Condensers and Ballast Resistors

Henry designed most of his electrical systems himself; as a self-taught electrical engineer he progressively improved his components, sometimes over many years. As a result they have become the subject of intense discussion and sometimes bewilderment. His ignition system is a case in point – today a **well maintained** 20hp ignition system can be a model of reliability; our cars will start immediately after a winter's hibernation and embark on a summer of extensive touring in all terrains and climates; a testament to his philosophy of designing for reliability and longevity. Nevertheless, there is ample opportunity for myths and legends and some of these are outlined below.

The principle of the ignition system is relatively simple, consisting of a low tension circuit and a high tension circuit. When the contact breaker opens the magnetic field generated by the primary coil almost instantly drops to zero and induces a high voltage in the secondary coil which is fed to the spark plug by the distributor. However the ignition circuit is exceedingly difficult to describe mathematically because of feedback between the two circuits and extremely rapid oscillations and resonances. Such dynamic electrical systems are always much more complex mathematically than steady-state, eg direct current, or slowly varying, eg normal alternating current, systems.

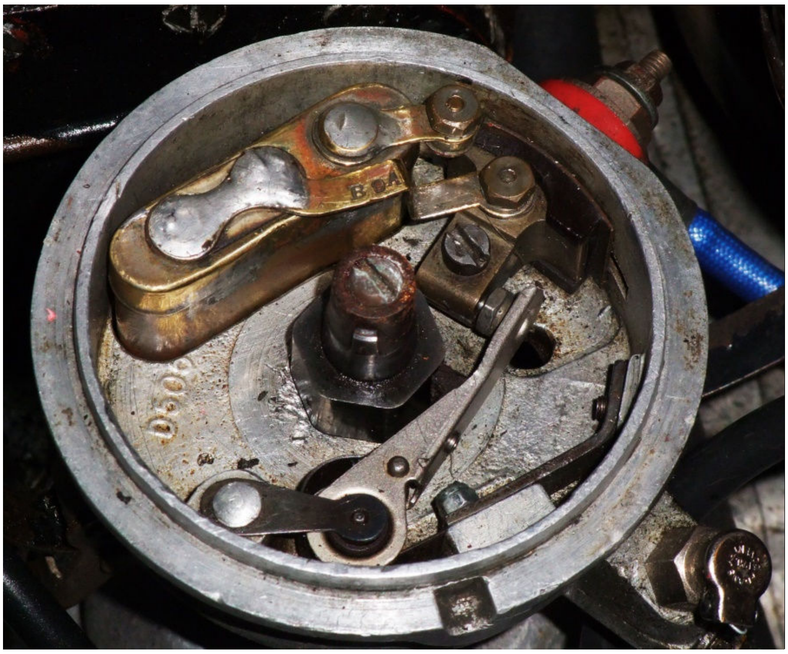
THE CONDENSER is an essential component which helps to control these resonating circuits, and it is fortunate that the exact capacitance (Farad value) of the condenser is not too critical. A modern 12-volt coil usually requires a condenser of about 0.2 micro Farad (µF). Its primary coil has a resistance of about 4 ohms designed to pass the optimum current (3-4 amps) for generating the magnetic field inside the coil.

The original Royce 4-volt coil has a 1.3 ohm primary and requires a ballast resistor of about 3 ohms to achieve this optimum 3-4 amp current. The 4-volt coil requires a condenser of higher capacitance, eg 0.3µF, for optimum performance.

The late David Else has researched this because in his spare time he used to restore original Rolls-Royce condensers for 20hps. He confirms that most modern "12-volt" condensers he has measured are about 0.2 µF. Before dismantling a Royce condenser he checks its value: where he can obtain a capacitance reading they are in the range 0.25 to 0.3µF, and this agrees with values shown on some build sheets (see for example page 164 of Fasal's book where the condenser fitted to 45G2 is recorded as 0.31 µF). Capacitance values were discussed by Michael Forrest for his P-II (B233 p42) and Nicolas Haran (B237 p77). Both agree with David, that RR originally supplied a 0.3µF condenser with their 4-volt coil.

David Else used to refurbish your original condenser. He dismantled and cleaned it and fitted a modern 0.3µF capacitor inside. In all he did more than 20 for owners, and to the best of his knowledge never had any failures.

For a short period in 1927 20hps were fitted with a condenser having two connectors at the top, the second one being to earth. Perhaps Royce worried that relying on a simple press fit to connect electrically the casing of the condenser with the distributor body was not adequately Roycean! However, the Company reverted to the original design after a few months, so the two-connector condensers are relatively rare. The photograph shows a two connector condenser fitted to my 1927 GXL39. It was found for me by David Else.



Two connector condenser fitted to GXL39 **Two connertor RR and Villiers condensers**

Original coils and condensers were manufactured using materials available at the time, eg using paper and wax for insulation so they were never totally reliable. However coils can be rewound and this is normally done to the original 4-volt specification. There has been much discussion on why Royce used the 4-volt ignition system. Royce's design ensured that the primary coil is well insulated thermally (the primary is wound *inside* the secondary coil, which is in turn encased in the Bakelite pot). Thus the heat generated in the primary coil is potentially a problem, especially if the ignition is inadvertently left "on" with the engine stopped, in which case the amps are higher than when the engine is running, and there is less wind cooling. A 4 -volt coil generates only a quarter of the heat of the equivalent 12-volt coil (heat = volts x amps). Bearing in mind the generally primitive and unreliable electrical insulation available then, perhaps it was not surprising that Royce tried to prevent overheating inside the coil. Reliability was King!

Villiers supplies a condenser (M1750) which is box-shaped and fits inside the well of the 20hp distributor, see photographs. It costs about £12 direct from Villiers Services. I measured its capacitance as 0.29µF, and fitted it to GXL39 which ran well with this condenser for several years.

https://villiersservices.co.uk/

BALLAST RESISTORS are also an essential component of the ignition system. They are another Roycean mystery, with their elaborate design and stories about their being specified as 3.06 ohm. Even today it would be difficult to manufacture to that degree of accuracy, so I subscribe to the view that someone in the distant past misread a poorly hand-written 3.0Ω as 3.06!

It is often asserted that the original ballast resistance wire is a special alloy which has low (about 1ohm) resistance when cold, increasing to 3.5ohm when hot: a cold ballast therefore could give a higher initial voltage to the coil while the engine is being started.

To ensure the ballast is cold the ignition must be switched on *last*, preferably just as you press the starter switch. However the 20hp instruction manual tells us just the opposite: to switch on the ignition *first*, ie before retarding the ignition, closing the throttle, opening the starting carburettor and setting the mixture control to "strong"! Similar advice is given in other handbooks, for 20/25 and 25/30 cars.

So what was this mystery resistance wire? On checking the physical constants of alloys it is apparent that the usual resistance alloys have a very low temperature coefficients of resistance, ie their resistance does not greatly increase as they get hot. Some pure metals and certain nickel/iron alloys do have a higher temperature coefficient of resistance; the best candidate would be 99.97% pure nickel. Using the published data for pure nickel, an 80cm length of wire 0.5mm diameter would indeed have a resistance of roughly 1ohm at 0°C and 3.5 ohm at 300°C. Maybe the mystery wire is simply pure nickel? I discussed this with the late Professor Ken Brittan, who was a 20hp owner and professional metallurgist, with extensive knowledge of pre-war Phantoms, electrical engineering and automobile history.

Ken told me that many years previously he worked on an original and unrestored low mileage P-I which had starting problems. He was surprised to notice that when he turned on the ignition, the indicated amps rose rapidly to a high level and then fell to normal within about 20 seconds. He confirmed this behaviour using modern instruments. Examining the ballast resistor he noticed the wire was only about 0.5 mm diameter, and corroded. Ken replaced the wire with "normal" ballast resistance wire and all was OK. He analysed the wire and found it was essentially pure nickel! He said that pure nickel is easily drawn into thin wire.

Ken noted that the ceramic ballast resistor housing on the P-I appeared to be original - not a modern replica, and all the other components of the car appeared to be original as well. Therefore the evidence suggested that nickel wire was indeed fitted to this car when new. However, Ken had never seen any other car of the period fitted with similar wire, nor had he seen this wire mentioned in any RR document.

Ken felt that a reasonable explanation for all this is that Rolls-Royce experimented with 0.5mm nickel wire for a period in the late 1920s, but the wire proved to be unreliable, possibly because of corrosion and/or low strength. Assuming the experiment was halted, the nickel wire concept would never have made it to the drivers' manuals. In those days 20hp and P-I cars were used for daily transport, many of them covering high mileages in atrocious weather on terrible roads, so poor reliability was unacceptable. This general problem of ballast wire corrosion has been mentioned before in the Bulletin, see Technical Manual 1 page 104. If anyone has documentary evidence to shed more light on this topic, perhaps you would get in touch.

It should be noted that high-nickel wire 0.5mm diameter is available from Ristes Motor Company for anyone wanting to experiment. https://ristesmotors.co.uk/

Postscript: Thanks to modern microelectronics the average enthusiast can now afford to buy a hand-held digital multimeter which accurately measures resistance down to 1 ohm or less, and capacitance up to 20μF. They typically cost £30 - £50.