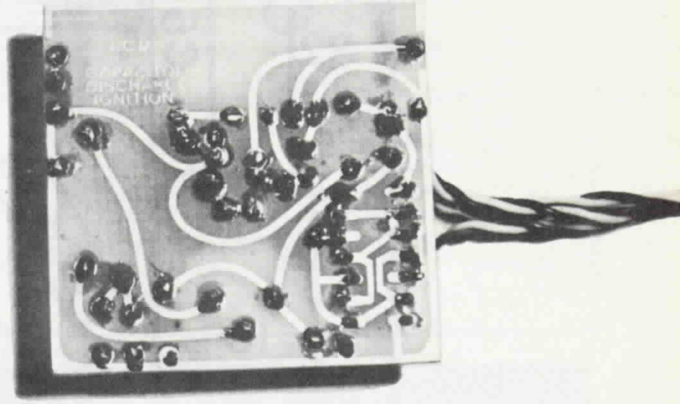
RCM CAPACITIVE DISCHARGE IGNITION SYSTEM



By Floyd E. Carter

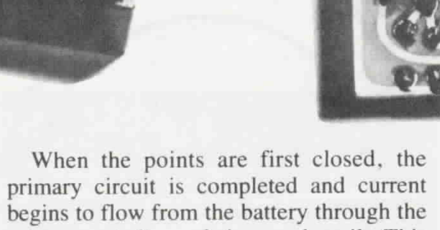
When Ray Arden produced the first glo plug for model engines, model builders were generally delighted to be rid of the recalcitrant spark ignition with its batteries, coil, condenser, and cranking, cranking, cranking. Little did anyone at that time realize that the old spark ignition would be back, thanks to the renewed interest in the Old Timer movement. Those who have ventured into the use of spark ignition have experienced a need for a dependable and efficient method for running their motors without the headache of the conventional ignition system.

The Quarter Scale folks don't seem to have any trouble running their chain-saw motors, because these are fitted with magneto ignition, a satisfactory, if not heavy answer to the task of spark ignition. But the Browns, Madewells, Spitfires, and Super Cykes did not have magneto ingnition, so have to rely on batteries and coil to run on gasoline fuel.

The conventional spark ignition system has been around for about 70 years, when Charles Kettering first designed one for the 1908 Cadillac. It has remained basically unchanged to this day. Two cycle model engines simply use a scaled-down version of the Kettering system.

Principal components of the external ignition system are a battery, coil, spark plug, points and capacitor. The unfying purpose is to provide a spark to ignite an air-fuel (gasoline) mixture in the cylinder. The spark causes a controlled burning that is timed to occur when the piston is at or near top center. The battery provides a source of current to the coil which, due to transformer action, changes this energy input into a voltage high enough to ionize the atmosphere in the spark plug gap and cause an arc.

When the points are first closed, the primary circuit is completed and current begins to flow from the battery through the primary winding of the spark coil. This current builds up slowly and the battery energy is converted into an expanding magnetic field around the iron core of the spark coil. The dwell time (the time that the points remain closed) must be long enough to allow the magnetic field to develop. When the points open, the current is suddenly stopped and the magnetic field collapses rapidly. The energy in the collapsing magnetic field is transformed into a high voltage pulse across the spark coil secondary winding, which consists of thousands of turns of very fine wire. This high voltage pulse is applied across the spark plug gap to generate the arc. The system works very well and has the advantage of simplicity and low cost, perhaps explaining why it has survived for so many years.



TOROID TRANSFORMER WINDING

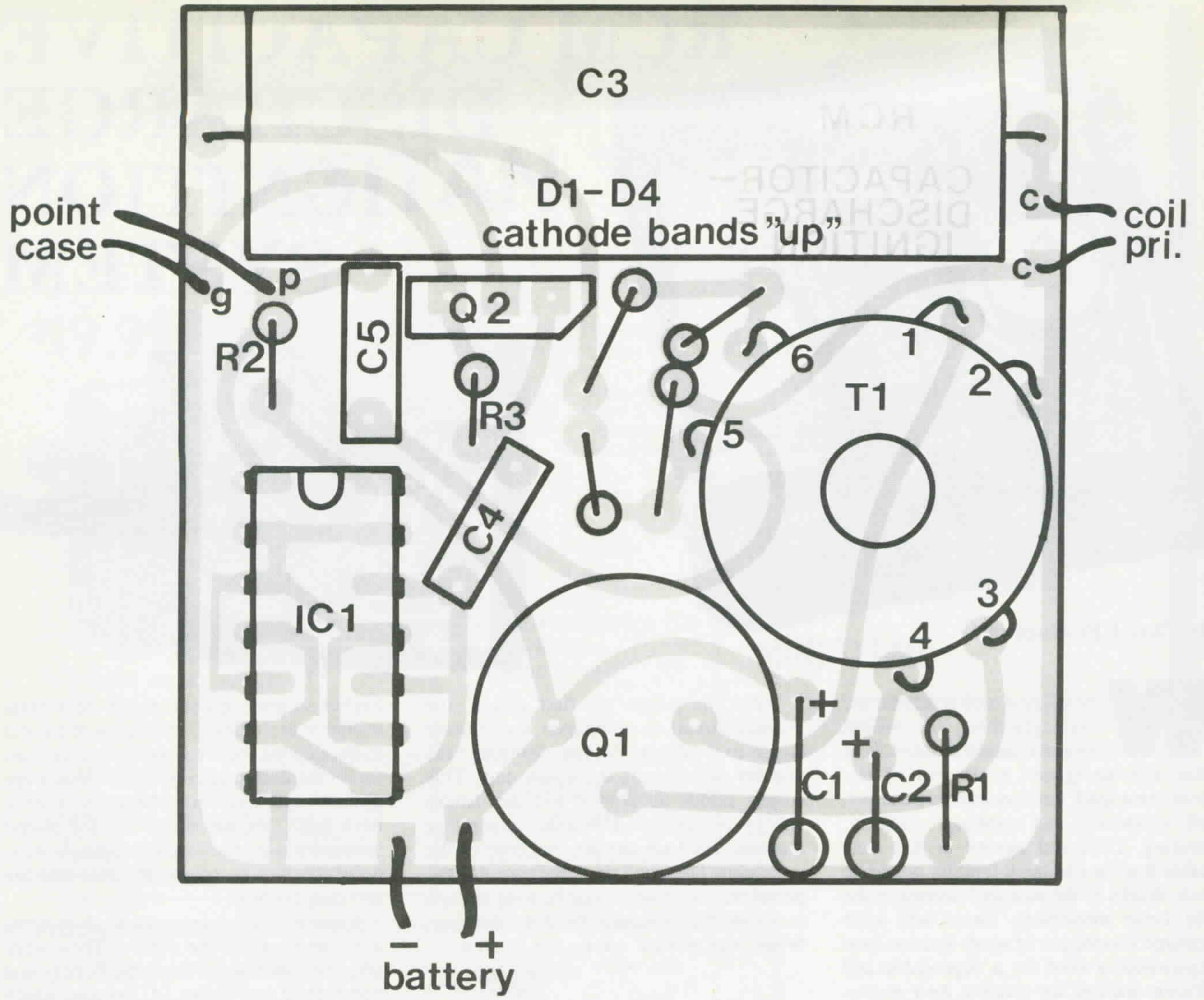
There is one major drawback, and this is inefficiency. Since the dwell angle is fixed, higher engine speeds allow less time available to "charge" the coil with current to develop the required magnetic field. This forces the design of coils which draw large primary currents from the battery in order to have them operate at the highest engine speed. Even so, the available spark voltage decreases at high speeds to cause missing and plug fouling.

Capacitor Discharge, or C-D systems were developed in the 1960's. These units take the low voltage from the battery and transform it to a higher DC voltage, which charges an internal capacitor. The charged capacitor is quickly switched across the coil primary causing a very short high current pulse to flow through the coil, and generating a much higher spark voltage than in the conventional Kettering system.

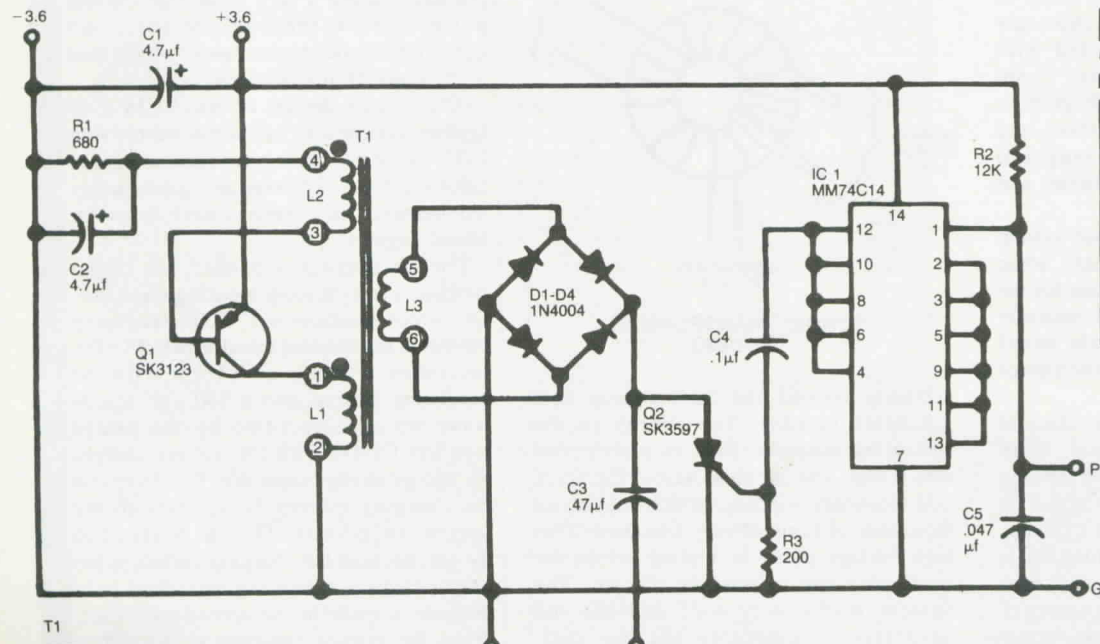
The circuit design of the RCM C-D Ignition system is identical in principle with C-D systems now manufactured for automotive use. The size and spark energy requirements have been scaled down for model engines.

For the technically minded, the circuit contains a free-running blocking oscillator, Q1, which produces a 17 KHz oscillating current in the toroidal transformer, T1. The secondary winding of T1 converts the oscillating current into a 160 volt square wave which is rectified by the bridge rectifiers D1-D4. This DC voltage charges the energy storage capacitor, C3. Note that the charging current flows through the ignition coil primary. This has no effect on the coil because the charging current is too low to create a strong magnetic field or to generate a spark in the secondary circuit. When the storage capacitor is charged to 160 VDC, it waits for the proper time to dump its energy into the spark coil.

When the ignition points close, pin 1 of IC-1 drops from 3.6 volts to 0 volts. Since

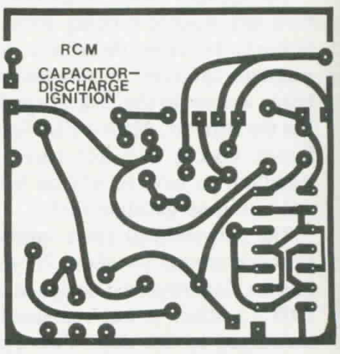


COMPONENT OVERLAY



T1
L1 15T #24
L2 6T #30
L3 450T #34
768T188/3E2A TOROID CORE

SCHEMATIC



ACTUAL SIZE
P/C BOARD

Etched and drilled printed circuit board available from:

State Circuit Boards, Inc., 1326 W. Collins, Orange, California 92667

U.S.: $5.50 postpaid, California add sales tax.

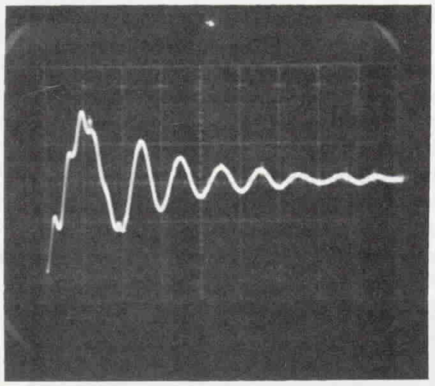
Foreign: $7.00 postpaid.

PARTS LIST

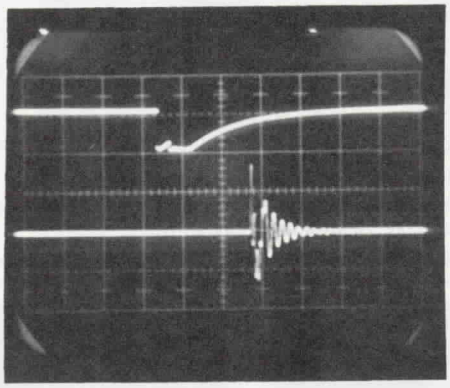
Quan.	Ref. Desig.	Name	Value	Part #	Mfgr.
4	D1-D4	Diode	1A, 400PIV	1N4004	Motorola
2	C1-C2	Capacitor	4.7 µf, 6v	162D475X 9006BC2	Sprague
1	C3	Capacitor	.47 µf, 200V	V146X-23 416P47492 3-WMF-2P47	Aerovox Sprague Cornell-Dubilier
1	C4	Capacitor	.1 µf, 50V	CK06BX104M	Erie
1	C5	Capacitor	.047 µf, 50V	CK06BX473M	Erie
1	Q1	Transistor	PNP, Germanium	SK 3123	RCA
1	Q2	SCR	200V, 4A	SK 3597	RCA
1	T1	Toroid Core	1/2'' O.D.	768T188/ 3E2A	Ferroxcube
1	IC1	Hex Buffer		MM74C14N CD40106BE MC14584B	National Semi. RCA Motorola
1	R1	Resistor	680 ohm	RC05GF681J	Allen-Bradley
1	R2	Resistor	12K ohm	RC05GF123J	Allen-Bradley
1	R3	Resistor	200 ohm	RC05GF201J	Allen-Bradley

Additional Parts

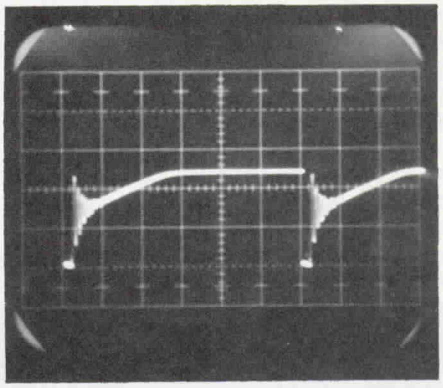
12'' #23 enameled magnet wire (Belden #8064)
12'' #30 enameled magnet wire (Belden #8041)
32' #34 enameled magnet wire (Belden #8043)



Voltage Across Spark Coil at time of firing. Vertical = 50V/division, Horizontal = 100 usec/division.



Top Trace: Voltage across points. Note the small spike caused by contact bounce. Bottom Trace: Secondary spark voltage. The peak firing voltage is 17 kilovolts. The actual spark is delayed 700 microseconds after the points first open. The engine timer must be rotated further to compensate for this. Horizontal: 500 microseconds/division; Vertical: top trace, 5V/division; bottom trace, 10 kilovolts/division.



DC output voltage of DC-DC converter. Note that oscillations stop during coil firing, and require 2½ milliseconds to recover to firing potential. This equates to an engine speed of 24,000 rpm for 2-cycle engine, and 48,000 rpm for 4-cycle engine, more than enough for any ignition application. Horizontal: 1 millisecond/division; Vertical: 50 Volts/division.

IC-1 provides double inversion, the voltage at pin 12 also falls from 3.6 volts to 0 volts. The negative-going step is coupled through C5 and causes a negative pulse on the gate terminal of SCR, Q2. This will not trigger the SCR because a positive pulse is required to cause conduction. Therefore, the action of closing the points has no effect. It is when the points open that we want the spark to be generated. When the points do open, pin 1 of IC-1 rises from 0 volts to 3.6 volts. The output of IC-1 also rises rapidly to 3.6 volts, coupling a positive pulse to the gate terminal of SRC and triggering it into conduction. The current path between the storage capacitor and the coil primary is then complete, the entire energy stored in the capacitor is discharged into the coil. After the spark has been generated, we want the circuit to recover quickly and to begin to recharge the storage capacitor for the next spark.

The capacitor and coil primary inductance form a resonant circuit. After the capacitor energy is dumped into the coil, the spark coil obligingly returns a portion of this

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SPECIFICATIONS

Type:	Electronic: Capacitive-Discharge system. Uses standard 3V model ignition coil.
Recommended Battery:	3.6 volt Nickel-Cadmium. 225 mah, or greater
Maximum Operating Speed:	Over 20,000 rpm (2 cycle engine)
Dwell Angle Requirement:	5 to 90 degrees
Contact Point Current:	400 microamperes, average
Permissible Contact Bounce:	500 microseconds, maximum (May be altered; see text)
DC-DC Converter Frequency:	17 KHz
Spark Delay:	700 microseconds (42 degrees @ 10,000 rpm). (Value may be reduced; see text)
Spark Duration:	100 microseconds
Spark Current:	3.3 ma, peak
Spark Voltage:	16-17 KV, open circuit
Spark Energy:	5.6 millijoule
Battery Current:	0.2 A @ 1000 rpm 0.3 A @ 10,000 rpm 0.4 A @ 20,000 rpm
Size (without case)	1.75'' x 1.75'' x .5''

ENGINE THROTTLE HOOKUPS

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solder along that portion of it to help keep it rigid when it is outside the plastic tubing.

Some support will be necessary along its length to prevent flexing. Unless yours is an extremely long airplane, the normal firewall and formers will offer adequate support, with only one more required at the aft end of the cable. A small block with a hole through which the tubing passes is more than adequate. Again, flow silver solder along the exposed end of the cable to stiffen it.

Obviously, all of this silver soldering has to be done with the flexible cable outside the plastic tubing, and supported so as to be perfectly straight.

At the throttle arm end, the only thing to remember is to use a nylon clevis to prevent that metal to metal contact that can sometimes cause us a radio problem. That is, unless yours is one of the few engines that has a plastic arm, in which case a metal clevis is best, as a metal in plastic fit is generally smoother in operation than a plastic in plastic.

Sometimes, especially with the smaller engines, there can be a rather sharp angle between where the cable comes out of the firewall and the throttle arm. In such cases, a ball and socket fitting, such as Du-Bro's No. 190 will move the connecting point out enough to make things work a little smoother, as well as compensate for any misalignment that might have crept in.

Assemble everything as mentioned, minus the servo connection. Operate the throttle by hand to insure that everything is working free and easy. When it works to your satisfaction, button it all up and adjust the length of the servo arm without any binding. There are no valid rule of thumb as to settings; the servo/engine combinations are so numerous. Follow the engine manufacturer's instructions on how to adjust the throttle, this hook-up to the servo will give you all the versatility, smoothness, and reliability required so that your engine can be adjusted to its maximum potential, which will add immeasurably to your flying pleasure. □

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energy back to the capacitor, which begins to charge in the reverse direction. The SCR, which up to now has been triggered into continuous conduction, becomes reverse biased. This resets it into a non-conducting state. With the coil now electrically disconnected, the oscillator again begins to charge the storage capacitor in the proper direction in preparation for the next cycle.

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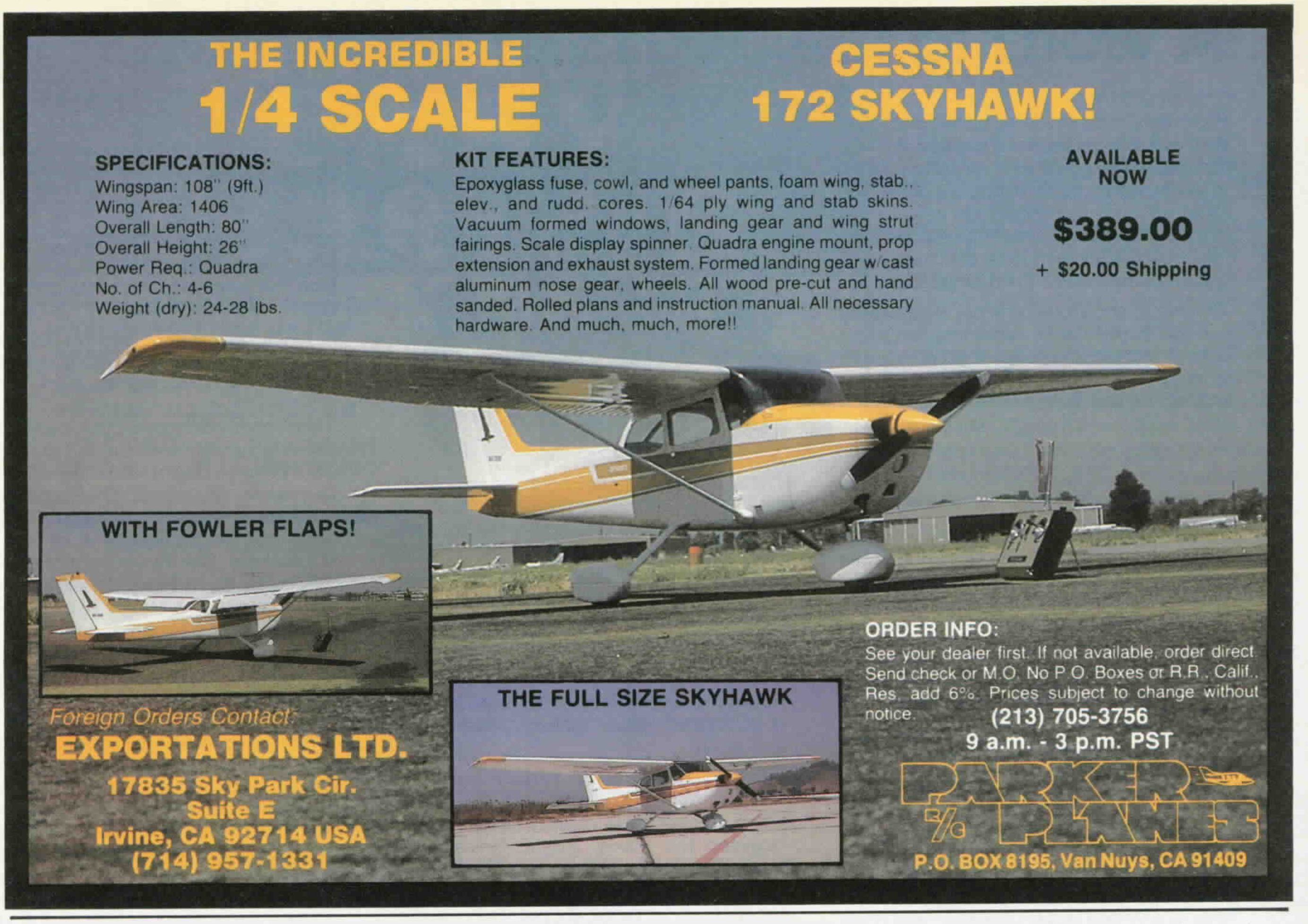

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One persistent problem in electronic ignition circuits is their very quick response, which can interpret point bounce as a valid signal to generate a spark. When the points first close, they can rebound far enough to open the point circuit for a fraction of a millisecond. This causes no problem in conventional ignition systems because the long dwell time is required to build up the magnetic field around the ignition coil. C-D systems must filter out point bounce and only react to a genuine opening of the point circuit. C5 and R2 serve as a simple integrator circuit, delaying the voltage rise at the input of IC-1. In addition, IC-1 is a Schmitt Trigger which has an input threshold of 2 volts. This combination of delay and triggering threshold means that the points must be open continuously for more than 0.5 milliseconds to cause a trigger. Five of the six available buffers of IC-1 are parallel-connected to provide adequate drive to the gate terminal of the SCR.

CONSTRUCTION

In spite of the simplicity of the circuit and the lack of expensive parts, the toroid coil, T1, is rather tedious to wind. The secondary side of 450 turns is wound first. Measure and cut 32' of #34 magnet wire. make a shuttle out of thin plywood about 1/4'' wide and 12'' long. Cut a notch in each end so the wire will not slip off. Now wind the wire on the shuttle along the long side. Each time a turn is wound on the core, the shuttle must pass through the center of the ''donut.'' Distribute the turns evenly around the core as you wind. When the secondary winding is finished, use a coat of varnish to insulate this secondary winding from the primary windings, which are wound next. Since the primary windings consist of just a few turns, a shuttle is not required. Wind both primary windings in the same direction, and mark the end of each winding where you started.

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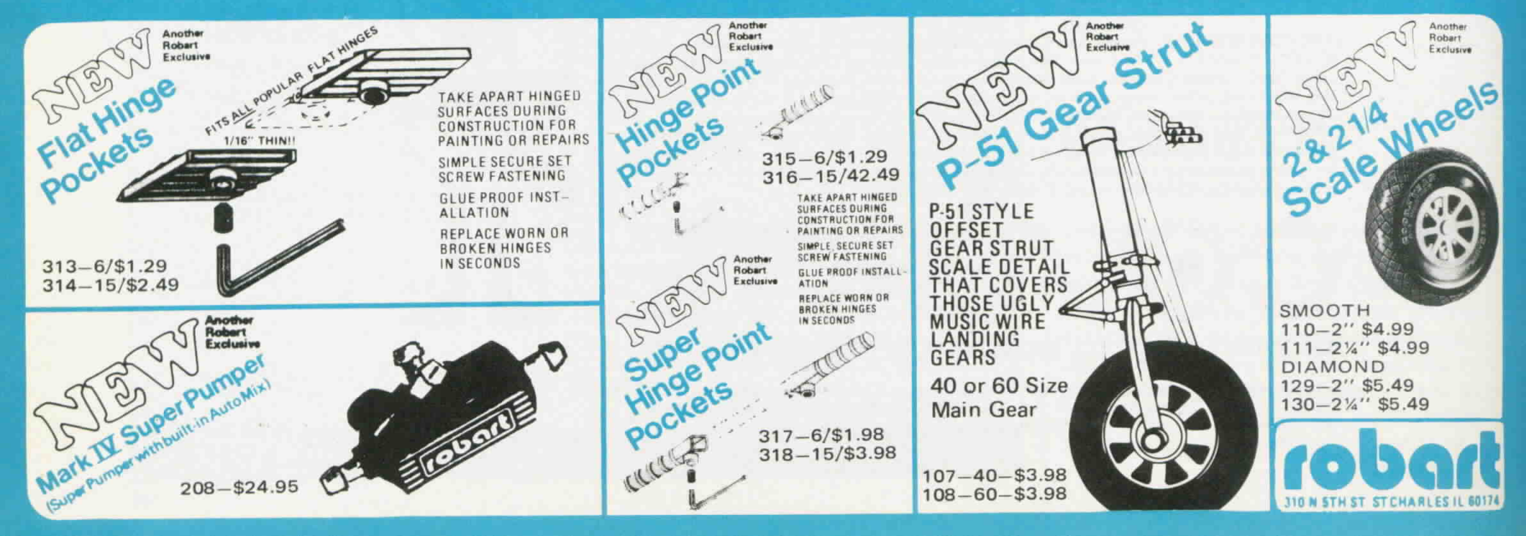

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This is the "start" end and is also noted on the schematic diagram with a heavy dot. The polarity of "start" and "finish" must be observed for the circuit to oscillate. (Otherwise, one of the primary windings will have to be reversed on the circuit board.) The secondary "start" winding does not matter.

The circuit may be built on a piece of epoxy glass board using point-to-point wiring, but it is most convenient and professional looking to use a printed circuit board. A full size pattern is shown. This can be photocopied to a film negative (or positive, depending on the type of PC board kit you have). A KEPRO #P-101A-G etched circuit kit is recommended. Available from Allied Electronics Inc. Catalog part number 835-0480. (About $15). The parts list gives component numbers which were selected to fit on the circuit board shown.

Connect the C-D unit to coil, battery, and engine as shown. Be careful to observe battery polarity, as there is no reverse voltage protection in the circuit. There are no adjustments to make, so go ahead and turn it on. Open and close the points. You should hear and see a fat spark each time the points are opened. If nothing happens, check the voltage across capacitor C3. It should be about 150 volts DC. Check pin 12 of IC-1 while opening and closing the points. It should measure over 3 volts with points open, and 0 volts with points closed.

As mentioned earlier, point dwell angle is not critical with the C-D unit. What is more important is freedom from contact bounce. Therefore, it is good to experiment with point gap and spring tension if contact bounce causes any problem. The circuit will reject bounce less than 0.5 milliseconds in duration. So without dwell angle restrictions, a lot of latitude is available to adjust for minimum point bounce. The integration delay built into the unit will have little effect at low engine speeds, but at high speeds, say 10,000 rpm, the delay equates to a 42° late spark. This will require the rotation of the point assembly an extra 42 degrees advanced to obtain the correct spark timing at high speeds. The values of the electrical integrator, C5 and R2, were chosen to compensate for a severe point bounce. By adjustment of gap and spring tension, the point bounce of your engine may be greatly reduced. In that case, the integration delay may be shortened so that the timer will not need to be advanced so far. Lowering the value of R2 will shorten the spark delay. The effect of R2 is a linear function. Therefore, lowering the value to 6K ohms will cut the delay in half, etc. The value of R2 has no effect on the rest of the circuit, and it may be safely lowered to

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about 1K ohms, if necessary.

It is not required to use a "booster" battery for starting. It delivers a hot spark even at cranking speeds, something the Kettering system will not do. Just remember that the battery drain stays constant, even with points open. So don't forget to turn off the switch unless you are actually starting or running the engine.

Using a Ni-cd battery of 3.6 volts (3 cells) and 225 mah capacity, you should get 30 to 45 minutes run time from a charge. High-rate cells may be used and "quick charged" at the flying site from an auxiliary storage battery.

Because of the simplicty of the circuit and the use of a printed circuit board, the constructor has a good chance of a successful project. The parts have been carefully chosen and are available nationwide from most retail electronic supply stores. To make things a little easier, the author has most of the parts available, although complete kits or assembled units are not anticipated at this time. My address is 11232 Crist Drive, Los Altos, California 94022. □

PIT STOP

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foot advantage. On the last lap Lavacot still had a 50 foot lead and a sure win, when he came around a corner and was hit head on by Jimmy Welch, who had spun out and was turning his car around. This knocked Lavacot into the boards, and before a turn marshall could get him, Kyes went on by to take the win with Lavacot 2nd and Kent Clausen 3rd.

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