# C-D Ignition Unit for 6-volt vehicles

**Over the past few years there has been a great amount of interest concerning capacitor-discharge ignition systems. The systems described to date have been for 12-volt vehicles. Many readers have requested information on a 6-volt circuit and this article has been produced to satisfy requests.**

**by LEO SIMPSON**

Although cars with 6-volt electrical systems are no longer being built, there are many 6-volt vehicles still on the road today. Probably most are pre-1968 Volkswagens, and when it is considered how many of these vehicles alone are still in use, there must be a sizable number of our readers who are interested in such a project.

Some readers may regard the installation of a CDI system on a vehicle such as the VW as a waste of time and money. After all, the engine has very modest performance so that any performance improvements are likely to be minimal. From the point of view of acceleration times from 0 to 60mph, this view is entirely justified. However, the main improvements are noticeably better engine smoothness and flexibility, and easier starting, particularly when the engine is hot. The improvement in petrol economy will be small, especially when compared with a well tuned car with conventional ignition.

Perhaps the biggest advantage of the CDI system is reduction in maintenance of distributor points and spark plugs. Do-it-yourself enthusiasts will tend to belittle this, but for the person whose time is strictly limited, even this reduction is worthwhile.

Design of the unit is straightforward and is based on a circuit published by the Applications Laboratory of Standard Telephones and Cables Ltd. The converter consists of two silicon NPN power transistors in a common-collector transformer coupled oscillator. Self-starting under full load conditions is ensured by the inclusion of the resistor network supplying base current to the transistors. A full discussion of basic converter operation was included in "A Capacitor Discharge Ignition System" published in the August 1970 issue of "Electronics Australia", so we shall not repeat it here.

The square wave voltage impressed across the primary windings by the transistors appears across the secondary winding, multiplied by the turns ratio to around 350 volts, with a 6-volt input. This is rectified by a bridge rectifier to charge the 1uF/600VW "dump" capacitor via the primary of the ignition coil.

A silicon controlled-rectifier (SCR) is used to discharge the dump capacitor back via the coil primary and thus apply the full capacitor voltage to the coil. This is "stepped up" by the secondary winding to fire the spark plugs. The capacitor voltage of around 350 volts is much higher than that developed inductively in the coil primary by a conventional ignition system so that the available "spark energy" is much higher. In addition, the "rise time" of the voltage across the plugs is considerably faster than for conventional ignition so that fouled plugs are easier to fire.

While the dump capacitor is being discharged, the converter stops functioning and does not restart until the SCR reverts to the "blocking" (or non-conducting) state. The 100uF capacitor across the 100 ohm bias resistor improves restarting of the converter to ensure good performance at high spark repetition rates. The charging time of the dump capacitor is approximately 3 milliseconds and the converter frequency around 3KHz.

Since the dump capacitor is charged very rapidly, there is a risk that the SCR will be turned on by the rapid rise time of the voltage across it — this is so-called "dv/dt switching". This tendency is avoided by connecting the .001uF/2KV ceramic capacitor between anode and cathode of the SCR and also by the 100 ohm resistor connected between gate and cathode. The latter component also reduces the risk of the SCR being turned on by its own leakage currents.

When the spark repetition rate is low, ie, when the car is idling, the converter tend to charge the dump capacitor to much higher voltages than if the spark rate is higher. This could be termed the "load regulation" of the converter and it is improved by the 330K/1W resistor connected across the SCR. Actually, the load regulation of the converter is quite good and the system works satisfactorily at spark repetition rates up to 300Hz, far higher than is ever likely to be required on 6-volt vehicles, as 300 sparks per second is equivalent to 9000rpm with a 4-cylinder motor or 6000rpm with a 6-cylinder motor.

With a 6-volt system, variation of the input voltage is far more of a problem than load regulation referred to above. In a typical 6-volt vehicle the input voltage to the converter could vary from as low as 4.5 volts when the battery is almost flat and attempting to crank the motor, to as high as 8 volts when the generator takes over the battery load at high speed. As it is, the converter works reliably with input voltages from 3.5 to 9 volts. It will work with even higher voltages but there is the danger of damaging the SCR.

Positive-going trigger pulses are generated by the distributor points with the aid of a simple network consisting of two resistors, a diode and a capacitor. When the points are closed, current flows through the 27-ohm resistor. When they open, the 0.33uF capacitor is charged up via the 27-ohm resistor and diode and the charging current triggers the SCR. When the points close, the capacitor discharges via the 1.8K resistor.

One of the advantages of solid-state ignition is that the points are relieved of the arduous duty of carrying and "breaking" the heavy coil currents, so that point wear is much reduced. However, if the current is reduced too much, the distributor points become fouled by oxidation and by oil fumes inside the distributor housing. Eventually, triggering of the SCR becomes unreliable. Ideally, the points should carry about 200 to 500mA to maintain a self-cleaning action. The 27-ohm resistor sets this current at around 220mA — a compromise between cleaning action of the points and heat dissipation inside the CDI case.

No steps have been taken to include a "point bounce" suppression circuit. With most of the cars that the unit is likely to be used point bounce should not be a problem since engine speeds are relatively low. Another reason for not including such a feature, is that it is difficult to obtain suitably high amplitude trigger pulses using UJTs with a 6-volt supply, and if transistors were used to do the same job, power transistors would be required. In practice we have found the trigger circuit shown quite satisfactory for Volkswagens.

## PARTS LIST

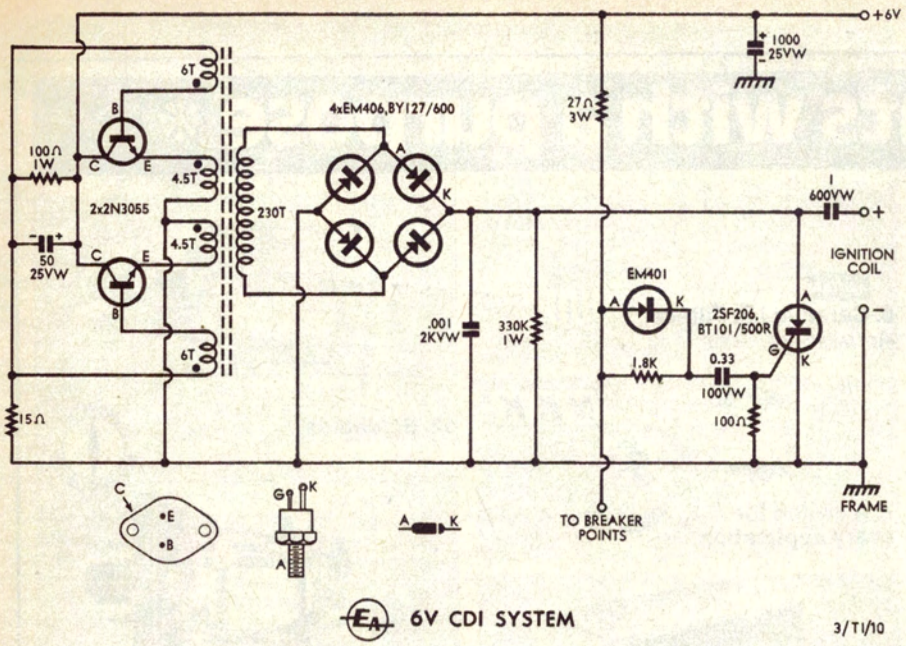
*1 Case with mounting brackets (see text)*
*2 FX2243 ferrite cup cores*
*1 DT2206 Delrin former*
*2 2N3055, BDY20 silicon NPN power transistors*
*4 EM406, BY127/600 silicon power diodes*
*1 EM401 silicon diode*
*1 2SF206, BT101/500R silicon controlled-rectifier*

*CAPACITORS*
*1 x 1000uF/25VW electrolytic*
*1 x 50uF/25VW electrolytic*
*1 x 1uF/600VW paper (Ducon 3S10)*
*1 x .33uF/100VW polyester*
*1 x .001uF/2KV ceramic*

*RESISTORS*
*1 x 330K/1W, 1 x 1.8/½W, 1 x 100 ohms/1W, 1 x 100 ohms/½W, 1 x 27 ohms/3W, 1 x 15 ohms/½W.*

*MISCELLANEOUS*
*Double-tough enamel copper wire (20, 24 and 26 B&S), heavy duty hook-up wire, spaghetti sleeving, miniature tagboard, octal plug and socket (optional), grommet, power cable clamp, screws, etc.*

*NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used providing they are physically compatible. Components with lower ratings may also be used in some cases, provided the ratings are not exceeded.*




*The circuit for the 6V capacitor discharge system. Full winding details for the converter transformer are given in the text.*

CONSTRUCTION: The prototype unit was constructed in a cadmium-plated steel box measuring approx 6in x 2½in. However, since this box was specially made and is not available we have not shown photographs. Boxes of a similar type, made by Heating Systems, are available through kitset suppliers. Alternatively, a diecast box measuring 4¾in x 3¾in x 2in made by STC or Eddystone will be suitable. The main requirement for a suitable box is that it should seal out dust and water spray. If a steel box is used, the lid should have a cork gasket.

Construction can logically begin with the winding of the converter transformer. This uses two Elcoma FX 2243 ferrite half-cups and a single section bobbin, type number DT 2206. The secondary is wound on first, 230 turns of 26 B&S double tough enamel (DTE) copper wire. DTE wire is used to allow the secondary to be wound without insulation between layers.

Winding the secondary can be done with the aid of a hand drill clamped in a vyce. Two large flat washers, a long bolt and nut can be used to clamp the bobbin — the bolt is held in the drill chuck. The inner washer should be suitably notched to allow the winding start to lay flat along the chuck during winding.

Begin by soldering the start of the winding wire to a 3in length of 5/.0076 (or similar) PVC hookup wire. Lay this across the width of the bobbin and anchor it with a short length of electrical insulation tape. Wind on 260 turns as evenly as possible. Cover this with two layers of insulation tape and terminate the finish in the same way as the start.

Leads for the primary and feedback windings need not be terminated as for the secondary — just leave the starts and finishes of the windings about six inches long, and cover with spaghetti sleeving. The starts and finishes should be securely anchored on the bobbin with insulation tape. The primary windings are wound over the secondary, and the feedback winding last. Both feedback and primary windings are wound bifilar, ie. both sections of each winding are wound simultaneously, with two wires together wound as one wire. There is no real need to label the windings as each uses a different gauge. The primary winding is 4.5 turns bifilar, 20 B&S. The feedback winding is 6 turns bifilar, 24 B&S.

Place the completed winding in the two cup core halves, ensuring that the faces of the core halves are clean before clamping. If there is dirt on the core faces, the cores may either crack when they are tightened together, or the resultant air gap may prevent proper operation of the converter. Having clamped the cores, the transformer may be impregnated.

The prototype was impregnated using Crown 6084 epoxy insulating varnish. This is an aerosol pack available from Plessey Rola Pty Ltd. Other compounds, such as Estapol, are also satisfactory for the job.

First step in assembling the components inside the case is to install the 2N3055 power transistors on each end of the case, using mica washers and silicone grease to improve heat conduction. Under normal operating conditions the transistors become only moderately warm to the touch and the heatsink area provided by the steel case or diecast box is quite adequate.

The rectifier diodes should have a voltage rating of at least 600 volts, and a high surge current rating since they have to carry the "back-swing" of the dump capacitor discharge current. Diodes recommended are the EM406 or BY127/600.

The recommended SCR is the 2SF206 from STC or the BT101/500R from Elcoma. The 2SF206 has a blocking voltage rating of 600 volts and the BT101/500R a rating of 500 volts. 400 volt SCRs such as the C20D should not be used as the converter output voltage rises above 400 volts with battery voltages above 7 volts.

The SCR does not require a heatsink but is mounted for convenience using a small L-shaped bracket made from a 1½in x ¾in piece of 16 SWG aluminium. The SCR is electrically isolated from the bracket using mica washers supplied at purchase. The bracket is mounted inside the case using two screws, nuts and lockwashers. All screw connections must have lockwashers otherwise everything will vibrate loose within the first 10 miles.

For maximum reliability, an oil-impregnated paper capacitor rated for high discharge currents should be used for the dump capacitor. Peak discharge currents as high as 25 amps are quite typical for this circuit and under these conditions polycarbonate, and in particular, polyester capacitors are a very dubious proposition. Recommended types are the 5S10A with 1000 volt rating and the 3S10 with 600-volt rating. Both types are made by Ducon and available from kitset suppliers. We used the 3S10 in our unit.

All the small components in the circuit were mounted on two small tagboards. Wiring layout is not critical except for the following point. The earth return for the coil primary must not be made via the car body, but must have a separate earth return lead back to the converter. Supply wires to the converter and the coil primary wires must be in heavy duty automotive wire to avoid unnecessary voltage losses.

Presuming that the transformer is the last component to be installed, proceed as follows: A suitable hole is drilled in the case to take the transformer clamping bolt. The bolt is passed through the case, through the transformer core, through a flat washer and lockwasher, and then the nut screwed on. Do not overtighten. otherwise the core will crack, an experience which is both frustrating and costly.

The primary and feedback windings are connected as follows: For the primary winding, connect the start of one section to the finish of the other and connect the junction to the negative supply. Connect the other ends to the transistor emitters. Proceed similarly with the feedback winding, connecting the start of one section to the finish of the other; the junction goes to the junction of the 100 ohm and 15 ohm resistors. The other ends of the windings connect to the transistor bases. If all is well, the converter should emit a whistle when the supply is connected. If not, swap the base connections to the transistors and it should start. Current drain when the unit is operating correctly will range from 400mA when the engine is idling, to around 4 amps at 300 spark rate.

An octal changeover plug was installed in the author's unit to enable easy change

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on his shoulder" which caused him to write his brief article was that amplifier manufacturers establish a figure for output resistance in the middle of the audio range and let it be assumed that the figure applies at the lower frequencies also. We did not get excited about the point you raise because we knew that it had been covered in George Tillett's article on "Choosing An Amplifier", which we already had set up in type. It appears on page 76 of the September issue. Incidentally, George Tillett sets a target figure of not less than 20, which would support Ron Cooper's dissatisfaction with the kind of figure you are prepared to accept. In regard to your second point, undoubtedly a long paper could be written about the implications of a capacitive output impedance, and the possible effects of resonance with transformers in electrostatic systems. However, the author's intention was not to get deeply involved in all this but simply to stress that the loudspeaker is more able to pursue its own inclinations if, at the frequency involved, it is isolated by a substantial reactance from the low impedance point of the drive circuit.

**NOISE PROBLEM:** While looking for a particular article recently, I found that I had apparently loaned or lost the relevant magazine. The article concerned the construction of a circuit to be connected in line with an AC outlet to eliminate and

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# RADIO: Unofficial history

My passion in amateur radio is known as "contest capering", and I have been at it more years than I care to remember. Winning a two-day contest requires a big effort, and even a few minutes away from the rig can mean many lost points. Being an old timer, I don't last as well as those in the prime of youth. Aches and pains develop from prolonged sitting as a contest wears on — and there's always a headache from the constant QRM.

Recently I was going great guns and really piling up points but began to suffer from the aforesaid aches. My modus operandi in the radio shack at night is to have a small light that shines only on the receiver and log book — the rest of the room is in darkness. Hearing my six-year-old daughter in the bathroom, I called to her to bring me a glass of water and a headache powder from the cabinet. This she did and I gulped it hurriedly down. It seemed to taste odd, but I was too busy to bother.

The contest dragged on and the headache only got worse. at bedtime, my daughter came in for a goodnight kiss. I asked for another powder and again it tasted lousy, but I blamed it on the dryness of my mouth. About one hour later I began to feel queasy and light-headed, and finally had to lie down on the divan in the shack.

"Honey," I called weakly to my wife, "you still up?"

"What's wrong?" The voice from the bedroom was unsympathetic.

"I don't feel so good — musta bin somethin' I ate."

"Well it wasn't dinner or supper 'cos you've been too busy to eat".

"I've only had a couple of headache powders and it couldn't be them".

There were sounds of the wife hurriedly getting out of bed. She appeared from the bathroom, switched on the light and held out a box of powders.

"There aren't any powders. I forgot to get some in".

"Well, what are these?"

"De-worming powders for the dog".

"De — WHAT?" Rage overcame my aches and pains. I sat up and bellowed, "That flaming hound has more status round here than the rest of the family. Since when does its medication mix with ours?" I sank back miserably on to the divan. "Get the doctor, I feel lousy".

"It's 11 pm. You can ring him up at this hour with a tale like that, but not me!"

The local GP is a pretty good friend of mine so I dialled him. "—er Mac", I said sheepisly, "I've swallowed a couple of de-worm dog powders. I thought they were aspirin —"

"You're on the booze —"

"No, no, no. It's fair dinkum. I feel crook and —"

A great guffaw echoed out from the headset. "Listen, pal, you don't need me, you need a vet!"

"Very funny", I said testily, "all I want to know is — well — will I be OK?"

"Ha, ha, ha. They're a purgative, you know, but they'll probably do an old dog like you more good than harm. Just ignore the symptoms and carry on".

I did carry on — all the next day — but not in the contest. (A.S., VK4SS, West End, Brisbane, Qld.)

Readers are invited to submit contributions to "RADIO: Unofficial History" and a publication fee will be paid for those used. Stories must be humorous and they must be true. Letters must be signed and the locale of the story indicated as a mark of good faith. The Editor reserves the right to rephrase contributions as necessary to preserve uniformity of style.

## 6V IGNITION . . . from page 77

between conventional and capacitor discharge ignition. However, this feature is somewhat of a mixed blessing because contact resistance may develop in the plug pin connections, so that the plug itself can be a possible source of unreliability.

The prototype was installed on a 1965 VW 1200. It is mounted on the firewall, adjacent to the fan housing, on the same side as the ignition coil. Since it is mounted in the air stream to the fan intake, it runs quite cool. If the unit is mounted in a conventional car it should be mounted on the bulkhead, as far from the engine as possible, and be protected from possible water spray.

Brackets are needed to mount the unit to the firewall. These can take the form of two flat steel strips, 6in x 1in, screwed or welded to the back of the case. The unit is mounted by four long screws (with nuts and washers) which pass right through the firewall, into the passenger compartment.

Spark plug and point settings were left as set for conventional ignition. There seems to be little point in deliberately increasing the spark plug gaps to obtain a better flame front — this places a higher load on the insulation of the coil, ignition leads and the distributor housing and means that the settings have to be redone if there is need to change back to the conventional ignition.

All ignition leads and spark plug connections must be in top condition with CDI, as the higher voltages will rapidly find any weaknesses in the system and cause misfiring. The author made up insulating spacers to suspend the ignition leads away from the fan housing and from each other to avoid misfiring. The insulators clip over the inlet manifolds and are made of a material similar to Paxolin or SRPB (synthetic resin paper board). These measures may not be necessary if double-insulated high tension cable is used. TVRS (television and radio suppression) ignition cables should be replaced with standard cable if their resistance is much above 20K per lead.