NATIONAL RADIO ASTRONOMY OBSERVATORY

RADIO FREQUENCY INTERFERENCE SUPPRESSION ON THE 1972 CHEVROLET VEGA

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At the direction of S. Weinreb, a 1972 Chevrolet Vega, squareback model, vehicle was purchased for experimental noise suppression tests. The vehicle was standard except for automatic transmission. After some delay (assembly plant on strike) the vehicle was delivered in May by Mountaineer Motors of Elkins. This particular vehicle was selected for the following reasons:

1) Engine physical construction promised good access to the ignition system.

2) The rear cargo area could be used for instruments, etc.

3) Small, economic on-site transportation.

The first reason was the primary consideration.

Ignition Noise

Two methods were considered for ignition noise suppression. The first method was a commercial-military version of a popular cable and distributor shielding unit. This unit has been successfully used by the military to protect communications systems in the HF range. Figure 1 shows the unit, manufactured by Livingston Industries (formerly Hallett).

The first step was to bond the frame and body together by means of 1-inch braid and ground the negative terminal of the battery to the engine in the same manner. The shielding harness was then installed as directed by the manufacturer, with close attention payed to small openings, unshielded wires and bypass capacitors. Original plans called for the coaxial cable to be painted with a conductive coating system, and all openings to be sealed with conductive caulking. However, this material was not on hand at the time the unit was installed, and the measurements were made without this added insurance. Because of the statistical nature of the wideband impulsive noise, no absolute measurements were made. The spectrum analyzer was used for comparison measurements showing relative signal levels. All tests were made in the following manner:

Vehicle

1) Hood up.
2) Engine speed approximately 1000-1500 r. p. m.
3) Probe as near source as possible.

Analyzer

1) Attenuation — 0 dB.
2) IF gain — 70.
3) Det — log.
4) IF bandwidth — 100 kHz.
5) Trigger — line.
6) Sweep speed — 10 ms/cm.
7) Spectrum width — as desired.
8) Frequency — as desired.

Preliminary tests showed ignition (or impulsive noise) decreasing in amplitude to about 2 GHz. Maximum noise occurred in the DC to 250 MHz range. (No preamplifier was available below 100 MHz.) The same measurements were made with the hood closed. Amplitude across the band decreased by about 10 dB. Following these tests, the military-type shielding harness was installed and identical tests were made. First indications were that the shielding harness gave little or no attenuation in the VHF-UHF range. Further investigation showed that most of the impulsive noise present was not ignition noise. In fact, the "other" noise almost completely masked the r. p. m. related impulses.

Filters were placed in the ventilation fan motor leads and the measurable noise decreased by about 20-30 dB, and ignition noise could then be seen, along with still more non-r. p. m. related noise. More probing traced the noise to the fuel pump which on this vehicle is immersed in the fuel tank in the rear of the vehicle. Attempts were made to filter the leads to the pump, with no success. This problem was solved by disabling the factory-installed pump and replacing it with a new unit mounted in a shielded-filtered enclosure under the hood. System noise was reduced until the ignition noise was now dominant, but about 40 to 50 dB below the reference level observed in the beginning. Since we had no conductive paint on hand, it was decided to proceed with shielding system number two.

RFI-Tight Metallic Enclosure

This system differs from the harness-type shield in that an aluminum RF-tight box-type enclosure is built around the entire ignition system, including plugs, coil, wires, and distributor. The only lead entering the enclosure is the 12-volt battery lead which is RF bypassed. A photo of the enclosure mounted on the engine is shown in Figure 2.

This shield proved to be very effective in eliminating ignition noise. Only traces of ignition noise could be found by probing along the edges of the box. Further refinements in mounting the box should lower these traces below detectable level of our equipment in the van, about 1×10^{-17} W/m^2. However, with ignition noise almost undetectable, another source of noise became apparent. This was found by probing into the vehicle wire harness and traced to the regulator-altenator system. Tests indicated an instability in the regulator system at the point of cross-over that seemed to behave like an on-off (or bang bang) servo system.

The regulator on this vehicle is integral with the alternator. A check of the regulator schematic indicated a possibility of circuit modifications (lengthening the time constant) that might smooth regulator action. The generator was removed and dismantled to allow access to the regulator. The regulator turned out to be an encapsulated thick-film circuit allowing no opportunity for modifications. The only method left was brute force filtering.

The generator system was set up remotely and driven with an electric motor. All leads were filtered. The low current reference leads were filtered by commercial in-line units. An NRAO L-section filter was constructed for the alternator output lead. This filter must be capable of handling the 30 to 40 amperes from the alternator under full load. Except for other auxiliary units, such as horn and windshield wiper motor, system noise was reduced almost to our detection level of $\approx 10^{-17}$ W/m^2 at point blank probe range with the hood up. The horn buzzer was not considered a serious problem (disconnected) and the windshield wiper motor was filtered.

With these modifications the vehicle was put into service to get some comments and operating experience. About one week later, operators at the 300-foot telescope thought they saw noise in the VHF range from the vehicle. General conditions were bad that day — lightning and rain — so the interference could have been coincidental. The next day the vehicle was started and stopped and driven around the telescope with no indications of interference. At the time of this writing (7-1-72), the vehicle is in the shop for refinements on the enclosure and better contacts on the hood to insure electrical continuity.

Advantages of This Vehicle

1) Four cylinder, fairly easy access to ignition system.

2) Economy, acquisition cost less than $2,300.00.

3) Usable cargo area in rear for instruments, etc.

Disadvantages of This Vehicle

1) Fuel pump inaccessible.

2) Ventilator motor runs continuously.

3) Regulator inaccessible.

4) Key necessary to open tailgate.

5) Difficult to remove key from ignition.

6) Vehicle ground clearance minimum.

7) Physically difficult to get into and out of particularly for larger than average person.

APPENDIX

Steps to suppress electrical noise on the 1972 Vega vehicle:

1) Test noise levels for future reference.
2) Bond with 1-inch braid as follows:
   a) Negative battery lead to motor block.
   b) Negative battery lead to chassis.
   c) Front corners of hood to body.
   d) Tail pipe to chassis.
3) Attach spring tension fasteners to rear corner of hood to insure contact to body.
4) Filter heater-ventilation motor lead with type 1 filter. *
5) Disable "lo" speed position of heater-ventilation motor to provide "off" position. (Remove resistance wire from switch.)
6) Disable original fuel pump (cut power lead).
7) Mount new fuel pump in engine compartment shield and filter using type 1 filter.
8) Filter sensing lead to regulator, use type 2 filters.**
9) Filter reference lead to regulator, use type 2 filter. (Mount filters on alternator housing.)
10) Wind 1-inch diameter air core coil of 10 turns of No. 8 wire. Place in series with generator output near generator terminal.
11) Bypass alternator output to ground with 0.1 μF mylar capacitor in parallel with 1000 pf silver ceramic. Keep leads short.
12) Disable (or adequately filter) horn buzzer.
13) Filter windshield wiper motor power lead using type 1 filter mounted on fire wall.
14) Construct RF-tight sheet-metal box to enclose coil, distributor, ignition wire and plugs. (Coil must be moved to location alongside engine.)

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* Type 1 filter, Cornell Dubilier, model NFR 102-6A.

** Type 2 filter, Components Corporation, model M115-P5.

15) Filter "ignition" lead to distributor using type 2 filter mounted to enclosure.

16) Check for unwanted radiation by probing under hood around enclosure and in cable harness.

Time and Cost Estimate for First Vehicle

Electronics Engineer	3 days
Technician	5 days
Mechanic	5 days
Sheet Metalist	7 days

Material			Total
Filters:	Type 1 - 3 required	$21.75 ea.	$ 65.25
	Type 2 - 3 required	$20.47 ea.	61.41
Fuel Pump		$21.65	21.65
Miscellaneous		$50.00	50.00
	Total		$198.31

Time required for another vehicle of the same type could probably be reduced at least 1/3.

Recommendations

1) Keep vehicle in service long enough to acquire feeling for reliability of auto and shielding system.

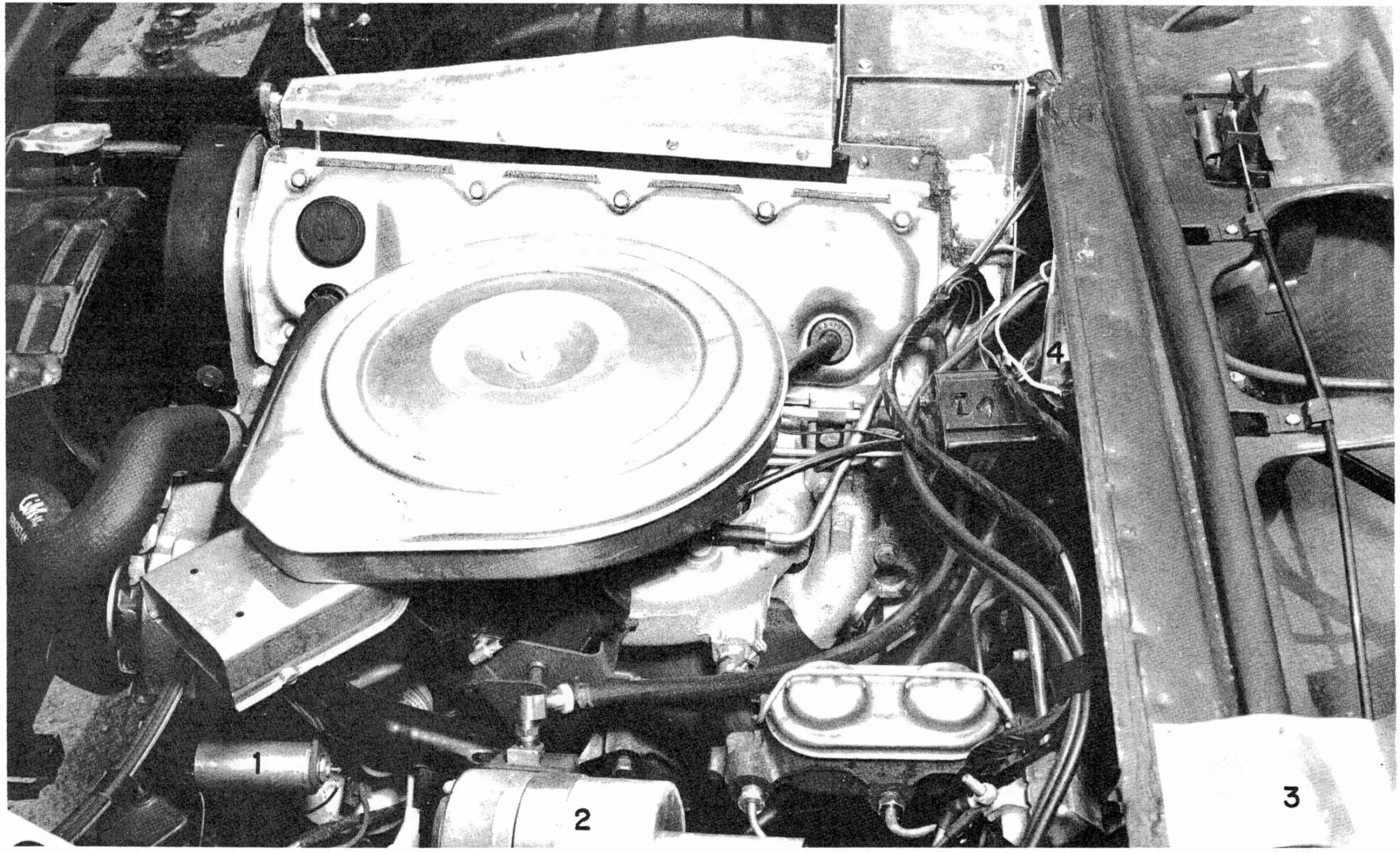
2) If the program is to continue, consider changing to a full-size, 6-cylinder sedan not having some of the disadvantages of the Vega model.

Subscript

September 7, 1972

The "before" picture shown is not the same vehicle, but another 1972 Vega. Engine compartment differences are minimal, largely the addition of the supercharge on the "before" engine.

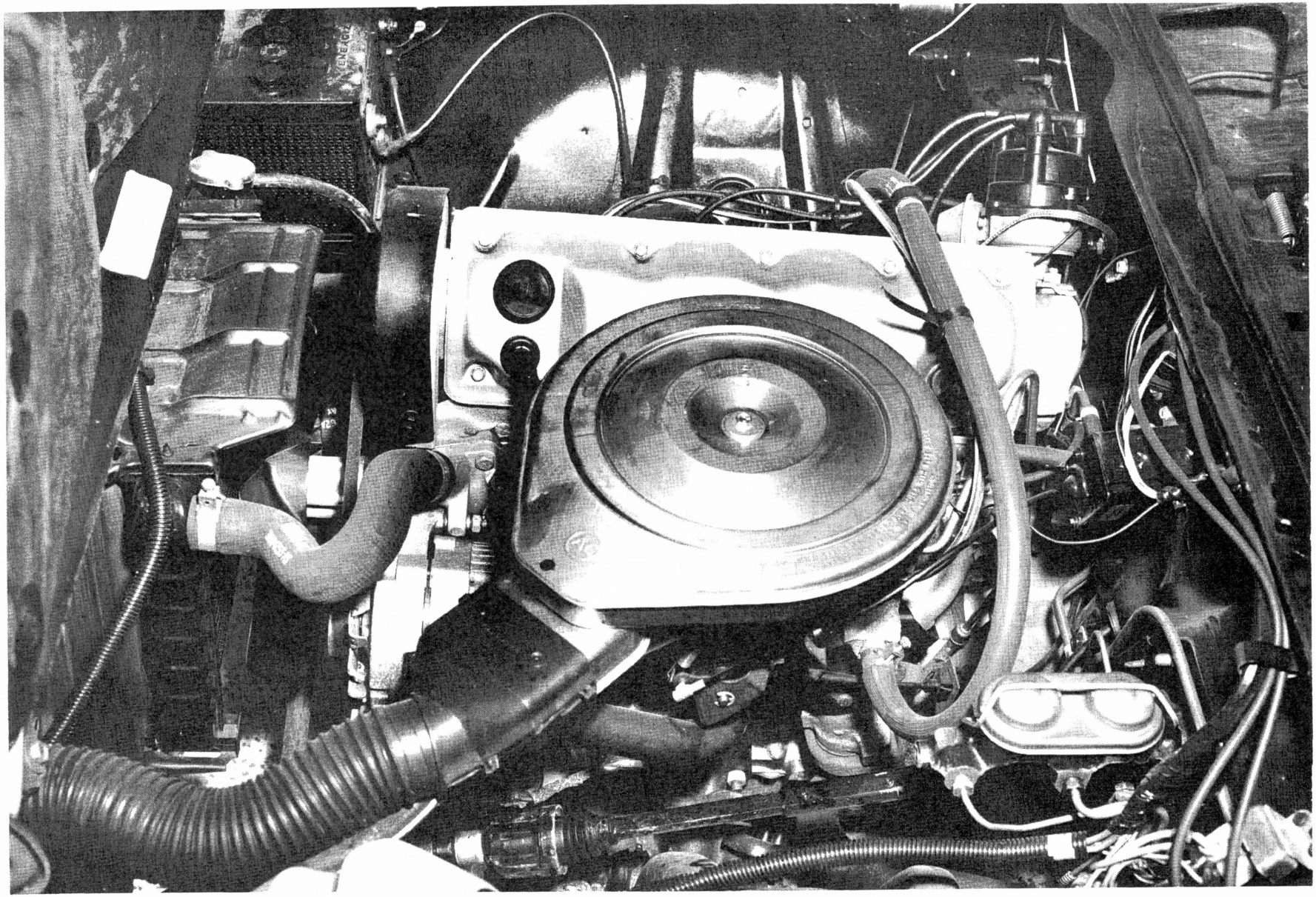
The Vega has been in continuous use for about 2 months now with no major mechanical difficulties and no further reports of possible ignition noise.



LEFT SIDE *"AFTER"*

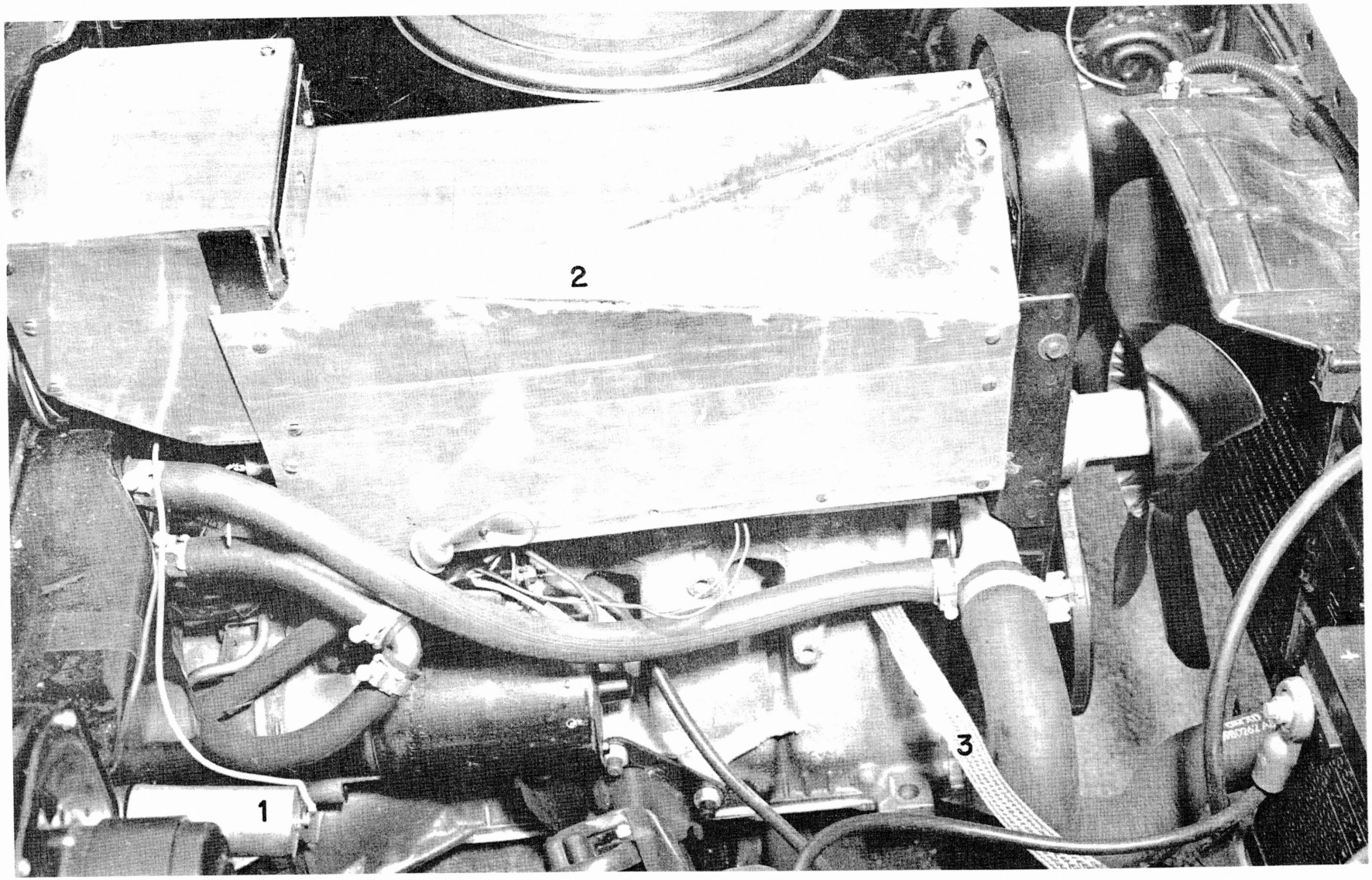
1. ALTERNATOR & FILTER
2. NEW FILTERED FUEL PUMP
3. HOOD CONNECTOR, R.F.
4. WIPER MOTOR FILTER

FIG. 1



LEFT SIDE *"BEFORE"*

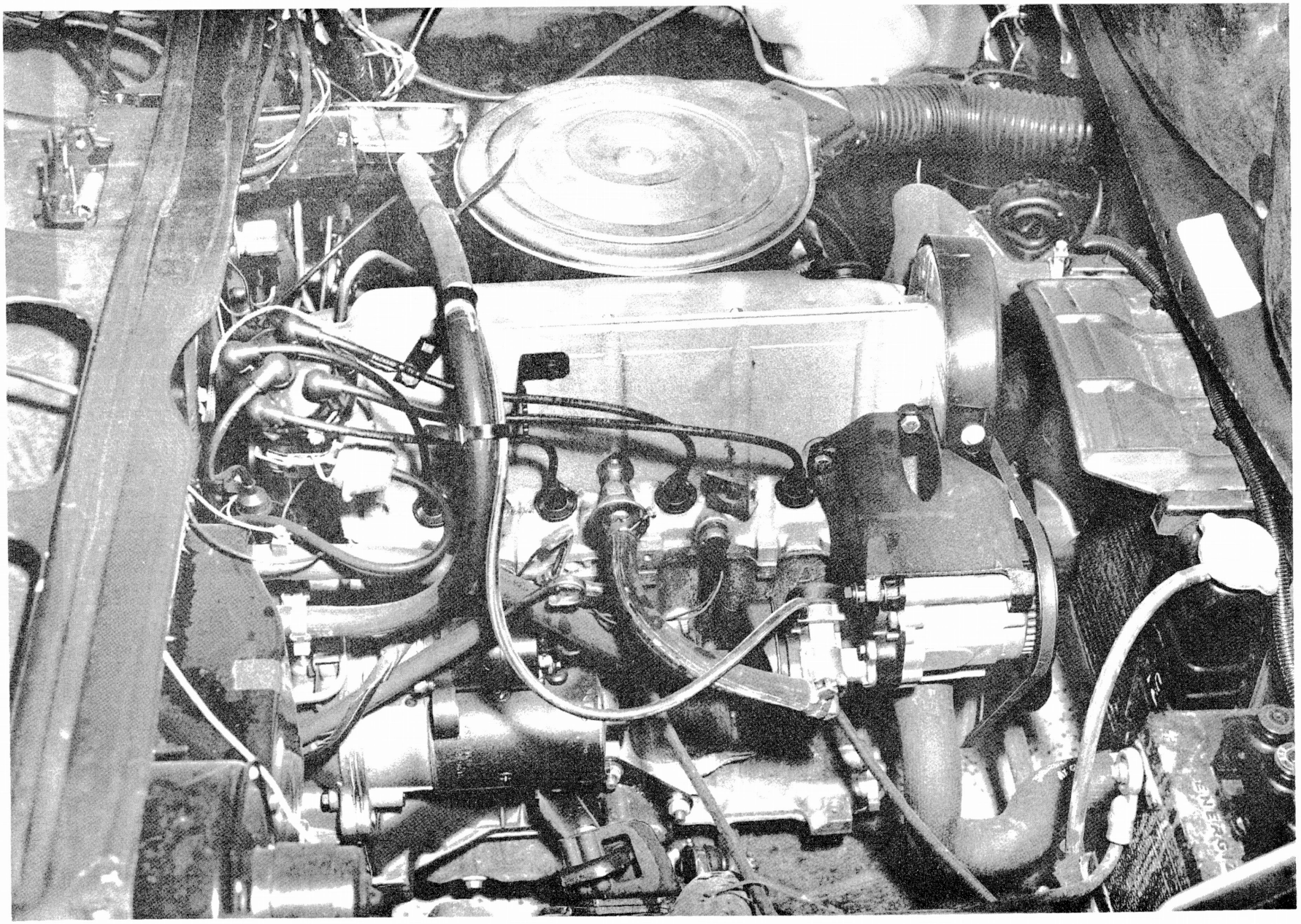
FIG. 1A



RIGHT SIDE *"AFTER"*

1. HEATER FAN FILTER
2. IGNITION COVER
3. BONDING STRAPS

FIG. 2



RIGHT SIDE *"BEFORE"*

FIG. 2A