State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-44-3
Relating to Exemptions under Section 27156
of the Vehicle Code

FAIRCHILD SEMICONDUCTOR
"BREAKERLESS IGNITION SYSTEM MODEL E-400"

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Section 39515 of the Health and Safety Code and Executive Order G-30A;

IT IS ORDERED AND RESOLVED: That the installation of the "Breakerless Ignition System Model E-400" manufactured by Fairchild Semiconductor, a division of Fairchild Camera and Instrument Corporation, 464 Ellis Street, Mountain View, California 94040 has been found to not reduce the effectiveness of required motor vehicle pollution control devices and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for all 1976 and older model year vehicles equipped with 4 cylinder engines and standard 12 volt negative ground Kettering ignition systems except for the following:

1. Volkswagen and other vehicles using Bosch distributors with unequal cam angles. (i.e. 1968-74 VW Beetle equipped with 4 speed and semi automatic transmission except 1970 VW Beetle equipped with semi-automatic transmission)

2. General Motors 4 cylinder engines.

3. Vehicles originally equipped with transistorized, capacitive discharge, or breakerless electronic ignition systems.

4. Vehicles equipped with dual point distributors where one of the points is used for emission control.

5. 1966-70 vehicles equipped with a retrofit NOx device which incorporates retard of basic ignition timing (i.e. Carter - CER, Echlin, STP-Air Computer, and AQP-Electro-NOx and Kar Kit).

The device consists of a magnetic pickup unit, compensator spring slipped over the distributor cam, adapter, solderless connectors, feeler gauge, and an amplifier module for transistor switching of the primary current to the standard ignition coil.

This Executive Order is valid provided that installation instructions for this device will not recommend tuning the vehicle to specifications different than those listed by the vehicle manufacturer.

Changes made to the design or operating conditions of the device, as exempted by the Air Resources Board, that adversely affect the performance of a vehicle's pollution control system shall invalidate this Executive Order.

Marketing of this device using an identification other than that shown in this Executive Order or marketing of this device for an application other than those listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board.

This Executive Order does not constitute any opinion as to the effect that the use of this device may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE "BREAKERLESS IGNITION SYSTEM MODEL E-400" DEVICE.

No claim of any kind, such as "Approved by Air Resources Board" may be made with respect to the action taken herein in any advertising or other oral or written communication.

Section 17500 of the Business and Professions Code makes untrue or misleading advertising unlawful, and Section 17534 makes violation punishable as a misdemeanor.

Section 43644 of the Health and Safety Code provides as follows:

> "43644. (a) No person shall install, sell, offer for sale, or advertise, or, except in an application to the State board for certification of a device, represent, any device as a motor vehicle pollution control device for use on any used motor vehicle unless that device has been certified by the State board. No person shall sell, offer for sale, advertise, or represent any motor vehicle pollution control device as a certified device which, in fact, is not a certified device. Any violation of this subdivision is a misdemeanor."

Any apparent violation of the conditions of this Executive Order will be submitted to the Attorney General of California for such action as he deems advisable.

Executed at Sacramento, California, this 19 day of ~~June~~ July 1976.

original signed by

Thomas C. Austin
Deputy Executive Officer-Technical

State of California
AIR RESOURCES BOARD

June 14, 1976

Staff Report

Evaluation of the Fairchild Semiconductor
"Breakerless Ignition System Model E-400"

I. Introduction

Fairchild Semiconductor, a division of Fairchild Camera and Instrument Corporation, 464 Ellis St., Mountain View, California 94040 has applied (Exhibit A and B) for an exemption from the prohibitions of Section 27156 of the California Motor Vehicle Code for the "Breakerless Ignition System Model E-400". An essentially similar design to Model E-400 was previously approved for Model E-300 by E.O. D-44-2 dated Oct. 30, 1975. The applicant intends to market the Model E-400 for 1976 and older model year four cylinder engine applications equipped with a conventional ignition system and 12 volt negative ground except for the following:

1. Volkswagen and other vehicles using Bosch distributors with unequal cam angles. (i.e. 1968-74 VW Beetle 4 speed and semi automatic transmission except 1970 Beetle with semi automatic transmission)
2. General Motors 4 cylinder engines.
3. Vehicles originally equipped with transistorized, capacitive discharge or breakerless electronic ignition systems.
4. Vehicles equipped with dual point distributors where one of the points is used for emission control.

5. 1966-70 vehicles equipped with a retrofit NOx device which incorporates retard of basic ignition timing (i.e. Carter-CEF, Echlin, STP-Air Computer and AQP-Electro-NOx and Kar Kit).

II. System Description and Function

The Fairchild "Breakerless Ignition System Model E-400" is a kit designed to replace the breaker points within the distributor. The kit consists of an amplifier, magnetic pick-up unit, adapter, compensator spring, feeler gauge, and installation instructions (Exhibit C). The magnetic pick-up is installed on the breaker plate with an adapter supplied with the kit. This adpater is custom made for specific distributor applications.

The heat treated spring steel compensator is slipped over the distributor cam. This "compensator spring" functions as a sharp edged cam causing the magnetic sensor to generate the correct wave form, regardless of the original equipment manufacturer (OEM) cam profile.

The air gap between the pick-up and the distributor cam lobe is determined by a feeler gauge. When the high points of the cam move past the magnetic pick up, an induced voltage signal is generated. This signal is transferred to the amplifier which triggers an electronic switch controlling the current flow to the primary side of the ignition coil. This signal stops the current flow to the primary side of the coil which causes the magnetic field of the coil primary to collapse. The collapse of the magnetic field builds up the voltage in the coil

secondary and causes the spark plug to fire. The electrical schematic is presented in Exhibit D. The model E-400 has basically the same circuit and components as the model E-300 except for the omission of the dwell calculator circuit incorporated in the E-300. The dwell calculator circuit was not necessary for four cylinder engine application according to the applicant.

III. System Evaluation

A. Applicant's Test Data

The applicant did not submit any emission data indicating the device will not have any adverse effect on the emission control system. The applicant did submit data characterizing the ignition system performance by comparing the output characteristics of the ignition system with and without the device. The tests were accomplished on an ignition system simulator according to the "Ignition System Measurements Procedure" SAE-J973a.

The applicant submitted back to back test data on 1971 Toyota Corolla, 1972 Datsun, and 1974 Pinto distributors. Summaries of the test data are shown in Table I through Table III inclusive.

The following are significant observations of the applicant's test data:

1. The test data submitted by the manufacturer showed consistently low values for available secondary voltage (simulating fouled spark plug) both with and without the

device. The applicant reviewed his test procedure and found a measurement technique error. The fouled spark plug simulator used in the measurement consisted of parallel resistors. This arrangement introduced additional capacitance on the secondary winding thereby lowering the output voltage below normal. This measurement error, however, will not affect other ignition parameters. By using series resistors to make up the load, the problem was eliminated and the output voltage increased to the proper level (Exhibit E).

2. The installation of the device on distributors equipped with a concentric breaker plate (i.e. Pinto, Datsun, and Toyota) introduced a maximum of 4 crankshaft degrees retard in centrifugal advance. The applicant's test data also showed minor retardation in vacuum advance which could be attributed to the experimental variability. Theoretically there should be no retard in the vacuum advance on distributors equipped with a concentric breaker plate. (ARB test data did not show any retard in vacuum advance on a distributor equipped with a concentric breaker plate.)

The combined maximum retard on any one type of distributor is 4 crankshaft degrees. This is within the ARB criteria of maximum allowable 4 crankshaft degrees retard.

3. The test generally showed an increase of approximately 10% in spark energy as a result of the device installation.

B. ARB Confirmatory Test Data

A confirmatory test on a 1974 Toyota Corolla was conducted by the ARB laboratory. Table IV shows a summary of this test data. The following are pertinent observations:

1. The available secondary voltage (simulating fouled spark plug) is within acceptable limits.
2. The combined centrifugal and vacuum spark advance are well within the allowable maximum 4-degree retard criterion.
3. There is a marginal 10% decrease in spark energy as a result of the device installation.

Data from the tests performed by the applicant and the ARB indicates there is no significant difference between the electrical characteristics of the baseline and device tests.

C. Manufacturer's Claims

The applicant did not submit any claims regarding the benefits of the device. It is the staff's judgement that the installation of the device on the vehicles could result in the following:

1. This breakerless system offers potential for reduced maintenance.
2. The electrical characteristics of this system do not indicate any significant benefits on performance, economy and emissions reduction greater than would be expected from a properly tuned engine.

D. Manufacturer's Amended Application

The manufacturer has previously submitted an application requesting that an exemption be granted on all 4 cylinder engine applications. However, the request for an exemption on certain VW models (1968-74 VW 4 cylinder engines equipped with 4 speed and semi automatic transmission except 1970 model equipped with semi automatic transmission) and General Motors 4 cylinder engines was later withdrawn because of the following reasons:

1. The above VW models have a 2° unsymmetrical distributor cam profile. This design was needed to alleviate a problem associated with the unequal cooling of the cylinders. The use of the device compensator spring will modify the OEM cam profile.
2. All General Motors 4 cylinder distributors are equipped with an eccentric breaker plate. ARB Laboratory and manufacturer's test data showed that the installation of the device on a Vega distributor introduced excessive ignition retard.

Excessive retard could cause valve overheating on some engines and reduce valve life with consequent increase in hydrocarbon emissions. Insufficient ignition advance also affects engine performance and could cause an increase in hydrocarbon and carbon monoxide emissions on some vehicles where the power enrichment circuit may be activated prematurely by excessive throttle application.

IV. Conclusion and Recommendations

Based on the evaluation of the application and the test data, the staff is of the opinion that the installation of the Fairchild "Breakerless Ignition System Model E-400" would not adversely affect the performance or operation of the OEM pollution control system. The staff, therefore, recommends that the Fairchild Semiconductor Corporation be issued an exemption from the prohibitions of Section 27156 of the Vehicle Code for its "Breakerless Ignition System Model E-400" for installation on 1976 and older model vehicles equipped with 4 cylinder engines and standard 12 volt negative ground Kettering ignition systems except for those vehicles previously specified in the introduction, which include vehicles equipped with distributors with unequal cam angles and vacuum advance eccentric breaker plate.

Table I - Fairchild Model E-400 Ignition System Data Summary for 1971 Toyota Corolla 4 cylinder engine (submitted by applicant)

A. Centrifugual Spark Advance in Crankshaft Degrees

Engine RPM	Baseline	Device
1200	2	2
2000	10	8
2800	18	14
3400	22	18
4000	24	22

B. Vacuum Spark Advance in Crankshaft Degrees

Vacuum in. Hg.	Baseline	Device
3	0	0
6	3	2
9	10	10
15	18	18
20	18	18

C. Spark Duration in Microseconds

Engine RPM	Baseline	Device
1000	1600	1500
4000	1200	1050

D. Secondary Voltage Rise Time in Microseconds

Engine RPM	Baseline	Device
1000	23	26
4000	24	30

E. Spark Energy in Millijoules

Engine RPM	Baseline	Device
1000	43.2	45.6
4000	20	25

F. Available Secondary Voltage in Killovolts* (simulating fouled spark plug)

Engine RPM	Baseline	Device
1000	11	12.5
4000	10	10.5

G. Available Secondary Voltage in Killovolts (with load)

Engine RPM	Baseline	Device
1000	26	28.5
4000	21	25

*See text for low voltage explanation

Table II - Fairchild Model E-400 Ignition System Data Summary for 1972 Datsun (S.P.) 4 cylinder engine (submitted by applicant)

A. Centrifugal Spark Advance in Crankshaft Degrees

Engine RPM	Baseline	Device
600	0	0
1000	6	6
1400	14	12
1700	20	18
2000	26	28

B. Vacuum Spark Advance in Crankshaft Degrees

Vacuum in. Hg.	Baseline	Device
3	0	0
6	0	0
9	0	0
15	7	8
20	9	8

C. Spark Duration in Microseconds

Engine RPM	Baseline	Device
1000	1400	1500
4000	800	850

D. Secondary Voltage Rise Time in Microseconds

Engine RPM	Baseline	Device
1000	26	25
4000	36	38

E. Spark Energy in Millijoules

Engine RPM	Baseline	Device
1000	42.5	43.3
4000	17.6	20.2

F. Available Secondary Voltage in Killovolts* (simulating fouled spark plug)

Engine RPM	Baseline	Device
1000	11	13
4000	10	10

G. Available Secondary Voltage in Killovolts (with load)

Engine RPM	Baseline	Device
1000	26	25
4000	20	20

*See text for low voltage explanation

Table III - Fairchild Model E-400 Ignition System Data Summary
for 1974 Pinto 4 cylinder engine (submitted by applicant)

A. Centrifugal Spark Advance in Crankshaft Degrees

Engine RPM	Baseline	Device
1200	3	1
2000	12	10
2800	22	19
3400	25	22
4000	28	25

B. Vacuum Spark Advance in Crankshaft Degrees

Vacuum in. Hg.	Baseline	Device
3	0	0
6	7	6
9	12	10
15	12	10
20	12	10

C. Spark Duration in Microseconds

Engine RPM	Baseline	Device
1000	1300	1300
4000	850	1000

D. Secondary Voltage Rise Time in Microseconds

Engine RPM	Baseline	Device
1000	33	28
4000	30	32

E. Spark Energy in Millijoules

Engine RPM	Baseline	Device
1000	39.7	44
4000	23.8	24

F. Available Secondary Voltage in Killovolts* (Simulating fouled spark plug)

Engine RPM	Baseline	Device
1000	12	13.5
4000	12-14	11.5

G. Available Secondary Voltage in Killovolts (with load)

Engine RPM	Baseline	Device
1000	28	28
4000	23.5	23.5

*See text for low voltage explanation

Table IV - Fairchild Model E-400 Ignition System Data Summary for 1974 Toyota Corolla 4 cylinder engine (ARB confirmatory test)

A. Centrifugal Spark Advance in Crankshaft Degrees

Engine RPM	Baseline	Device
1200	1	0
2000	8	7.5
2800	15	14
3400	18.5	17
4000	22	20

B. Vacuum Spark Advance in Crankshaft Degrees

Vacuum in. Hg.	Baseline	Device
3	0	0
6	0	0
9	1.5	1
15	10	10
20	13	13

C. Spark Duration in Microseconds

Engine RPM	Baseline	Device
1000	2300	2200
4000	2000	1800

D. Secondary Voltage Rise Time in Microseconds

Engine RPM	Baseline	Device
1000	40	40
4000	40	40

E. Spark Energy in Millijoules

Engine RPM	Baseline	Device
1000	23.0	21.2
4000	19.6	17.7

F. Available Secondary Voltage in Killovolts (simulating fouled spark plug)

Engine RPM	Baseline	Device
1000	18	17
4000	16	15

G. Available Secondary Voltage in Killovolts (with load)

Engine RPM	Baseline	Device
1000	24	24
4000	24	22

FAIRCHILD
CAMERA AND INSTRUMENT
CORPORATION

464 Ellis Street, Mountain View, California 94042

(415) 962-5011
TWX: 910-379-6435
Cable: FAIRSEMCO

Refer Any
Reply To 19-109
Mail Stop:

Exhibit A

20 January 1976

Mr. Richard Kenny
California Air Resources Board
9528 Telstar Ave.
El Monte, Ca. 91371

SUBJECT: REQUEST FOR EXEMPTION FROM VC27156 PROHIBITION

Dear Mr. Kenny:

Fairchild Semiconductor is planning to market a retrofit breakerless ignition system for 4 cylinder applications, Model E-400, as an addition to our line of previously exempted models; E-300 and E-100. Please consider this letter an official request for exemption from Section 27156 of the California Vehicle Code. Our testing and accumulated data shows installation of the E-400 will not adversely affect OEM specifications beyond allowable limits, as specified by the California A.R.B. To aid in establishing our exemption for the E-400, please find enclosed:

A. Description of system construction and circuit (Attachment I).
B. Installation instructions (Attachment II).
C. Applications list (Attachment III).

After your review of our applications list and system description, please request data for those specific models you require and I will forward them immediately.

Thanking you in advance for your cooperation in this matter, I am available for any problems or questions you may have at (415) 962-3548.

Sincerely,

Ron Grable
AUTOMOTIVE PRODUCTS DIVISION

/tmg

Enclosures (3)

E-400

ELECTRONIC IGNITION

CONSTRUCTION

The unit is constructed according to the best OEM ignition system manufacturing practices. Its outer case consists of a cast aluminum housing which provides primary protection against the adverse underhood environment, and a convection heat exchange surface for transferring the circuit's small internal heat away from its electronic components.

Internally, all circuit components (transistors and resistors) are mounted on a high quality printed circuit board. Heat transfer from the output power Darlington transistor is via a metal heat sink attached to the housing. External electrical connection is via a four conductor 'zip' cord type wire harness of sufficient length and diameter to prevent interconnect problems due to mechanical failure. Terminals are attached to leads for ease of installation.

The magnetic sensing unit is mounted within the distributor on individual adapter plates, which are then securely fastened down to the vacuum advance plate. The coil is encapsulated to make it impervious to the distributor environment. Coil termination is done by using strain relieved silicone rubber insulation #22 AWG wire, flexible enough to withstand the flexing encountered in normal operation.

A heat treated spring steel "compensator" is supplied, to be slipped over the existing distributor cam. This "compensator spring" functions as a symmetrical, peaked cam, causing the magnetic sensor to generate the correct wave form, regardless of the OEM cam profile. The spring is manufactured to MIL SPEC tolerances and in worst case application is stressed to only 25% of its allowable limit. The connection is by 6 spot welds giving a very high degree of reliability to the joint.

In addition to the normal protection offered by their individual packages, all circuit components are then cast in a highly filled epoxy potting compound similar in composition to that used in current production Ford and Chrysler ignition systems.

The finished unit is then electrically tested and packed for shipment.

CIRCUIT DESCRIPTION

The Fairchild E-400 Ignition System consists basically of three major building blocks.

a. The signal conditioning stage.

b. The buffer stage.

c. The output stage.

The first stage conditions and amplifies the output from the magnetic pick-up, and generates the proper dwell information for the system. It also controls the system hysteresis to ensure noise-free operation. The buffer stage provides signal phase inversion as well as sufficient current gain to drive the power stage. The power output stage consists of a monolithic Darlington pair, designed specifically for Ignition System applications. This stage performs the switching of the heavy primary current, thus assuming the same role as mechanical breaker points in a conventional system. The output stage is actively clamped to 360 volts (V_{CE} Max) for improved reliability.

ATTACHMENT II

1/20/76

ADDITION TO E-300 INSTRUCTIONS FOR E-400

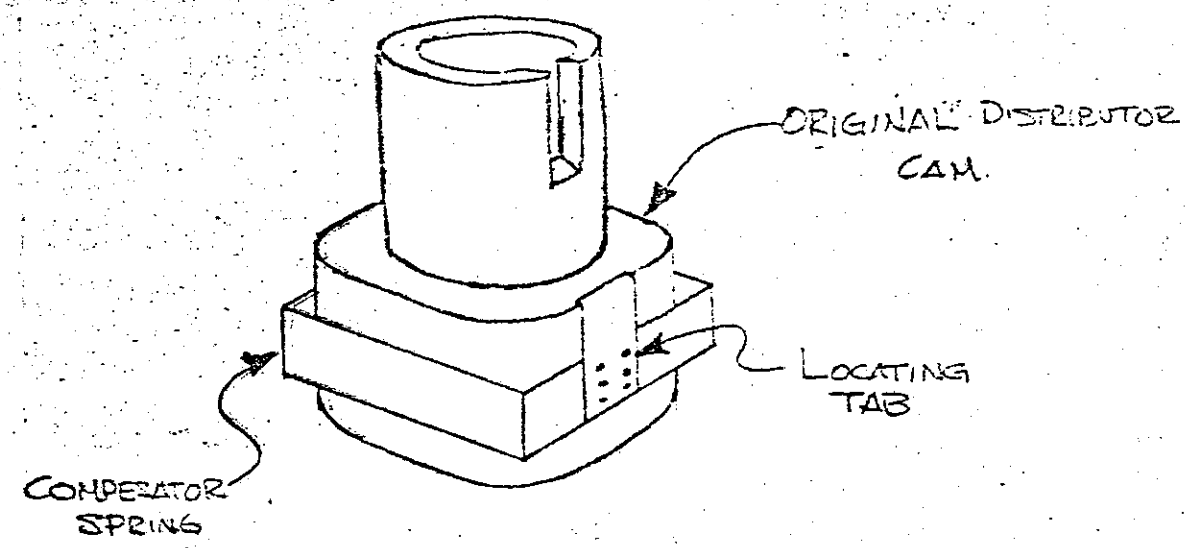
New Step 3.

Select proper compensator spring and slip it over the distributor cam shaft. The proper height is indicated by the tab on the spring which will be level with the top of the distributor cam surface as shown in Fig. 3. The compensator "grips" the cam surface and must be flexed slightly to slip it over the cam itself. Exerting slight pressure on two opposite flats, between thumb and forefinger, expands the opposite sides and the spring will then slide over the cam.

New Step 4.

Rotate distributor cam (if equipped with manual transmission, push car in high gear; if automatic transmission, use starter) until point of compensator spring is centered to the pick-up pole piece and adjust gap to .008" using feeler gauge provided. Use another screwdriver to wedge pole piece arm (using slot provided in adapter plate), while tightening pick-up holding screw. Recheck gap setting after tightening.

FIGURE 3. COMPENSATOR SPRING INSTALLATION



ADAPTER PLATE CROSS-REFERENCE LIST (REPLACES E-300 LIST)

MAKE	YEAR	ADAPTER PLATE #	COMPENSATOR SPRING	COMMENTS
AUDI	68-74	205	White	
BMW	68-74	205	White	
CAPRI	69-74	205	White	
✓ DATSUN	65-74	202	Yellow	Single Point
HONDA CIVIC	73-76	202	Yellow	
MERCEDES	68-72	205	White	
PINTO (1.6 & 2.0 L)	71-74	205	White	Bosch Distributor
✓ PINTO	73-75	208	Black	
✓ TOYOTA	67-75	204	White	
VOLKSWAGEN	68-74	205	White	
VOLVO	68-74	205	White	

ATTACHMENT III

1/20/76

The Fairchild E-400 fits the following 4 cylinder applications:

MODEL	YEARS	SPECIAL REQUIREMENTS
Audi	68-74	
BMW	68-74	
Capri	69-74	
Datsun	65-74	Single Point
Honda Civic	73-76	
Mercedes	68-72	
Pinto (1.5 & 2.0 L)	71-74	Bosch Distributor
Pinto (2.3 L)	73-75	
Toyota	67-75	
Volkswagen	68-74	
Volvo	68-74	

FAIRCHILD
SEMICONDUCTOR
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

313 FAIRCHILD DRIVE, MOUNTAIN VIEW, CALIFORNIA 94041 • (415) 962-5011 • TWX: 910-379-6435 • CABLE ADDRESS: FAIRSEMCO

June 14, 1976

California Air Resources Board
9528 Tel Star Ave.
El Monte, California 91731

Attention: Mr. Fernando Tan

Dear Fernando,

Per our telephone conversation regarding VW and Vega test results, we will withdraw our application for exemption for Vega and VW beetle. This information has been added to the application list on the outside of the carton along with the following:

Applications not exempted:

1) Vehicles equipped with retro-fit Nox devices which introduce 4 degrees retard.

2) Vehicles originally equipped with breakerless electronic ignition systems.

3) Vehicles equipped with dual point distributors.

Regarding VW beetle model years with asymmetrical cams, we appear to be in agreement that the only model with a symmetrical cam is 1970 semi-automatic.

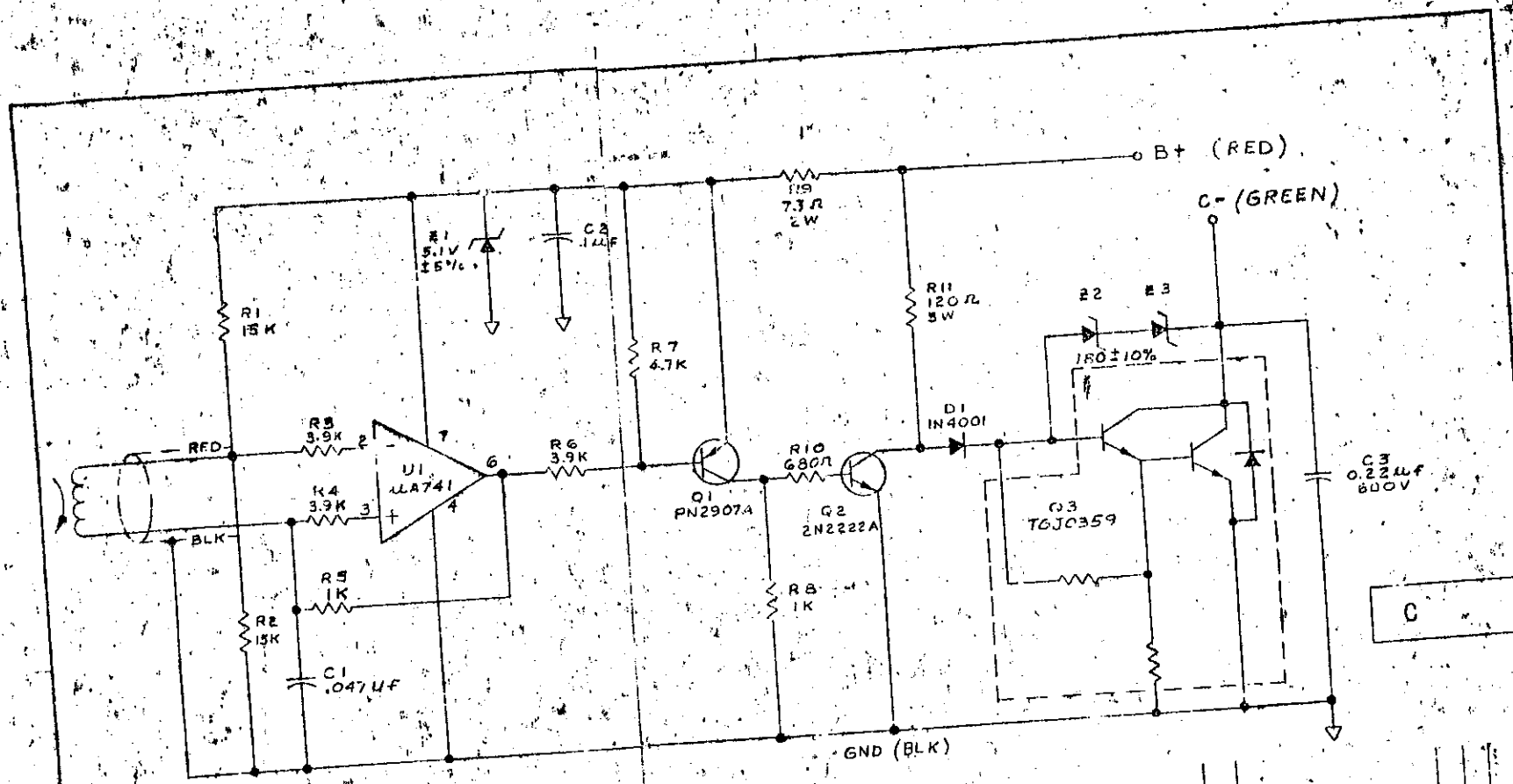
We would like to add Opel (66 – 74) to our application list. We recently reinvestigated possible applications and found that Opel uses the same distributor and contact set as Audi and Capri which are exempted.

Sincerely,

FAIRCHILD SEMICONDUCTOR

Jim Holt
Engineering Manager

JH/tb



NOTES:
1. ALL RESISTORS ARE IN OHMS (Ω), 1/4W UNLESS OTHERWISE SPECIFIED.

REV	DESCRIPTION	BY	DATE	ENG APP

REVISIONS

COMPANY PRIVATE
FAIRCHILD
ULNICONDUCTOR

TOLERANCE UNLESS SPECIFIED: ON FRACTIONAL DIMS ±1/16; ON 2 PL DEC DIMS ±.010; ON 3 PL DEC DIMS ±.005; ON 4 PL DEC DIMS ±.0050; ON ANGULAR DIMS ±1°
SURFACE FINISH 63
SCALE NONE

FSD 411 USED ON ASSY
NEXT ASSY
PARTS LIST

H. HOWELL 12-1-74
CHK
APP'D
MFG
ENG

TITLE: SCHEMATIC, KV-E400

PLANT	AREA	ASSY NO	MODEL	DETAIL NO
		FSC 413		C

C

FAIRCHILD
CAMERA AND INSTRUMENT
CORPORATION

464 Ellis Street, Mountain View, California 94042

(415) 962-5011
TWX: 910-379-6435
Cable: FAIRSEMCO

Refer Any
Reply To
Mail Stop: _____

Exhibit E

March 26, 1976

California Air Resources Board
9528 Telsfar Ave.
El Monte, California 91731

Attention: Mr. Richard Kenny

Subject: Discrepancy between Measurement of Fouled Plug Output Voltage. (data point #11. of standard A.R.B. Ingition data sheet).

Dear Dick,

Per our telephone conversation of 3/16/76.

As it turned out, parameter #11 in the data we sent you with our application, is low by approximately 50% on measurements of devices as well as baseline. We found the reason to be a measurement technique error on our part. The fouled plug simulator that was used for our original measurements, consisted of a number of resistors connected in parallel to make up a 1 Mn, 10W resistor (per S.A.E. only requirement), but using this load also introduced a lumped capacitance of approximately 20pf, which increased the load on the coils secondary winding to make the output lower than normal. By using a series string of resistors to make up the said load, eliminated this problem and the output voltage, as per data point #11 (ARB data sheet) increased to the proper level.

As soon as the new data is available I will forward it to you. I am very sorry about the inconvenience.

Yours truly,

Len Arguello
Senior Design Engineer

LA/tb