The Rover SD1 V8 Electronic Ignition System – Description and Analysis.

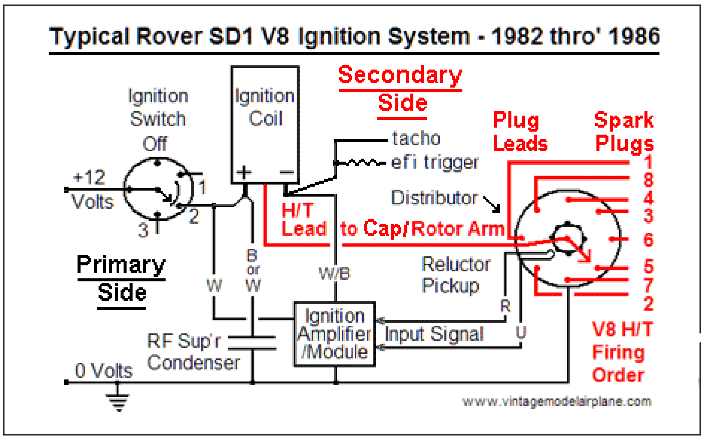
Prologue! For me, recently trying to learn, and then write up a complete description of an unfamiliar system from different view-points has created some conscious repetition in order to re-emphasize key points! No bad thing for me and I hope for the reader, as it also reduces errors and omissions, otherwise gratefully received to improve the sense and accuracy of this article.

Ignition is the main provider to an engine's overall performance which demands lively, fat sparks for efficient fuel/air mixture combustion. The aims of the SD1 V8 ignition system are:

- Generate typically, a 10-20,000 volt spark from a 12 volt supply.
- Direct the spark to each combustion chamber as its piston approaches top, dead center on its compression stroke.
- Manage how/when the spark appears inside each combustion chamber depending upon variable engine speed and load.
- Send a spark with sufficient energy to guarantee complete mixture combustion.
- Perform all the above over the full range of engine temperature, engine speed and load.

Synopsis! The standard Rover SD1 V8 ignition system works by taking relatively high current from battery voltage and converting it into a very high voltage capable of jumping a spark plug gap that ignites the combustible mixture inside a cylinder. Known as induction, it happens inside a coil, not unlike the workings of a transformer. From the coil, the high voltage is routed along a single high tension lead to the distributor and thence, via eight leads to the spark plugs where the spark must appear prior to the respective piston reaching the top of its compression stroke.

Primary Components deal only with low voltage from a 12 volt battery using normally insulated wiring. After the battery come the ignition switch, the coil, an ignition amplifier switching module (whose input signal comes from the distributor pick-up coil) and various other connections to coil negative and positive terminals. Inside the coil is where the primary and secondary sides get together taking in low voltage pulses and sending out high voltage sparks.

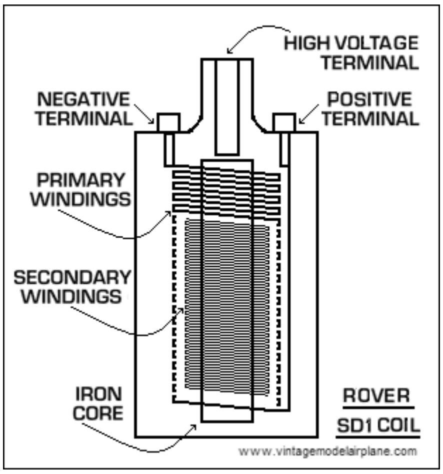


Secondary Components begin inside the coil, on to a high tension cable (king lead), as the typical 10-20,000 volt pulses scramble urgently to get to the middle terminal of the distributor cap where they connect via a carbon contact to the centre of the rotor arm, along to the rotor tip, jumping a tiny gap to one of eight distributor cap turret terminals. From there, the pulse of high voltage energy transfers via a spark plug lead to eventually leap across a larger plug gap inside the combustion chamber to earth. The distributor cap, rotor arm, leads and plugs are all service items to be regularly inspected and/or replaced according to predetermined schedules.

Maintenance on the highly stressed secondary components is crucial. The rotor arm tip and cap contacts do wear out. Plug leads, co-existing with extreme heat cycles, moving parts, oils, fluids and vibration, tire of delivering 10-20,000 volts. Spark plug contacts simply erode. So, routinely:

- Inspect distributor cap and rotor arm yearly (more often in humid areas) for contact erosion.
- Look for carbon tracking where external sparking occurs. Arcing can be seen after dark.
- Visually inspect plug leads for burns or tears.
- Periodically check plug leads for high resistance indicating a broken conductor.
- Inspect, clean and re-gap spark plugs annually. Replace full set of spark plugs biennially.

The Coil, mystifying to almost everyone, is provided with a stream of 12 volt pulses across its positive and negative terminals which it converts into 10-20,000 volt pulses by a basic electro-magnetic process known as inductance. Like a transformer, it has two sets of windings made up of insulated wires surrounding an iron (or similar metal) core. The primary windings are generally several hundred turns of heavy wire whilst the secondary windings are many thousand turns of thin gauge wire. Coil makers typically work on a ratio between the secondary and primary windings of 100:1. What this means is one hundred secondary turns to every one of the primary turns, a figure often seen in manufacturers product information.

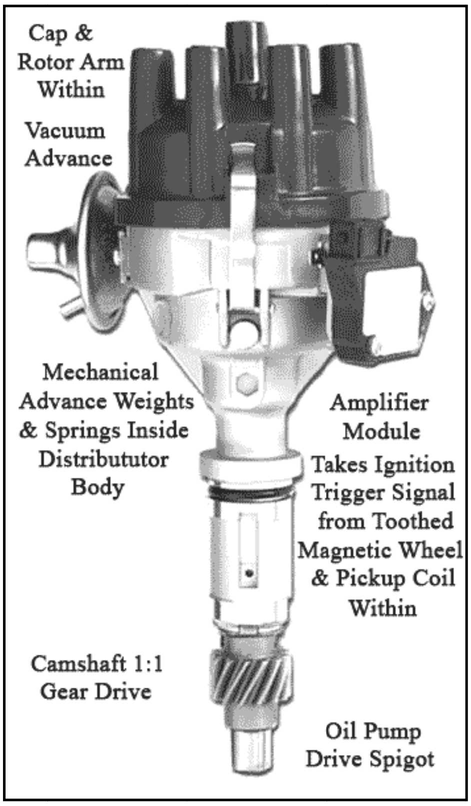


When the voltage pulse is applied by the switching module, current from the battery passes through the thick primary windings of the coil creating a powerful magnetic field that builds relatively slowly due to the electrical characteristics of the iron cored inductor (in electronics, an inductor resists rapid changes to the flow of current). However when the switching device opens (emulating points in early systems) the flow of current through the primary windings is instantly broken and the powerful magnetic field collapses very quickly at this sudden loss of primary current. This rapidly collapsing field induces a small voltage in each and every one of the many thousands of secondary windings. The more secondary turns, the higher the total voltage. This stepped up voltage is sufficient to jump a spark plug gap and ignite an air/fuel mixture.

Distributor Functions are multiple, far more than generally recognized by the average owner enthusiast. Apart from steering high voltage pulses to the correct spark plug at the right time, it tells the ignition switching module when to operate, it alters the ignition timing according to the engine load as determined by the vacuum present in the throttle body, it also varies ignition timing according to the rotational speed of the engine, and finally is often responsible for turning the oil pump. Despite all that, this very hard working device generally has a life expectancy anywhere between 100,000 and 200,000 miles. So, in brief, these are its responsibilities:

- Trigger the secondary side of the ignition.
- Alter the ignition timing according to engine load and speed.
- Steer the ignition spark to different cylinders.
- Drive the oil pump.

Driven from the camshaft by equal gearing means it turns at camshaft speed, which is half crankshaft speed. Two key parts are firmly attached to its vertical shaft, a trigger wheel and a rotor arm. The trigger wheel has equally spaced teeth (or lobes) for each engine cylinder. Inside the typical Rover SD1 V8 distributor the wheel is made of a special magnetic substance having eight lobes that pass very close to a pick-up coil. This, in turn, generates its own output signal synchronized to each passing lobe to send a small sine wave voltage through its two electrical connections to the ignition amplifier. The rotor arm, obviously synchronized exactly to the lobes on the trigger wheel, delivers the high voltage pulses from the coil to the correct cap terminal. The vacuum and mechanical advance mechanisms respond to their two different stimulii by rotating a base plate inside the distributor, upon which is mounted the pick-up coil.



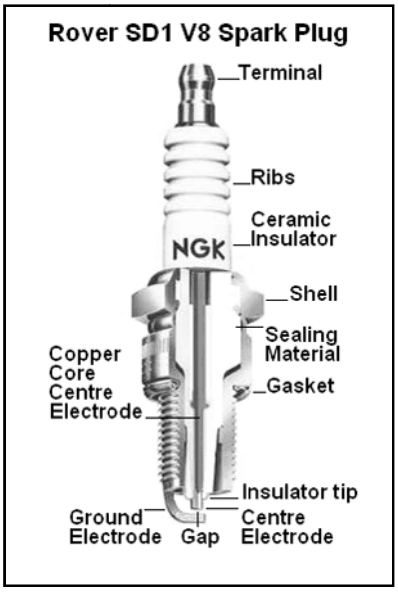
The Ignition Amplifier Module (common abbreviation, ignition amp or ignition module) is simply an electronic switch that emulates the opening/closing contact points of earlier ignition systems. The sine wave input derived from the distributor trigger wheel and pickup coil is converted by the amplifier to become "open circuit" the instant a spark is required. This open circuit causes the rapid collapse of the coil magnetic field generating the high voltage charge that will produce the spark. All these actions are instantaneous, there being no delays as may occur in spring contacts and obviously no burned points, a perpetual problem of earlier distributors.

Firing Order of a Rover SD1 V8 engine is 1-8-4-3-6-5-7-2, predetermined by engine design. As the coil fires, voltage is transferred through the king lead to the center terminal of the distributor cap to the centre contact of the rotor arm, across the arm to jump the small gap to the spark plug terminal of the cap. All this, occurring more than 330 times/second for 5000rpm engine speed.

Spark Plugs are the final barrier the ignition system has to overcome. The high voltage must jump across the gap with a healthy burst of energy, visibly, a fat blue spark. To get there, the current travels through the plug lead to the threaded tip of the centre terminal reaching through the ceramic insulator ending with the exactly centred electrode having a space between it and a side electrode connected to the metal housing of the plug which is also electrical ground.

The only common adjustment with conventional spark plugs is gap size. Opening the gap makes it more difficult for the spark to jump across, causing the high tension components to try and build up a larger voltage before the spark will propagate. This added strain on the secondary components of the ignition system will shorten their life. If the gap is too small, life is effortless resulting in weak sparks, perhaps not strong enough to initiate full combustion of the air/fuel mixture. Both situations may have consequential misfires and noticeable poor performance.

Spark plug cleaning might also be considered an adjustment, best carried out with great care not to damage the electrodes or leave scratches or conductive deposits on the ceramic insulator.



A wide variety of spark plugs are available for experimenting. Different brands/types, platinum tips, multiple electrodes, resistor/non resistor, hot/cold, each designed to meet the theoretical need of specific applications! Migrating to a magical new spark plug suggested by a guy in the pub does wonders for the manufacturer's profitability but back on planet earth, for urban use, choose the bog standard plug recommended in the workshop manual, correctly gapped, of course!

Spark Plug Leads are the main highways of the ignition system, the path allowing the high voltage pulse of current to move safely and efficiently from the distributor cap to the spark plugs where it readily jumps to earth across the inviting gap.

Living in a harsh environment, the importance of good quality leads cannot be over-stated having to cope with extremes of temperature, abrasion, contamination and vibration induced flexing. They must also safely insulate the HT so the voltage cannot jump to earth outside of the combustion chamber. An added complication is that when such high voltage energy passes through a conductor it sets up a magnetic field resulting in something called electromagnetic interference (EMI) which is embarrassingly the cause of a buzzing noise heard typically through a radio or television receiver. This interference can also wreak havoc on other electronics systems such as the ECU of a fuel injection equipped car.

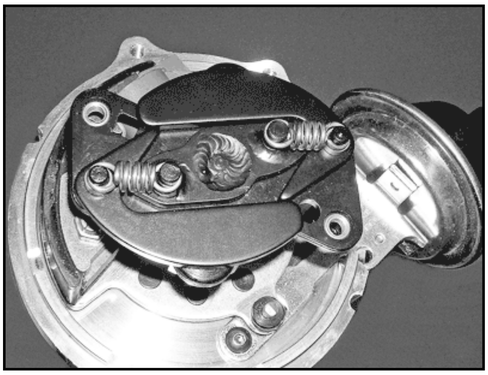
Original equipment plug leads generally combat EMI by using a carbon core material that has a high resistance to the flow of the spark energy. High street or internet boy racer outlets offer a variety of leads with lower resistance to maximize spark energy but if tempted, also investigate the specification for good EMI suppression. It's important to ensure that the terminal to wire crimp is in good order otherwise a poor connection thereabouts will cause intermittent performance, or maybe even a lifeless cylinder. Lastly, bear in mind that good quality plug lead boots are needed to resist the extreme heat of exhaust manifolds.

Battery and Alternator must be in good working order because even with a clever ignition system, tuned to perfection, an engine will under-perform with a dud battery that has already struggled to crank the starter motor on a high compression lump on a cold day. Worse, it must also provide power for lights and cabin comfort systems, and may simply not have sufficient capacity to pump up the ignition system to full effect resulting in weak or missing sparks.

Capacitive Discharge Ignition is an alternative to the original equipment on a Rover SD1 V8, whose main downfall is that inductive ignition takes a finite time, called dwell, to build up its coil voltage before it can be rapidly discharged to create the high voltage required to jump a spark plug gap. It works perfectly well for general use but is incapable of peak performance at higher rpm when a truncated output voltage results in misfire and loss of power.

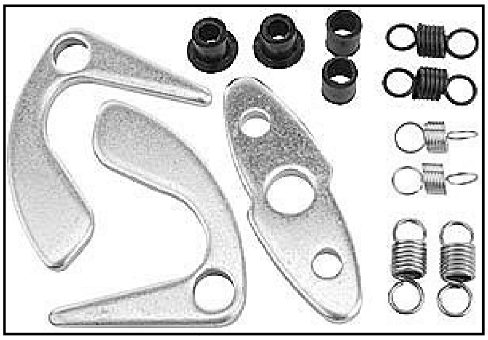
Not exclusive to race tracks either, CDI is a commonly available legal upgrade, its main advantage being able to produce higher voltages over the complete rpm range of the engine. It incorporates electronic circuitry and a transformer to step up battery voltage close to 500 volts to be stored in a capacitor which fires out all the energy instantly when instructed to do so by the distributor. A perverse short-coming is the spark has very short duration, not a problem at high rpm, but possibly so at low rpm. However a higher voltage spark with near instant recovery can be fired several times on the same cycle. A multiple spark system can deliver several sparks, reducing in number at higher rpm. Specialist help may be needed to retrofit CDI to an RV8.

Ignition Timing, often poorly understood, is a condition which is varied according to engine load and rotational speed. At idle speeds, sparking takes place only a few degrees before the piston reaches TDC on its compression stroke igniting the fuel/air mixture to start the combustion process. The inducted cylinder volume is the same for all engine speeds and even with a varying fuel/air ratio the combustion period remains fairly constant. Consequently, as engine rpm increases so the combustion process must be started progressively sooner which means the spark must occur earlier in the compression stroke enabling best possible combustion and power. To meet that need, distributors are equipped variously with a speed sensitive mechanical advance mechanism, operated by centrifugal force, similar to the simple example seen here.



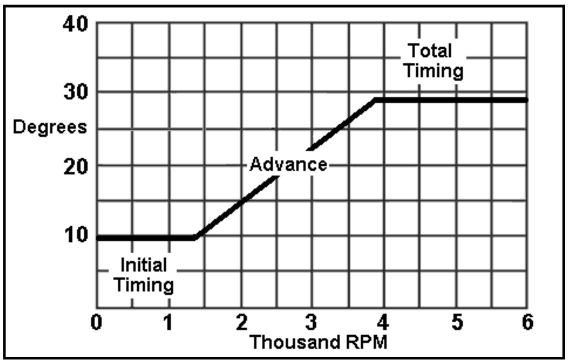
Mechanical Advance is essential in making an engine perform efficiently. It consists of two weights being flung outwards by the rotational forces within the distributor. Springs attached to the weights control the rate at which they are forced out by the motion. The weights are attached to an advance plate upon which is also mounted the pick-up coil assembly. As the plate moves forward it results in the ignition being triggered earlier on the compression stroke (advanced).

Delayed advance hampers power and therefore, performance. Conversely, sparking too soon, and the result is premature detonation, lost power and possible percussion damage inside the engine. When moving away from standard set-up, it’s important to check ignition timing at idle and higher rpm to know the total amount of advance. Substituting different tension springs alters how quickly the timing advances. Springs with less tension allow the weights to come out easier to advance the timing sooner. Kits are available containing special shape weights, plates and a variety of springs to fit most types of distributors, enabling ‘expert’ advance curve adjustment to match special engine performance needs, beyond normal urban use. The following timing jargon describes variously what happens and when it happens.



Initial timing tells us where the timing is set without vacuum advance at a low idle speed. It is also where the distributor is positioned during installation. Generally, this is between 2° and 10° before TDC for a standard RV8 SD1 depending these days, upon the fuel generally available.

Mechanical timing is the degree of advance added to initial timing as the weights are flung out by rotational forces. For example, a distributor might be set up to supply (say) 18° of mechanical advance.



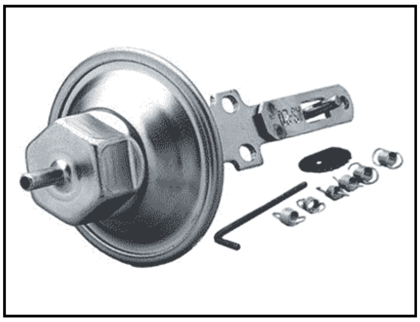
Total timing describes the maximum amount of advance occurring when initial timing is added to mechanical timing. If an engine has 10° initial combined with 18° mechanical, the total is 28°.

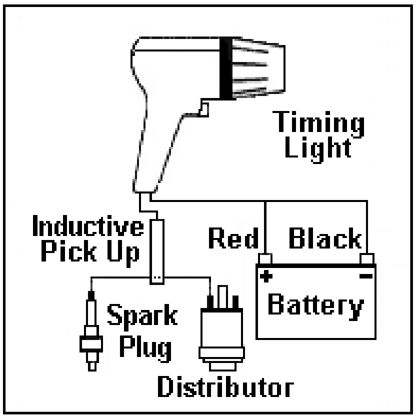
Advance Curve defines the rate of timing change seen on the chart showing initial timing at 10°, mechanical (centrifugal) timing starting to move at 1300 rpm, reaching total timing of 28° at 3800 rpm, an 18° linear timing advance curve achieved over 2500 rpm.

Vacuum Advance is not conventionally added to Total Timing, it being generally referred to as a separate process. It senses manifold depression only when the throttle plate moves away from the idle position and advances the timing to capture maximum efficiency from the combustion process at low engine speed before handing over ignition advance duties to the mechanical system. By improving launch efficiency it fulfills its primary function of optimizing economy. It becomes relatively unimportant at higher loads and high end performance with little or no vacuum available during part/wide open throttle, therefore no vacuum advance anyway! Some vacuum is available at low load, low engine speed, cruising situations which the vacuum advance system will sense it and feed in some small amounts of advance accordingly.

A vacuum can containing a diaphragm sits on the side of the distributor pulling a rod fixed to the timing advance plate. When engine load is low and vacuum high, the plate advances the trigger signal. As the engine accelerates, vacuum drops, and the rod ceases to pull on the advance plate.

A vacuum suction tube generally connects to a hole above the throttle plates and is called ported vacuum as opposed to manifold vacuum, which comes directly from the intake manifold. The distinction being, at idle, manifold vacuum is always present but the ported vacuum only occurs when the throttle plates open. The extent of advance is typically 10°-15° and generally fixed by factory specification. However, adjustable vacuum canisters as seen in this image are also available enabling a variable setting.





Timing Lights can be lightweight, cheap and nasty affairs or quite sophisticated tools incorporating features such as tachometer and dwell measurement. For the home enthusiast a basic model from a popular outlet is sufficiently capable of setting/checking timing occasionally on a road going SD1. However, if one requires accuracy within a half a degree, better quality timing light would be called for.

Timing Tape may help in making accurate adjustments if the timing pointer is too thick or the timing marks on the harmonic balancer are dull or corroded. A small amount of local cleaning of the pulley and white wax rubbed into the timing marks is all that is really needed to brighten the reflected light for basic set-up. A tape is needed when checking for total advance requiring a longer scale than is generally seen on the SD1 V8 engine.

Ignition Timing can Never be Totally Right for all eventualities on a standard RV8 SD1. It's self-evident, from what we have seen, that a single setting of ignition timing cannot satisfy the broad range of conditions an engine encounters. The advance needed during cranking and idle is not enough for higher engine speeds. On the other hand high rpm timing cannot satisfy the needs at cranking or low speed. To maximize torque and power over the full rpm range, a correctly designed timing curve is imperative but even with the good quality, original equipment of the period, some compromises were inevitable. For example, as timing advances with rpm, so the engine may also require subtle timing adjustment due to simultaneous changes occurring to the air/fuel mixture entering the cylinder, caused by (say) changing temperature, load or acceleration. Such sophistication was simply unavailable on the original system, yet the basic requirements were largely satisfied. As rpm increases, during the ever reducing time available, the mixture has to completely combust before or around the time the piston reaches TDC.

Originally then, there was little leeway beyond idle advance/retard and swapping out weights/ springs and even then a degree of special knowledge would be called for to understand what each adjustment might achieve. That said, anyone wanting to experiment and who has the means to measure the various factors could review this table showing what might be done to adjust timing for a raft of reasons when seeking to optimize timing for higher performance applications.

Reason	**Advance for**	**Retard for**
Cylinder Pressure	Low	High
Vacuum	High	Low
Energy of ignition	Low	High
Fuel Octane	High	Low
Mixture (Air/Fuel)	Rich	Lean
Temperature	Cool	Hot

To help with reading the chart, take the well known example of octane rating. Most of us are already aware that a higher octane fuel will tolerate more timing advance.

Spark Plug Gap is the sharp end of the ignition system where the electrical energy is converted into extreme heat by generating a nice fat spark. The larger the gap the more spark (heat) is available to ignite the air/fuel mixture. Too large a gap however, combined with the already high cylinder pressure can put too much strain on the available voltage which now fails to cross the gap, the spark is effectively quenched resulting in a misfire. Misfire meaning incomplete or non-combustion. Worse the frustrated high voltage now attempts to put too much stress on the plug lead, cap, rotor arm, king lead and coil windings, with the increased likely-hood of component failure and/or reduced lifetime. OEM ignition systems define optimum spark plug gap but some experimentation may lead to perceived or subjective improvement. In advanced applications finding the optimum plug gap would be crucial to optimizing performance because there are more variables to consider. Such considerations may come into play if CDI is installed.

If making adjustments, a basic rule would be, increase plug gap by (say) .005” followed by testing/tuning, remembering that larger gaps place increased stress on the secondary components already mentioned, so they must all be in perfect condition and checked periodically. Electricity takes the path of least resistance to ground so if the gap is too large the spark will probably jump to earth via another point with lowest resistance leaving damaging carbon tracks in its wake.

Differences between RV8 OEM and CDI Ignition Systems may be summarized as follows: The inductive RV8 OEM ignition was used for simplicity and low cost, being entirely adequate for normal motoring but has little capacity for adding performance because the coil has a double duty of stepping up the voltage and storing the power in its magnetic core until the ignition is triggered. As engine rpm increases, the time available to step-up the voltage progressively decreases before the ignition is triggered again, resulting in gradually weaker sparks that eventually fail to ignite the fuel mixture in the cylinders resulting in misfires and loss of power.

CDI generates powerful sparks over the full rpm range. It takes battery energy using electronics and a transformer to step the voltage up to about 500 volts which is stored in a capacitor. When triggered, the capacitor discharges all the voltage into a single purpose coil where it is converted again into very high voltage, typically 30,000-45,000 volts. From there the energy is sent in the usual way, but using enhanced components, to the plugs via king lead, rotor arm, cap and plug leads. The improved abilities described, allow for complete combustion, faster starting, better acceleration, more power, smooth idle, superior economy and cleaner combustion.

In Conclusion the Rover SD1 V8 Original Ignition System provides adequate spark generation for normal motoring but it’s a ‘close-run thing’. For an enthusiast wishing to improve road going performance, let alone prepare an engine for track work, there is nothing left in the original system to play with so conversion to CDI is the most obvious alternative for improvement.

Epilogue! Having accessed and studied internet information on ignition systems for many, many hours, this article is my take on the material seen on various sites as it relates to the Rover SD1 V8 engine. Notwithstanding my personalization of what appears here I readily acknowledge those sources of material and inspiration for some of the redrawn images. Errors and omissions are expected and notification would be gratefully received to improve the accuracy of the article.

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