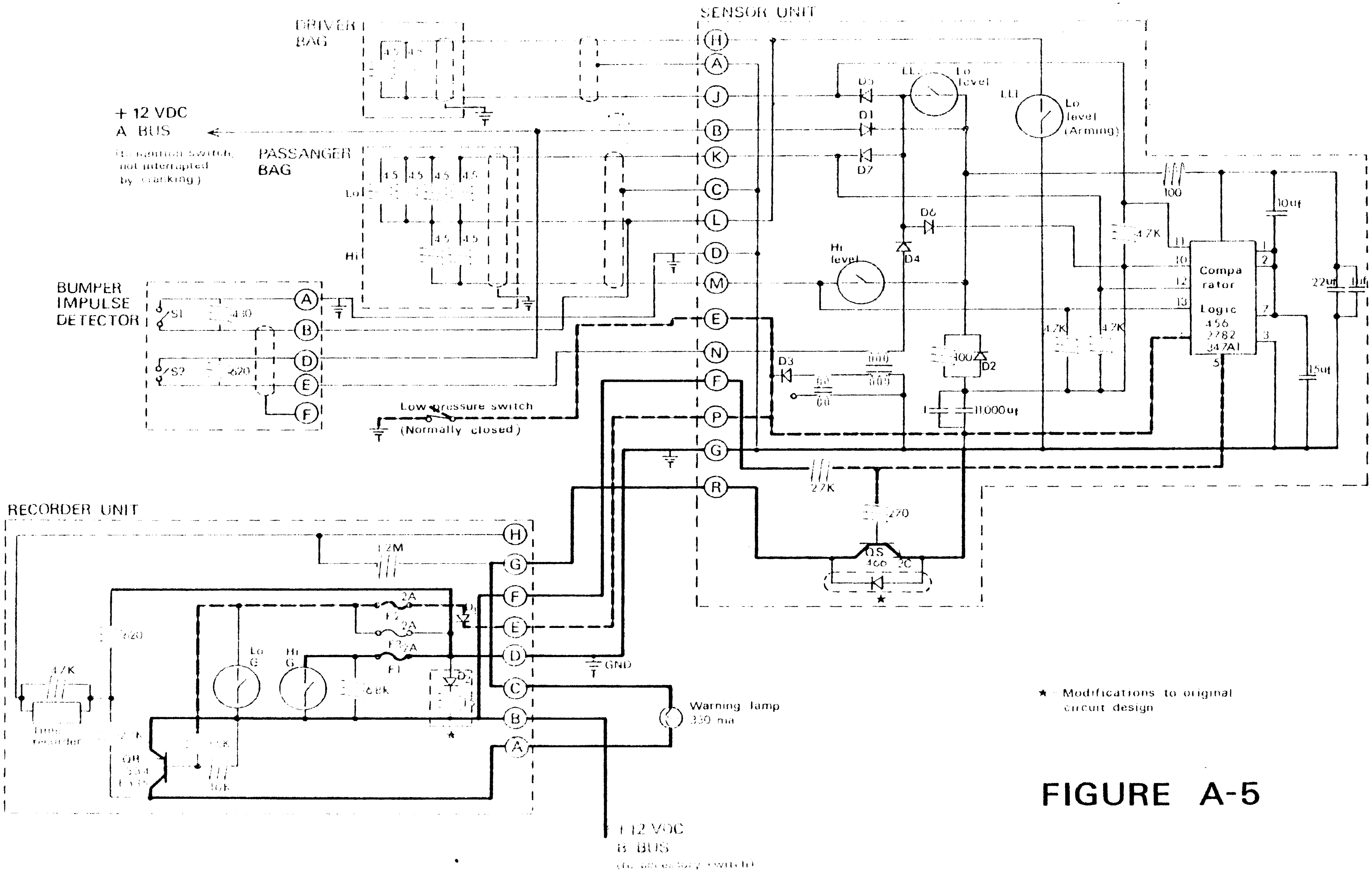

FIGURE A-5

G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

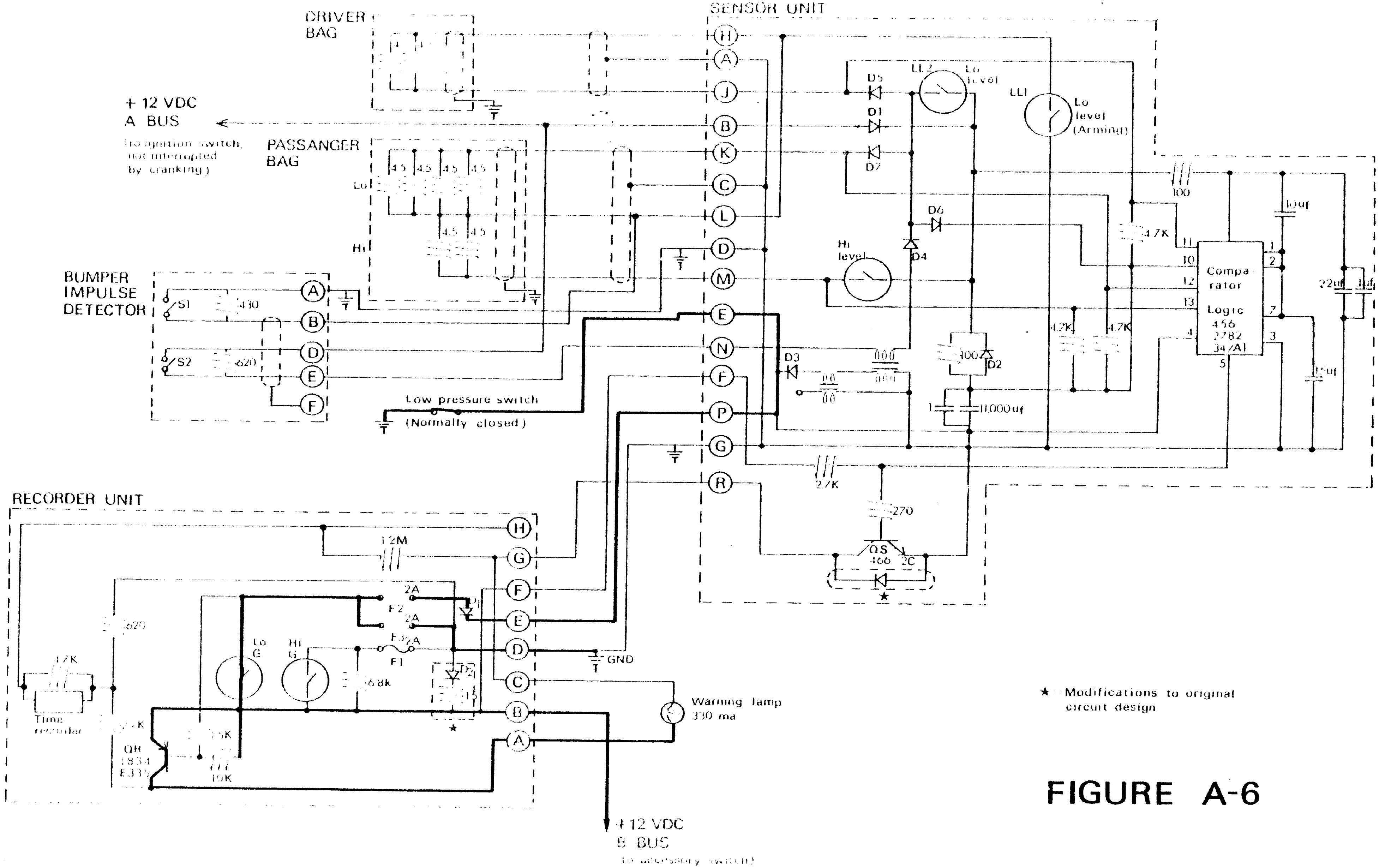

FIGURE A-6

G.M. AIR CUSHION RESTRAINT SYSTEM ELECTRICAL SCHEMATIC

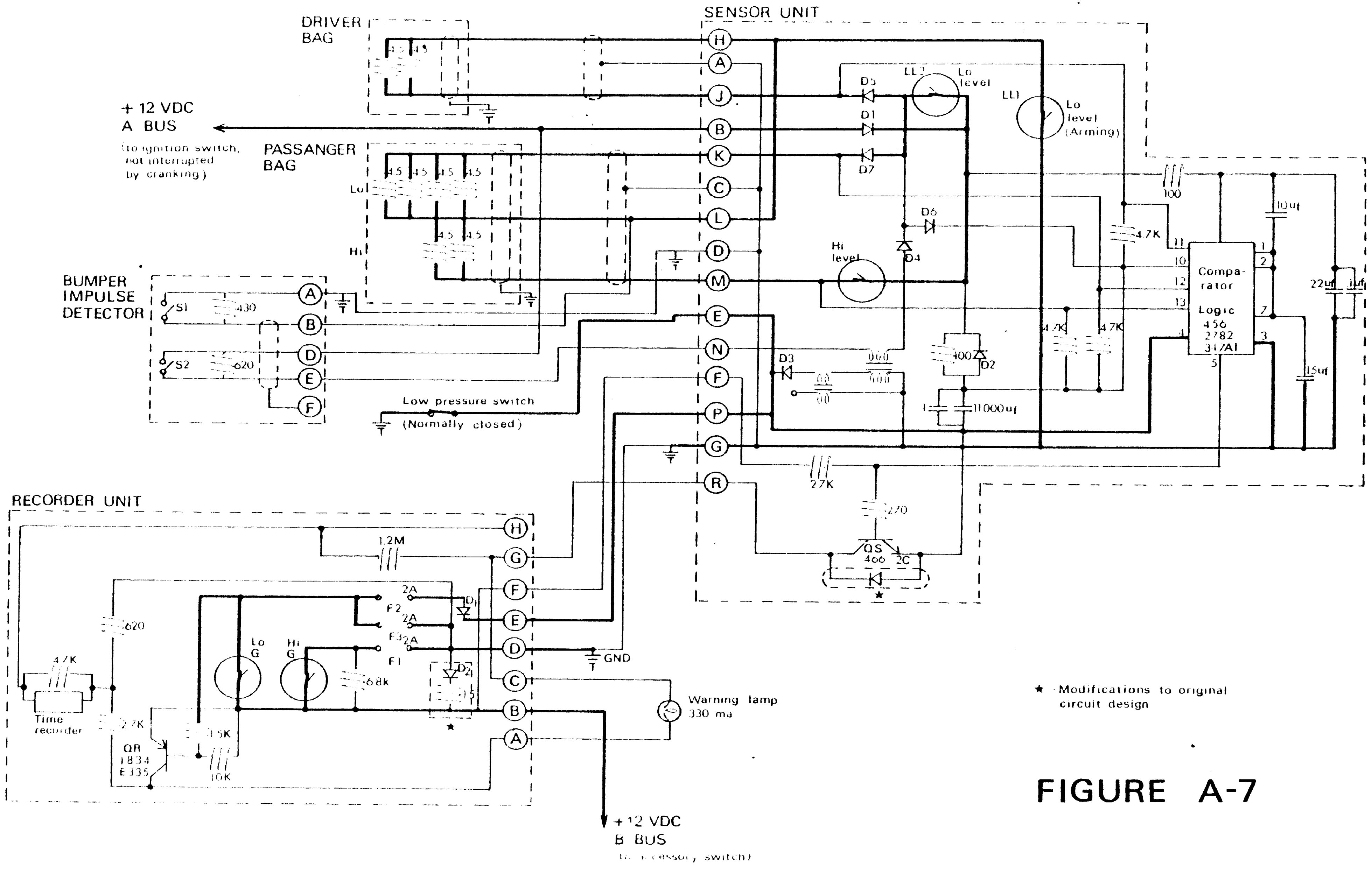

FIGURE A-7